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Minister for the Environment and Heritage

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STATE OF THE ENVIRONMENT REPORTING

Australian State of the Environment Committee

Chair: Professor Bruce Thom

Minister for the Environment and Heritage
Parliament House
CANBERRA ACT 2600

Dear Minister

It is with pleasure that I present the second independent and comprehensive report on the state of Australia's environment. It has been prepared by the Australian State of the Environment Committee in line with the Committee's terms of reference.

The preparation of the Report has been guided by seven theme reports on atmosphere, coasts and oceans, biodiversity, land, inland waters, natural and cultural heritage, and human settlements.

The Committee wishes the Report to be used by decision-makers at all levels of government and in the community. It should help people to be better informed about the state of our environment, the pressures we exert on it and the effectiveness of our responses. The Report and associated theme reports provide data and information on important environmental issues. The challenges facing Australia's environment require responses based on the best available information.

I personally wish to thank all those who have contributed to the preparation and publication of this comprehensive Report.

I am pleased to commend the Report to you and, through you, to the people of Australia.

Yours sincerely

Professor Bruce Thom
Chair

14 December 2001

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Executive overview

Condition of the environment

Australians have a high stake in the state of their environment. Our lifestyles and livelihoods depend on its health. People have used the continent's natural resources over tens of thousands of years and, following European occupation, have employed technologies which accelerated this exploitation. Our natural capital in air, land, minerals, water, oceans and ecosystems is continually encroached upon and our Indigenous and non-Indigenous heritage and traditions are often threatened or destroyed.

This Report by the Australian State of the Environment Committee (ASEC) provides an independent assessment of the condition of Australia's environment in the year 2001. The ASEC has, to the extent possible, provided information on environmental trends and changes and what these mean for more effective environmental planning and management. Despite some areas of significant improvement, Australians still have major challenges in the sustainable use of resources and in the maintenance of our natural and cultural heritage. This Report concludes, as did SoE (1996), that progress towards sustainability requires the integration of environmental with economic and social policies.

Pressures on the environment

Pressures on the Australian environment continue to grow. The seven theme reports (see http://www.ea.gov.au/soe/) that guided SoE (2001) identify such pressures, some of which arise from the political and economic conditions of Australian society.

Degradation of lands and waters remain of critical concern, especially in the intensive land use zone upon which much of Australia's agricultural production depends.

Population growth has particular effects on coastal Australia. Urban sprawl, high energy consumption, stormwater pollution of estuaries and coastal waters, and the continued decline in biodiversity as a result of land clearing all arise from population and economic pressures. Other processes such as habitat fragmentation and the introduction of pests across the continent and into marine environments threaten some terrestrial and marine ecosystems.

Beyond local pressures are those that occur on a national and global scale. These include economic and political effects which can inhibit the capacity of individuals, communities, or the nation to properly care for the environment. Australia alone cannot prevent global warming or sea level rise, nor, in isolation, create sustainable development. However, we have a responsibility to contribute to global solutions to these problems.

Responses to environmental pressures

The SoE (2001) identifies many responses since 1996 to pressures which affect the Australian environment. These include the following:

1 More legislation that embodies principles of ecologically sustainable development (ESD) including the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

2 Companies are factoring environmental issues into decision making. The Australian Mining Industry Code for Environmental Management is an excellent initiative. The fishing industry and the aquaculture industry are also developing codes of practice for more environmentally responsive operations.

3 Organisations such as the Australian Conservation Foundation (ACF) and the National Farmers' Federation (NFF) have combined in their presentations on the urgency to repair the country, including a possible costing.

4 The Regional Forest Agreement (RFA) process has provided increasing levels of certainty in forest management for the next 20 years.

5 Funded programs are emerging through cooperation of Commonwealth, state and territory governments to address many of the problems in a more integrated way.

6 The Council of Australian Governments (COAG) has set about the complex task of water reform.

7 Australia's Oceans Policy is addressing important marine environment planning and management issues.

8 The National Action Plan (NAP) for Salinity and Water Quality, announced in 2000, proposes joint Commonwealth, state and territory funding of $1.4 billion to address dryland salinity.
9 Natural Heritage Trust programs have engaged almost 400 000 Australians in environmental projects including Landcare and Coastcare.
10 The commitment to a five-year budget of $1 billion from 2001–02 for the Extension to the Natural Heritage Trust is expected to be more strategic in approach.
11 State government investments in new environmental programs are often innovative and far-reaching (e.g. the New South Wales 'coastal package' involving a RFA-type assessment, and stricter planning regime and legislative reform designed to better manage the effects of expected population growth).
12 Vehicle emission standards and fuel quality standards, recently mandated, will ensure that air quality in the large urban centres can be maintained or improved despite a projected increase in vehicles.
13 Announcements in 2001 that amendments are to be made to capital gains tax rules to ensure landowners who set aside part or all of their land for conservation in perpetuity will not be disadvantaged.

In addition, the ASEC notes that government interventions of various kinds, including legislation and regulations, codes of practice—formal or informal—have been effective in protecting and managing the environment. Examples are given in the *Thematic findings*.

An urgent need for action

Despite initiatives such as noted above, the state of the Australian natural environment has improved very little since 1996, and in some critical aspects, has worsened.

The increased area of land affected by salinity has captured the nation's attention and some action has been initiated. As well as the NAP for Salinity and Water Quality 2000, a new 15-year plan for the Murray–Darling system, and a similar plan for agricultural lands in Western Australia were announced in September 2001, each dealing with the problems of salinity, water quality and availability. The theme reports of SoE (2001) provide further information on the effect of land clearing, water extraction, forestry practices and the use of fire on biodiversity.

Throughout Australia, both physical and cultural heritage, including Indigenous languages, continues to be threatened and lost. As species are lost and habitats fragmented, degraded or destroyed, we lose our heritage and part of our life-support system. What happens on land also occurs to a lesser degree in the coastal waters surrounding Australia; sediment and

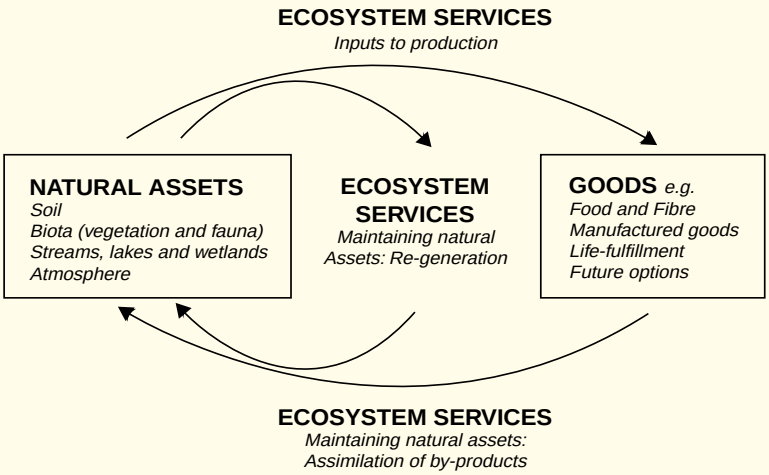


Figure 1: Ecosystem services conceptual framework.

Conceptual framework developed to illustrate the role of ecosystem services in maintaining natural assets and in supporting the production of goods of value to the Goulburn Broke catchment in Victoria.

Source: after CSIRO (2001).

pollution are threatening some habitats. Not all fisheries can be assessed as sustainable, thus posing some risk to on-going sustainability of food supply and livelihoods that depend on the sea.

Improvements are still needed because the environment provides us with essential processes that are critical to life on Earth. These processes are known as ecosystem services (Figure 1) and include soil formation, nutrient cycling, clean water supply, pollination and waste assimilation. Without these ecosystem services, the world's economy would grind to a halt.

Learning to live on this continent

Australia has responsibility for the management of 7.6 million km^2 of land, one of the largest marine areas in the world (about 16 million km^2) and nearly six million km^2 of Antarctic interests. The diversity of climatic zones ranges from tropical in the north, to temperate in the south and polar in Antarctica. Much of our flora and fauna is unique.

The landscape has been transformed to varying degrees by human activities over 60 000 years. After European settlement in 1788, the pace of change quickened so that within a few generations, large tracts of the country were irreversibly modified and degradation beyond the capacity of individuals to restore or reverse it had begun. Indigenous peoples and cultures and land management practices received little respect during this period. The agriculture, mining, and urban settlements that form the basis of the successful economy and multicultural society that constitutes Australia today have come at a cost, some of which has yet to be paid.

As knowledge of the limits of the environment's ability to recover from damage has increased, there has emerged an awareness of the irreversibility of many actions and the need to learn how to use the environment within constraints imposed by the fragile soils and climatic extremes of drought and floods. In the extensive land use zone comprising much of semi-arid Australia, for example, some excellent examples exist of stocking practices which anticipate and cope with drought (following the early Kidman model of stock withdrawal and agistment), but use of these is far from widespread.

Severe and often irreversible degradation in many local and regional environments show, however, that we have often failed to understand the constraints on development. Indigenous Australians learnt over thousands of years to live in a sustainable and spiritual relationship with this distinctive environment. There is a growing recognition that this knowledge, attitudes and experiences can inform present day land management. Nonetheless, where Indigenous peoples are responsible for control and management of extensive land areas, poor living conditions, health and lack of educational opportunities are often seen as hampering their ability to exercise effective land management practices.

Complexities of environmental issues

Managing the activities of people in a way that conserves habitats while sustaining resources and industries is extraordinarily complex and difficult. For example, the clearing of mature forests, woodlands and grasslands for economic reasons continues to raise many environmental concerns about the consequences of such actions on river water quality, soil quality and ecosystem loss in catchments and in areas far removed from the land clearing activities. Landholders frequently operate as if what they do on their property or lease is an unfettered right. Understandably, however, many local communities fear the loss of their forest heritage and tradition when the forest industry is threatened.

There is a clear need to provide incentives to landholders, communities and local governments to achieve long-term, regional solutions to the many complex problems which individuals alone cannot solve.

Caring for our country

Fundamental to better management and planning is the recognition that the environment, including our cultural and natural heritage, is everyone's business. Caring for country has long been entrenched in the traditional beliefs and practices of Indigenous Australians. The Industry Commission (1998) presents a strong case for a more formal and widespread adoption of the concept of duty of care for our lands, waters, seas and air. SoE (2001) uses this

concept as a focus to encourage all Australians to take responsibility for our actions by caring for country.

The fundamental value underlying ecologically sustainable use of resources is that current society should meet its needs in ways that ensure that the health and diversity of ecosystems, on which life depends, is maintained and does not reduce the capacity of future generations to meet their needs. Our use of resources should not cause our descendants to inherit a diminished natural and cultural heritage, less potable water, polluted air, contaminated soils, reduced variety of foods, and degraded landscapes. Environmental management in all its aspects should aim for ESD outcomes.

Landcare is an example of how an informed sector of the community has developed new attitudes and practices to land management. Such activities express what the ASEC sees as critical for Australia's future, cooperatively addressing our environmental problems so that we move towards sustainability. This task is beyond the public sector alone. All Australians need to commit themselves to achieving healthy waterways, productive soils, clean air, diversity of flora and fauna, and respect for our heritage.

The size of many of the problems demands responses that are beyond the capacity of existing institutional arrangements and individual landholders. This will be a challenge for all Australians, it will involve investments by urban Australians in the restoration of rural land, and rural Australians in a reassessment of the rights and responsibilities of landholders. We have put off this challenge for too long. This decade is the time for change, to implement the principles and objectives of ESD.

Key findings

This section presents the key findings in brief for each of the state of the environment (SoE) themes. For more detail on the scope of the issues and the findings for each SoE theme, refer to *Thematic findings* (page 22) and to the Theme Reports (see http://www.ea.gov.au/).

Atmosphere

Favourable news

Urban air quality has generally improved. Concentrations of sulfur dioxide, nitrogen dioxide and lead are not of concern in any urban area. Carbon monoxide is of concern in a few specific urban locations.

In rural and regional Australia, levels of most pollutants are well below actual or proposed standards. Sulfur dioxide emissions have decreased substantially in regional locations and are now of concern only in a few limited localities.

Accumulation of total chlorine from ozone-depleting gases in the stratosphere slowed during the early 1990s and is now declining slowly.

Public action in avoiding excessive ultraviolet radiation has increased significantly.

Unfavourable news

There has been no decline in four-hourly concentrations of ozone in urban areas, indicating that photochemical smog in those areas is still an issue.

Australians have a high per capita level of greenhouse gas emissions by world standards. Greenhouse gas emissions increased by 16.9% between 1990 and 1998.

Dust and other particulates, including woodsmoke, are of concern in some regions and localities.

Australia has the highest per capita number of hay fever sufferers in the world, but monitoring is poor with the exception of Melbourne.

Since 1910, Australian average surface temperature has increased by 0.76°C, consistent with the global temperature increase of 0.6–0.7°C.

Uncertain news

Ozone loss over Antarctica appears to have stabilised during the 1990s, although there is no direct evidence of long-term ozone recovery.

Many of the warmest years on record have occurred in the 1980s and 1990s.

A mean sea level rise around Australia during the last 100 years appears to be about 12 to 16 cm. This value is consistent with the Intergovernmental Panel on Climate Change (IPCC 2001) global estimates for the last century (10–20 cm).

Coasts and oceans

Favourable news

The fragmentation of ocean environmental planning and management has been addressed in Australia's Oceans Policy, released in 1998.

A new national management and emergency response system for introduced species is being trialed, after the Black Striped Mussel was found and eradicated from Darwin Harbour in 1999.

Bycatch Action Plans have been developed and implemented in Commonwealth-managed fisheries. In early results from trials, significantly fewer turtles were caught in the Northern Prawn Fishery as a result of using excluder devices on nets.

Local government, industry, community groups and companies now give more attention to urban stormwater management and prevention of litter pollution of coastal waters.

A further 17.6 million hectares of marine protected areas have been established since 1996, including the Tasmanian Seamount Marine Reserve.

The Natural Heritage Trust provided substantial funding for coastal and marine environment issues since 1996. There has been significant participation in local and regional environmental actions as a result of this funding.

Unfavourable news

Australian waters are more susceptible to exotic marine pests than previously thought, with threats to tropical habitats as well as to temperate habitats.

The management of the coastal environment, including catchments and estuaries, is still fragmented among many agencies at a local and state level.

Further loss of coastal habitat has occurred through the encroachment of human settlements and growth in pressures due to tourism in the coastal zone.

Pressures on Australia's coral reefs continue unabated from downstream effects of land use and other human activities.

Large nutrient loads of nitrogen and phosphorus are still being discharged to coastal and estuarine waters from both point sources and non-point sources.

Our national ability to measure the condition of coastal and marine waters through a system of standard indicators has not improved since SoE (1996).

Uncertain news

Our knowledge of the marine environment remains limited, particularly the status of many marine species and habitats and the deep sea environment.

The environmental effects of aquaculture activities are still not fully understood. Some activities have the potential to adversely affect the marine environment.

The coastal population continues to expand and the use of coastal resources is increasing. There is uncertainty in the ability of coastal ecosystems to absorb rising levels of sediment and pollutants from land uses in the coastal zone.

Land

Favourable news

Compared with SoE (1996), much of Australia has better vegetative cover because of:

- several good seasons (La Niña years) after droughts in early 1990s
- reduced sheep numbers (by 30%) since the late 1980s
- reduced rabbit numbers (up to 90%) from rabbit calicivirus disease (RCD), particularly in arid areas.

Indigenous involvement in land management has a higher profile than it did five years ago. Indigenous knowledge is being better integrated into policies and programs.

Unfavourable news

There is still a net loss of vegetative cover. Broadacre land clearing continues in Queensland and New South Wales. This is one of the key threatening processes to biodiversity. However, it is difficult to verify the land areas that have been cleared since 1996.

Land degradation, including erosion, is still a major contributor of turbidity, nutrients and pesticides to waterways, as well as loss of soil fertility.

Altered fire and grazing regimes, pests and weeds continue to affect the health of the rangelands.

Large areas of acidic and sodic soils contribute to poor water quality, secondary salinity and loss of ecosystem function.

Uncertain news

Since the 1960s, there has been a dramatic increase in pesticide use, but regular monitoring in inland waters and in groundwater is uncommon. The effects on the environment are uncertain.

Because of lack of data on the number, location and status of contaminated sites, the environmental effects associated with these sites remain unknown.

Inland waters

Favourable news

Some appropriate Government responses to management of water resources have been adopted, but implementation is patchy, and the controls may not be sufficient.

The use of biological assessment of river health has developed to the stage where national assessments of river health can be achieved.

Unfavourable news

Increasing pressures to extract surface and groundwater for human use are leading to continuing deterioration of the health of water bodies.

Surface water quality has deteriorated further in many areas because of increasing salinity.

Difficulties of managing water resources across state borders continues to hamper effective management.

The complexities of the linkages between inland waters and their catchments are often beyond the capacity of our management systems.

As more controls are placed on the use of surface waters, more groundwater is used. The overuse of surface and groundwater resources affects aquatic ecosystems. About 26% of Australia's surface water management areas are close to, or have exceeded, sustainable extraction limits.

Water use has increased from 1985 to 1996/7 by 65% and water is overused in some regions.

Water extracted for irrigation has increased by 76% from 1985 to 1996/7.

The increase in salinity in the Murray–Darling Basin and other areas is causing water quality decline and land degradation. River water in several catchments is predicted to have salinity levels that will exceed drinking water guidelines within the next 20 years.

Although it is difficult to determine, the frequency, size and persistence of harmful algal blooms in inland waters seems to have increased over the past 50 years. Algal blooms in dams cost farmers more than $30 million per year, and in rivers, storage and irrigation channels about $15 million per year.

Uncertain news

It is difficult to assess the state of inland waters nationally, because of poor data availability and patchy water quality and stream flow data in some jurisdictions.

Biodiversity

Favourable news

The protection of biodiversity values in Australia has progressed significantly with the enactment of the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) being a major response since 1996.

A wide range of people and organisations is involved in protecting Australia's biodiversity (e.g. Landcare, Bushcare and Land for Wildlife). The Natural Heritage Trust has funded many of these programs since 1997.

The protection of biodiversity values now extends well beyond the reserve system into many non-reserve areas. The comprehensiveness and adequacy of the reserve system has improved.

In early 2001, the Commonwealth government declared land clearance as a key threatening process (under the EPBC Act) for biodiversity.

Urban biodiversity initiatives such as the Western Australian Government's *The Bush Forever* is a world leading program.

Industries have developed codes of practice on environmental management and employ biologists to evaluate biological values in many parts of Australia, rather than relying solely on biologists employed in public sector agencies.

Unfavourable news

Many of the key threats to biodiversity identified in SoE (1996) still persist.

Many threatening processes such as salinity, changing hydrological conditions, land clearing and fragmentation of ecosystems still pose major problems for protecting biodiversity.

The rate of land clearance rate has accelerated, with as much cleared during the last 50 years as in the 150 years before 1945. Only four other countries exceeded the estimated rate of clearance of native vegetation in Australia in 1999.

The loss and depletion of plant species through clearance destroys the habitat for thousands of other species.

Dryland salinity, one of the legacies of broadacre land clearing, is predicted to affect some two million hectares of native vegetation by 2050.

There is still limited knowledge on many biodiversity values in Australia.

Exotic organisms identified as a major threat to biodiversity in SoE (1996) remain so. Invasive species such as weeds and insects pose a serious problem.

Uncertain news

Although fire mapping has improved, the effect of various fire regimes on the conservation of biodiversity remains uncertain.

Natural and cultural heritage

Favourable news

Overall conservation of heritage improved during the reporting period 1995 to 2000.

Identification of many new heritage sites occurred through RFA surveys and some other large-scale regional studies.

A significant increase (16%, 11 000–13 000 places) in the number of heritage places listed on the Register of the National Estate has occurred during the last five years. A survey of 1250 historic places found that many were in fair to good condition.

The National Museum of Australia opened in 2001.

The Australian Museums Online Database has been established.

Most museums collections examined in a survey are in fair to good state. For the first time, collections of objects in universities have been surveyed.

The number of heritage places and landscapes that Indigenous peoples owned and managed increased slightly over the last five years. Thirteen Indigenous Protected Areas have been established since 1998 as part of Australia's National Reserve System.

The Return of Indigenous Cultural Heritage Property Program instituted in 1998 is facilitating the return of cultural property to Indigenous peoples from Australian museums and other collecting institutions.

Australia continues to be a leader in heritage practice. The Burra Charter, developed in Australia for the conservation of the cultural environment, is being used internationally.

The number of Australian World Heritage properties increased from 11 to 14 over the last five years.

Unfavourable news

The loss of heritage places continues. Several thousand heritage places identified during the RFA process have not received protection by being added to heritage registers.

In contrast to the Natural Heritage Trust's assistance to natural heritage places, there are no long-term national funding programs of similar magnitude for Indigenous or historic heritage places.

Indigenous heritage is the most extensive category of heritage in Australia and is the most neglected.

The number of Indigenous languages and the percentage of people speaking them fell during the period 1986 to 1996. Of the 20 Indigenous languages classified as strong in 1990, by 1996 only 17 are considered strong and three have become endangered. All Indigenous languages may be lost in the next 100 years.

There is no coherent agreed national definition or shared view of what constitutes cultural heritage collections, despite the National Conservation and Preservation Policy and Strategy, *Australia's Heritage Collections*, released in 1998.

Documentation systems to meet the demands of scholarly and public access to small and large museums are idiosyncratic and inadequate.

Limited resources are available for the systematic treatment of museum collections. Storage capacity is an issue for many organisations.

Uncertain news

Future heritage management arrangements and how these will affect conservation regimes are unclear.

The proposed demise of the Register of the National Estate will create gaps in the identification and conservation of heritage places.

It is difficult to gauge community support for heritage issues since there are no nationwide surveys of attitudes to, or support for, natural and cultural heritage.

Human settlements

Favourable news

Streetscapes and parks in most urban centres have been improved significantly. There has also been some revitalisation of strip and village shopping centres.

Energy efficiency in residences has improved as a consequence of a variety of energy efficiency programs and increased use of insulation in buildings.

The reuse of treated wastewater and stormwater is increasing, but is still at low levels.

Domestic water use per capita declined for most large urban centres during the 1990s because of water pricing, consumer education, use of water-saving appliances and higher residential densities (linked to lower outdoor water use).

Unfavourable news

Existing pressures from human settlements are not consistent with a sustainable environment.

Uneven distribution of wealth in our human settlements means that some communities (e.g. Indigenous communities and small rural towns) do not always have the capacity to look after their environment.

Most indicators of resource consumption continue to outpace population growth. An example is personal mobility, as measured by vehicle kilometres travelled, which is increasing in metropolitan areas.

There is a high and increasing per capita energy usage in human settlements leading to increase in greenhouse gas emissions, particularly through electricity generation and transport usage.

Environmental noise and its effects on residents are increasing as a result of trends such as increased residential density, traffic volumes and the 24-hour city.

Uncertain news

Reurbanisation has resulted in the growth of population and residential densities in the inner suburbs of Australia's major cities, reversing a pattern of consistent decline since early post-World War II. However, the overwhelming trend remains suburbanisation (the reverse process).

The volume of waste appears to have stabilised at a level which is high by international standards, and there has been a recent rapid increase in the quantity of hazardous waste generated.

The uptake of recycling of waste is mixed, depending on the waste streams. In some States, and for particular waste streams, recycling rates are approaching disposal rates. Waste reduction targets generally have not been met.

Introduction

The State of the Environment Report in 1996 (SoE 1996) provided the first independent and comprehensive account of the Australian environment and provided an excellent foundation for the ASEC to produce this State of the Environment Report (SoE 2001).

The membership of the ASEC and its terms of reference are given in *Appendix 1*. SoE (2001) is drawn from seven commissioned theme reports, summarised in the *Thematic findings*. The theme reports are: atmosphere, coasts and oceans, land, inland waters, biodiversity, natural and cultural heritage, and human settlements (see http://www.ea.gov.au/soe/). Each theme report used a set of environmental indicators (*Appendix 2*) to report their findings. An expert reference group supported each theme author and the reports were peer reviewed. Contributions to SoE (2001) are summarised in *Appendix 3*.

The conceptual structure of the modified 'pressure–state–response' model of the Organization for Economic Cooperation and Development was used in SoE (1996), and also underpins SoE (2001) (see *Appendix 1*). For SoE (2001), more emphasis has been placed on implications of conditions, pressures and responses consistent with the terms of reference.

The overall message and key findings of SoE (2001) have been developed by the ASEC following a review of the theme reports and their synopses by ASEC members (see *Thematic findings*). The 2001 Report also contains the views of the ASEC on the context within which Australia's environment is managed and its views on future directions.

The principles of ESD are now well recognised in Australian legislation, including the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. Although there is some legislation to protect cultural heritage, traditional Indigenous rules for care of the land and its sacred places, and the philosophy enshrined in the Burra Charter of the International Council on Monuments and Sites (ICOMOS) Australia, form a good basis for conserving cultural heritage. These principles have broad community and industry support and they form a powerful philosophy for use in both environmental and heritage management.

Sound information and understanding of issues are vital to enable Australians not only to feel, but also to be, part of a society capable of managing or ameliorating the changes which affect our distinctive environment. This Report offers Australians an understanding of the Australian environment and highlights how they might relate, individually and collectively, to the major issues affecting their country. Australians should strive to pass on to future generations a healthier environment than they inherited.

State of the environment reporting

State of the environment reporting aims to support decision making at all levels of society. It provides reliable information that can foster a more integrated and longer term perspective to environmental management. Four objectives were used by the ASEC for these purposes for SoE (2001). They are to:

- provide accurate, up-to-date and accessible information about environmental conditions, and where possible, trends for the Australian continent, surrounding seas and Australia's external territories
- increase public understanding of issues related to the Australian environment
- provide an early warning of potential problems
- report on the effectiveness of policies and programs designed to respond to environmental change.

SoE reporting is made more complex by the challenge of analysing incomplete or inconsistent data sets. Since 1996, there has been a significant improvement in the data available for SoE reporting involving many organisations. These include the Cooperative Research Centres (CRCs), the National Land and Water Resources Audit (NLWRA) and the Australian Greenhouse Office (AGO). However, major problems of access to data and consistency of standards and methods of data compilation still exist. Development of adequate and effective responses to environmental challenges is often hampered by the lack of data and information with which to portray accurately how the Australian environment is changing over time.

Australia's environment in context

Land and water systems—an historical perspective

Significant environmental degradation has occurred to land and water systems in Australia. Despite numerous examples of good irrigation practice, tillage systems and pasture and rangeland management, enormous areas are still suffering from damage, and large areas are being degraded or are under threat of degradation in the future.

Parliamentary debates, media reports, recommendations from inquiries, and first-hand accounts by landowners, travellers, scientists and government officials all attest to abuse of the land (and to a lesser extent, the sea) since 1788. Indigenous peoples had over many thousands of years developed a spiritually based relationship with the land, even as modified through the use of fire. European occupation quickly transformed the landforms, soils and biota. Research and observations, in the Northern and Southern Tablelands of New South Wales, demonstrated how quickly grazing pressure in the 1830s and 1840s induced slope instability and soil loss. Although such effects were quickly identified, they persisted and grew with consequences that remain with us.

Ignoring lessons has become a characteristic of Australian natural resource management. It is only in the last 30 years that many Australians have developed a renewed commitment to a conservation ethic. Yet what has emerged is a very complex and contradictory set of attitudes and processes. Some economic and social imperatives require individuals, communities, financial institutions and governments to give priority to wealth creation, whereas there is a powerful and growing desire to pass on to the next generation a land in better shape than was inherited. It is increasingly recognised that individual interests, operating through the exercise of property rights in a market economy, cannot be the sole mechanism for ensuring sustainability.

The condition of the settled coastal strip of Australia with its hinterland catchments and forested areas is heavily affected by population growth, localised intensive resource use and booming recreational demands. Continued conversion of land to freehold and division into ever smaller parcels, has meant that the remaining Indigenous heritage places within this zone are significantly threatened. Results of an initial qualitative assessment of 972 of Australia's estuaries show that heavily populated parts of the south-east coast, the south coast and Bass Strait, the South Australian gulfs and south-west Western Australia show a concentration of modified or severely modified conditions.

About 50 000 km of streams have been degraded by sand deposition, mainly in south-east Australia. Sediment is moving off hill slopes much faster than soil is formed, an obvious

A small sediment-loaded stream with steep banks, typical of active accelerated gully erosion.

Source: Ann Hamblin.

Salinity: exacerbating native vegetation loss, increasing soil erosion.

Source: Peter Richardson, CSIRO Land and Water.

problem for those areas seeking to sustain agricultural or forestry yields. Sediment movements modify habitats along watercourses, lakes and estuaries, and deliver suspended sediment to inshore coral reefs of the Great Barrier Reef region with localised loss of coastal seagrasses and associated habitats of inshore species.

Maintaining the economic, social and environmental health of the intensive land use zone south from central Queensland through New South Wales and Victoria and into southern parts of South Australia and the wheatbelt of Western Australia poses formidable problems. Although these zones embrace some of the most productive and agriculturally efficient arable lands in Australia, major stakeholders such as the NFF, the ACF and all levels of government recognise the need to address the adverse conditions which affect the region's long-term sustainability. Many factors contribute to this dismal prognosis as discussed in the *Land*, *Inland Waters* and *Biodiversity* theme reports.

According to the Prime Minister's Science and Engineering Innovation (PMSEI) Council (1998) the spread of salinity and its highly adverse consequences typifies the threat to the economic and environmental sustainability of whole rural communities. Since that report was released, the National Land and Water Resources Audit (NLWRA) (2001a) has released their dryland salinity assessment in collaboration with the states and territories. This assessment, which described the distribution and effects of dryland salinity across Australia, estimated:

- about 5.7 million hectares, mostly in the agricultural regions, are at risk of or are affected by salinity, potentially increasing to 17 million hectares in 50 years
- up to 20 000 km of inland waters could be salt affected by 2050
- up to two million hectares of native remnant vegetation could disappear over next 50 years
- at least 200 rural towns could experience salt damage over the next 50 years.

The PMSEI Council (1998, p. 11), further noted that:

> There are clear market failures in that the costs of degradation to downstream users and to the environment, where known, are not borne by those benefiting from the upstream exploitation of the landscape. In many cases the costs will be borne by future generations. Rational market behaviour at the enterprise level will cause (and has caused) serious and irreversible offsite impacts to biodiversity, rural infrastructure and downstream water users, as well as causing unnecessary hardship to landholders.

Weeds of national significance include Prickly Acacia.

Source: QDNR.

The major governmental response to the long-term risk posed by dryland salinity has been the NAP for Salinity and Water Quality (Commonwealth of Australia 2000), reported in the *Land* and *Biodiversity* theme reports.

Salinity reflects only one of many problems facing the agricultural regions. Soil acidity, soil erosion, land clearing, weed infestation, pesticide contamination, habitat modification of land and water areas, and loss of river flows all have severe local and regional effects.

Between 1995 and 2000 a cyclic return of good rainfall (La Niña) conditions has promoted vegetation, pasture and crop growth. The number of sheep has dropped, and rabbit populations reduced substantially following the escape and spread of RCD in 1995.

The cyclical benefits of good seasons on vegetation cover in the semi-arid areas of Australia over the past five years are also noticeable. Biodiversity has been assisted by the demise of rabbits and there has also been a small reduction of 3.7 million hectares (1.4%) in the total area of grazed leases. Where leases have been purchased by mining companies, Indigenous owners, or for conservation purposes, destocking has generally occurred. However, some areas are still overgrazed with owners attempting to maintain or increase

Drowning in a dry landscape

Appreciating how water flows through and under our landscapes is crucial to understanding why some of our major environmental issues will take decades to solve or stabilise.

Crops and pastures have replaced native vegetation in many areas. They have shallow root systems that do not use nearly as much of the rain and the irrigation water that percolates into the soil as do native plants and trees.

Rain or irrigation water that is not taken up by plants or trees either finds its way slowly to the water table (groundwater) or moves laterally underground to adjacent streams. Because crops and pastures use less water, the excess water finds its way to the groundwater up to 10 times faster.

Consequently, groundwater levels slowly rise, and in so doing dissolve the natural salt in the weathered soils found over vast areas of Australia.

It can take from 10 to 100 years for these changes to bring salt to the land surface or to the streams. The nature of the landscape, the depth of groundwater, the amount of rainfall and irrigation and the amount of a catchment that is cleared influence the time for salt to become apparent.

Halting or reversing the rise of groundwater requires farming systems with similar water use outcomes to those of vegetated landscapes with deep-rooted plants and trees. Such changes are complex and we are still looking for the appropriate mix of land uses in the many land systems that exist in Australia. What is certain is that such systems of water balance at a catchment and subcatchment scale are essential if salinity is to be managed.

Even when changes to land use like this are made, it will take many decades or even centuries to reverse the rise in groundwater levels and improve the water balance.

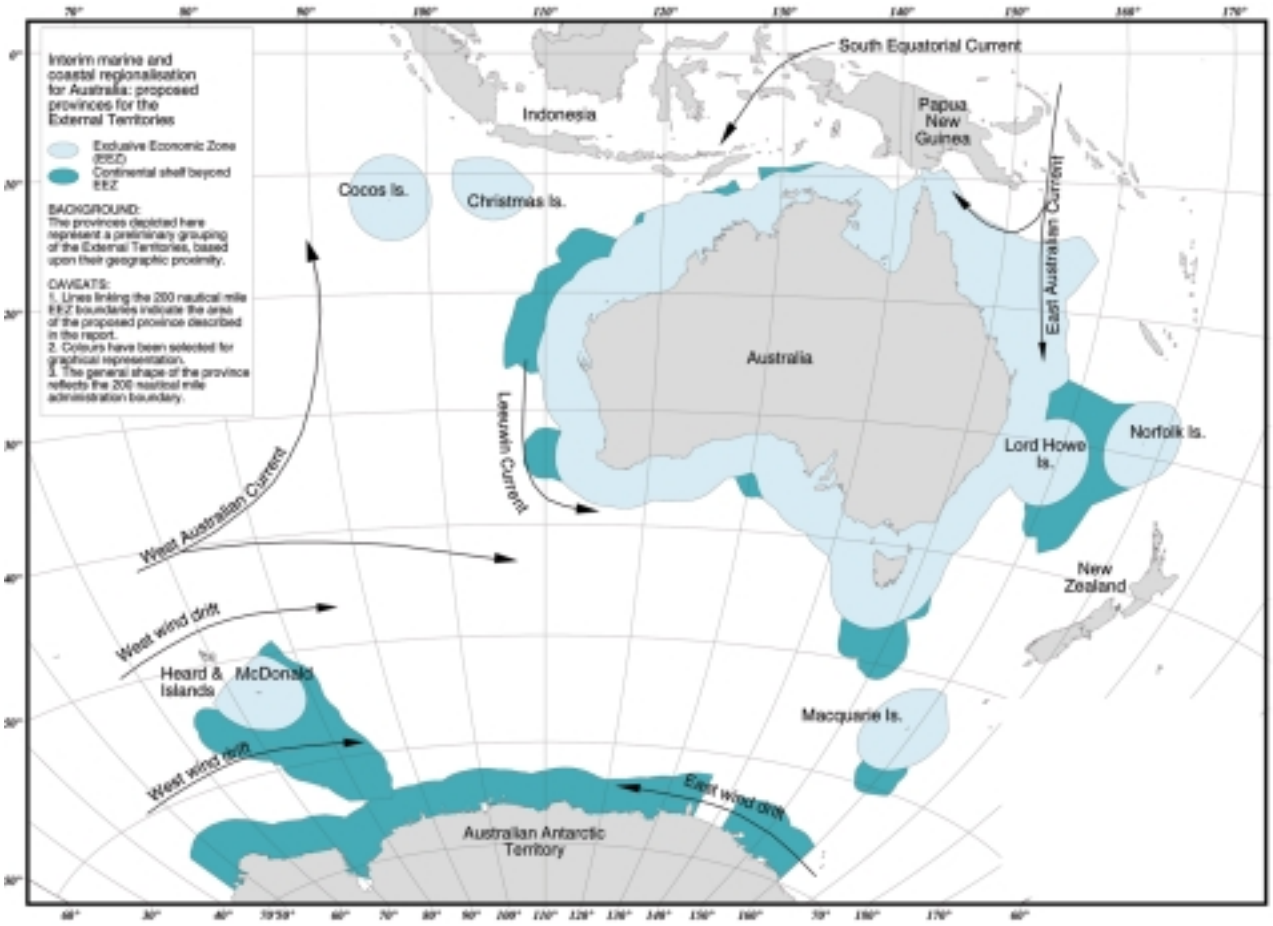


Figure 2: **Australia's marine area.**

Source: Environment Australia (2000).

stocking rates to protect income. Wind erosion is often accentuated in such circumstances. Feral animals and weeds provide further cause for concern over many areas. The marginality of many of these lands raises the option of compensating landholders to manage for biodiversity not for production.

Australia in its global setting

Australia and its external territories are encompassed within the Indian, Southern and Pacific oceans (Figure 2). The dynamics of surface and subsurface oceanic flows are now understood to influence global climate systems. Air masses circulating across the globe determine the continent's often irregular rainfall regimes. The high year-to-year variability of Australia's climate is partly attributable to the El Niño–Southern Oscillation (ENSO) phenomenon (every 2 to 5 years). A concurrent Pacific oscillation superimposes much longer-term swings in ocean temperatures and rainfall in the Pacific Basin.

Since the 1970s, Australian scientists have demonstrated how our landscapes have responded to global-scale climatic changes over recent centuries and over geological time. The interconnectedness of planetary forces driving shifts in atmospheric circulation and temperature/rainfall regimes and how these shifts affect water budgets, sea levels and ecosystems are reasonably well understood for various regions of Australia.

Recognition of the possible effect of human activities on global climate has triggered a major international initiative: the Intergovernmental Panel on Climate Change (IPCC). The major global-scale findings of the IPCC are contained in IPCC (2001). Climatic trends for Australia are consistent with those of other parts of the world, and include changes in rainfall pattern, temperature rise and probable rise in sea level.

Although SoE (2001) is largely focused on environmental issues on the Australian continent and marine areas, ever-changing global environmental, economic and political factors undoubtedly influence how Australian society can and will manage its lands, waters

Australian land cover 1999 to 2000.

The remote sensing image data were developed for the National Carbon Accounting System. The image shows land cover across Australia in pseudo-natural colour. In general, forests appear as dark green, healthy crops and pasture lands as light green, bare earth and dry vegetation as red, brown and yellow tones, and water as blue. Note: this time period coincided with the peak of a La Niña event when conditions over most of Australia were much wetter than usual.

Source: AGO and AUSLIG.

and air. This is evident, for instance, in the continuing debate on responses to global warming predictions.

Challenges faced by Australia

Vastness

Although Australia is the world's smallest continent (7.6 million km^2) it assumes further responsibility for about 16 million square kilometres of marine area and some 5.9 million square kilometres of Antarctica, totalling about 29.5 million square kilometres. This is an enormous area of land and sea and presents a huge management challenge to the resources of Australia's estimated population of 19.3 million people (in 2001). In this regard, Australia is proportionately worse off than Canada, another country with a vast area (about 10 million km^2) but a population of 30.5 million people (in 2000).

In much of the country, there are simply not sufficient numbers of people to monitor, assess and manage the environment. Australia is information rich yet data poor and has partially overcome the challenge by using information technology and technological means to gather data and information. For example, remote sensing of the environment has become essential to monitoring the condition of the extensive land use zone, covering some six million square kilometres.

Selected data are collected in some states and territories in a comprehensive way but not in all. Information about the condition of the land and oceans is often 'patchy' and concentrated in more populous parts of the country. In preparation of many of the 2001 theme reports, there have been difficulties in accessing national scale data and information.

The cumulative effects of many small decisions

The cumulative effects of innumerable small developments can severely affect our natural and cultural resources especially as many decisions on land use, water use and lifestyle, in the past as well as at present, have been made independently of any consideration of broader regional or environmental issues.

Toilet block on Cape Byron, NSW, obstructing a superb view of Tallow Beach.

Source: Jane Lennon.

In urban and near-urban Australia, local councils help assess and approve development applications. Pressures for *ad hoc* approvals, at times involving legal proceedings, are intense, often at the expense of strategic outcomes. Recent population growth in cities and in coastal areas has exacerbated these pressures. Frequently, development-oriented councils or state governments will put aside controls in order to fast-track individual developments without appropriate environmental impact assessment. This behaviour is particularly apparent in coastal areas experiencing population and tourist growth.

Similarly, the effects of individual choice for personal mobility can be seen in the information on total vehicle kilometres travelled (VKT) by residents of Sydney. The VKT increased by 24% between 1991 and 1998. Motor vehicles and particularly diesel vehicles emit pollutants such as particulates which are known to be injurious to health. Continued growth in vehicle use, either by taking more or longer vehicle trips adds to the cumulative pressure on urban air quality.

The effect of many small decisions on cultural heritage is apparent everywhere. For instance, harmonious and pleasing 19th century streetscapes can be seriously damaged by one demolition or development, removal of post offices from a main street can contribute to its demise, and improving the road surface can bring unwanted tourism pressure to an Indigenous site. Integrated planning, which aims to conserve the whole landscape and all its values, is still lacking across most of Australia.

Institutional arrangements and limitations

Environmental management

Environmental management in Australia is primarily the responsibility of states and territories with local government carrying out many environmental management responsibilities. The Commonwealth has limited responsibilities. The states and territories generally have the primary role in marine management to the three nautical mile limit (about 5.5 km) and the Commonwealth has jurisdiction beyond those waters to the outer boundaries of the Exclusive Economic Zone (EEZ). The Offshore Constitutional Settlement established jurisdiction between the Commonwealth and the states over marine matters in 1983.

Each state and territory distributes its management responsibilities among various agencies (see *Appendix 4*) and, in addition, devolve many of these responsibilities to local government. As a result, planning and management of the environment is often highly uncoordinated between the Commonwealth, the states and territories and local government.

There are five specific difficulties confronting the institutions involved in environmental management. They are:

- varying regulatory arrangements applied to different land uses in adjacent areas making it difficult to achieve conservation on a landscape scale

Farmers at a crop management field day.

Source: A Hamblin.

- responsibilities that are fragmented within and between the levels of government and various agencies
- differing philosophies and approaches between non-Indigenous and Indigenous environmental managers
- fewer resources to ensure compliance with governmental legislation, policy and regulation
- limited cooperation between public and private sectors in long-term environmental management.

A regional approach exists in some administrations, for example the Great Barrier Reef Marine Park, and in some areas of water management such as in the operation of the Murray–Darling Basin Commission and the Lake Eyre Basin Coordination Group involving state and Commonwealth agreements.

Public sector reforms in the 1990s created efficiencies, but also resulted in reducing the number of people with valuable technical skills. For example, agricultural extension staff were reduced in many states, thus removing a valuable conduit of information between farmers and scientists. Some environmental tasks were devolved to state or local government without additional resources to undertake them.

An emerging challenge is how to apply equitable property rights so that the actions of individual landholders do not stimulate or continue to promote long-term degradation of natural systems. This problem applies not only to farmers or graziers but also to those seeking to subdivide unsuitable land for residential purposes and protect such property from natural forces such as flooding, landslide or erosion.

The Commonwealth *Native Title Act 1993* enriches the opportunity for Indigenous peoples to protect their heritage while not impairing the rights of non-Indigenous landholders to pursue their interests. The management of land and the marine environment has become more complex as a result of claims and challenges to the exercise of native title, especially regarding pastoral leases.

Administrative reform

Since 1996, there have been some important national administrative reforms. Those discussed in the following paragraphs are relevant to SoE reporting.

1 The EPBC Act came into force in July 2000. The Act provides protection for matters of national environmental significance (e.g. World Heritage properties, Ramsar wetlands, nationally threatened animal and plant species, and ecological communities). The process for environmental assessment of actions that may affect matters of national significance

has improved through providing greater certainty to proponents, ensuring assessment is done early in the planning process, and reducing duplication between the Commonwealth and states in assessing projects. The EPBC Act promotes ESD through formally requiring the principles of ESD to be taken into account when considering project approvals. Compliance with the Act remains a challenge.

2 The COAG Water Reform Framework's goal is an efficient and sustainable water industry. In February 1994, COAG agreed to implement the Framework that includes provisions for water entitlements and trading, environmental requirements, institutional reform, public consultation and education, water pricing and research. The time and complexity involved in implementing the necessary legislative change to enact the Framework has generally been greater than expected and further implementation will also be complex and demanding.

3 The *National Environment Protection Council Act 1994* established a system for making environment protection measures through a statutory instrument—National Environment Protection Measures (NEPMs). The National Pollutant Inventory (NPI) NEPM was formalised in 1998. The agreement resulted in implementation of the NPI in a nationally consistent manner. Since 1996, the Commonwealth has committed more than $12 million to develop and support the Inventory. The publicly accessible database provides a comprehensive record of major pollutants entering the air, land and water throughout Australia.

4 To implement Australia's National Forestry Policy, Commonwealth and state and territory governments agreed to negotiate 20-year RFAs. The objectives were to:

- establish a Comprehensive, Adequate and Representative (CAR) reserve system based on nationally agreed criteria
- facilitate an internationally competitive wood and wood products industry
- ensure the ecologically sustainable management of the native forest estate.

The RFAs have provided a level of certainty for the forest industries and have resulted in more than 2.5 million hectares being added to the national reserve system.

5 The Mandatory Renewable Energy Target program commenced on 1 April 2001. The *Renewable Energy (Electricity) Act 2000* requires the generation of 9500 gigawatt hours (2%) of extra renewable electricity per year by 2010, enough power to meet the residential electricity needs of four million people.

Cultural heritage

Cultural heritage management lags well behind natural heritage management in terms of coordinated action. The RFA process produced a good model for the integration of natural and cultural heritage assessment and for joint management agreements for heritage conservation between the Commonwealth and the states. The Australian Heritage Commission has also carried out significant pilot projects on integrated assessment. Joint management of World Heritage Areas by the Commonwealth and the states occurs. In general, the governmental and administrative fragmentation of elements of Australian heritage remains a significant problem for its effective conservation.

Community awareness and action

Individuals, groups and enterprises are making significant efforts to overcome actual and perceived threats to the environment. Community empowerment and participation in the 1990s includes:

- Natural Heritage Trust-funded programs in rural and urban areas
- participation on high-level advisory bodies
- representation on local and regional catchment management boards and other natural resource management committees
- inputs to planning decisions such as under the *NSW Environmental Planning and Assessment Act 1979* (as amended)
- development of partnership programs supporting local councils and their communities.

From an Indigenous perspective, community participation can be complex and subject to social and religious rules which are intimately related to land ownership, management responsibilities and spiritual values.

Since 1996, it is apparent that individuals, communities, non-government organisations (NGOs), business and industry, the educational sector, and researchers have made numerous commitments to understanding the state of Australia's environment. For instance, higher education research and development expenditure on the environment has risen from $121 million (6.6% of total) in 1994 to $190 million (7.3%) in 1998 (ABS 2000a).

Community monitoring of a *Zostera capricorni* seagrass meadow in the Whitsundays, Qld.

Emerging role of industry in environmental management

Since SoE (1996), there has been a significant change in the attitude of many corporations to environmental issues. This shift can be seen, for example, in the uptake of environmental reporting by corporations and the adoption of industry-driven initiatives, such as the Australian Minerals Industry Code for Environmental Management and the Business Council's Statement on Strategies for Sustainable Development.

There is a growing acceptance that strong corporate environmental performance can be a means of delivering additional value to shareholders. Reliable environmental performance is increasingly being valued by the finance sector, as the connections between environmental performance and credit, investment and reputation risks become more apparent. Experience with environmental reporting shows that it is not only an important communication tool, but also can drive improved management systems within companies and help identify areas of poor environmental performance.

Since 1996, there has also been a focus on partnerships between corporations and other stakeholders. Recent examples include the partnership between the ACF and Southcorp to address salinity and the Commonwealth government's partnership programs, such as the Ecoefficiency Agreements. Cooperation between mining companies and Indigenous peoples is increasing, for instance in the Weipa area of North Queensland and in the Pilbara, Western Australia.

Although the shift in corporate attitude is significant, it is not universal. The change is most apparent among major corporations or smaller businesses driven by the personal ethics of their owners or managers. The use of ESD principles in decision-making amongst financial institutions remains unclear.

Earthwatch volunteers assisting the Australian Platypus Conservancy to monitor the platypus population in a tributary of the upper Wimmera River, Vic.

Source: Blain Crellin/Earthwatch Australia.

Indigenous land occupancy and management

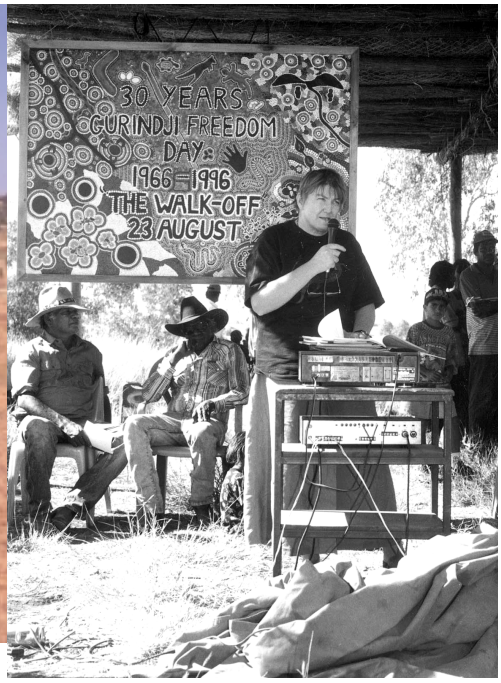
According to Lewis and Rose (1998, p. 55):

> Victoria River Aborigines say that people take care of country and that a country takes care of its people.

Aboriginal people were hunter-gatherers, with a profound spiritual attachment to land, epitomised through Dreaming stories, sacred sites and a rich array of cultural

Wave Hill, NT.

Source: P Forrest, Australia Heritage Commission.



Gurindji celebrations at Victoria River Downs, NT.

Sharon Sullivan, former Director of the Australian Heritage Commission, addressing the 30th anniversary celebrations of the 1996 Wave Hill Walk Off. The Walk Off sites were inscribed on the Register of the National Estate in 1998.

Source: R Muhlen-Schulte, Australian Heritage Commission.

and religious practices. They practised regular patch burning to stimulate preferred flora and faunal habitats, and significantly enhanced the fire-climax vegetational assemblages across much of the continent. Many Indigenous peoples still practice these traditions. With European settlement, Indigenous populations declined. Many groups were forced from their lands or their movement restricted to small areas.

In the latter part of the 20th century, Indigenous citizenship rights and interests in land have been slowly recognised. In the 1970s to 1980s, land rights legislation was passed in various states and territories. In 1976, the *Aboriginal Land Rights Act 1976* (NT) was passed by the Commonwealth to recognise traditional Aboriginal interests in land, and provide traditional owners with effective control over activities on these lands. In New South Wales, the State Government passed the *Aboriginal Land Rights Act 1983* (NSW) and the *National Parks and Wildlife Amendment (Aboriginal Ownership) Act 1996.* Under the former Act, some land can be automatically granted and certain Crown land is claimable. The latter Act provides recognition of lands of cultural significance to Aboriginal people. In 1993, the Commonwealth government passed the *Native Title Act 1993*, which both recognises and protects native title, establishing ways in which dealings affecting native title may proceed and improving mechanisms for determining claims to land.

Unlike land rights, which is a grant of land to Indigenous peoples, native title provides recognition of the pre-existing rights and interests of Indigenous peoples to land and waters. Where there are inconsistencies, other rights prevail over native title rights. The Wik decision of the High Court (*The Wik Peoples* v *The State of Queensland & Ors (Matter No B8 of 1996, The Thayorre People* v *The State of Queensland & Ors (Matter No B9 of 1996) FC 96/044 (1996) 187 CLR 1*) found that certain forms of pastoral leases do not necessarily remove (extinguish) native title, which may coexist with leases that are not for the exclusive use of the leaseholder.

In 1998, amendments were made to the *Native Title Act 1993* including provision for alternative state-based regimes to deal with certain native title issues, but by March 2001, only Queensland had introduced this process. Although native title claims are made to the Federal Court, the Court refers claims to the National Native Title Tribunal for mediation in the first instance. By 2001, there were 551 active claimant applications; 21 determinations of native title had been made (13 by consent, 8 after a trial), and 42 claimants were before the Federal Court for judicial review. New claimant applications continue to be made, and usually take several years to resolve.

Outcomes of the return of Indigenous land are a cause for hope, but not for complacency. Certainly more land can now be conserved in the traditional way, but more land means more

responsibility, and the support for this responsibility is not yet present in any integrated way. Much of the land being returned to Indigenous peoples is degraded. Indigenous peoples themselves suffer from alarming rates of infant mortality, ill-health, addiction, unemployment, imprisonment and other social disadvantages. In many parts of Australia, they have been separated from their land for more than a century. They are being asked to take responsibility for problems which European settlers have created either directly by practices such as land clearance or overstocking, or indirectly by the introduction of pests.

One of the challenges for the management of the Australian environment is to ensure for Indigenous peoples a strong capability for management of land which they control. This requires effective support mechanisms provided in a culturally suitable way.

Thematic findings

Atmosphere

Climate, weather and the state of the atmosphere are of prime importance in the economic, social and environmental health of our cities, regions, offshore territories and oceans. Australia, like other countries, spends a considerable effort on forecasting the weather nationwide, including warnings of extreme events, and in understanding and predicting the global climate and its changes. All Australians face major problems of living sustainably in a climate with extreme and highly variable weather, and a society in which agriculture and industry, population and the built environment all continue to grow.

Since 1996, Australian governments have introduced ways to improve the health and understanding of the atmosphere. This includes the establishment of the AGO, charged with managing a whole-of-government approach to greenhouse matters and ways to abate the greenhouse effect (see http://www.greenhouse.gov.au).

The quality of urban air has generally improved or remained constant for most years, but emission of pollutants in cities, mainly from vehicles, remains of concern.

The National Pollutant Inventory (NPI), established in 1998, is a major advance in environmental management (see http://www.npi.ea.gov.au). Before its establishment, data on emissions were sporadic and of poor quality, where data are now collected in a nationally consistent manner.

The 1997 Inquiry into Urban Air Pollution by the Australian Academy of Technological Sciences and Engineering (AATSE) was a major force behind introducing ways to improve or maintain urban and regional air quality. The AATSE was asked by the Commonwealth government to identify practical solutions to air quality problems that could be implemented by all levels of governments, industry and the community.

Recommendations of the Inquiry were used to inform Commonwealth government actions on air quality as part of the Air Pollution in Major Cities Program. This Program aims to:

- support the development of national air quality standards under the auspices of the National Environment Protection Council (NEPC) and other national cooperative forums
- improve the consistency of air quality monitoring across Australia to allow improved targeting of management strategies
- support air quality research and community education on air quality issues.

Source: CSIRO.

Table 1: The Air NEPM—Standards and goals for Australia set in 1998

Pollutant	Averaging period	Maximum concentration	Goal within 10 years[A]
Carbon monoxide	8 hours	9.0 ppm	1 day/year
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day/year None
Photochemical oxidants (as ozone)	1 hour 4 hours	0.10 ppm 0.08 ppm	1 day/year 1 day/year
Sulfur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day/year 1 day/year None
Lead	1 year	0.50 µg/m^3	None
Particles as PM10	1 day	50 µg/m^3	5 days/year

[A] Maximum allowable exceedences.

Source: NEPC (1998).

Australia has an agreed set of national ambient (outdoor, as opposed to indoor) air quality standards for each of the major air pollutants listed in Table 1. These standards, made by the NEPC on 26 June 1998, are contained in the National Environment Protection Measure (NEPM) for Ambient Air Quality (Air NEPM) (Table 1) and http://www.nepc.gov.au.

Jurisdictions commenced reporting air quality data to NEPC under the Air NEPM in 2001, with the goal of meeting the standards within 10 years (by 2008). However, available air quality data indicate that the standards have been exceeded only a few times in most urban and regional areas since 1997. This can be attributed to the substantial efforts to reduce pollution from vehicles and major industrial sources.

Since 1996, many policy and regulatory structures have been put in place and a wide variety of other government, non-government and private industry initiatives have been developed to improve environmental performance.

In considering the state of the atmosphere, there were four key issues examined:

- climate variability and change
- stratospheric ozone
- urban air quality
- regional air quality.

A summary is presented in *Key findings* (page 5).

Key issues

Climate variability and change

Australia's climate is strongly influenced by the surrounding oceans, and weather systems such as the monsoon, tropical cyclones and cold fronts that give each region of the country its own characteristics. High year-to-year variability obscures any short-term background trends. Most of the year-to-year variations are linked to large-scale events such as the ENSO phenomenon**.** The Southern Oscillation is a two to five year sequence of differences in atmospheric pressure and changes in sea temperatures between the tropical central or eastern Pacific and the tropical eastern Indian Ocean or northern Australian region. El Niño (Figure 3) causes below-normal rainfall, and often drought, over much of Australia. The reverse effects occur during La Niña. These effects are additionally influenced by changes that occur in the Pacific over decades.

Australia's mean annual rainfall has increased slightly since 1910, mostly from the monsoonal north and west through to the south-east (Figure 4). A slight but cyclic increase in extreme wet conditions (Figure 5) has also occurred. Average and extreme amounts of rainfall have decreased in south-west Western Australia.

The total number of cyclones has decreased marginally since 1969–70, but their intensity may have increased slightly. The projected increased temperatures and reduced rainfall over some parts of Australia could lead to changes in agricultural patterns in marginal areas. Extreme events, including extensive flooding, will continue, with significant effects on agriculture, industry and infrastructure as well as on coastal habitat and coral reefs.

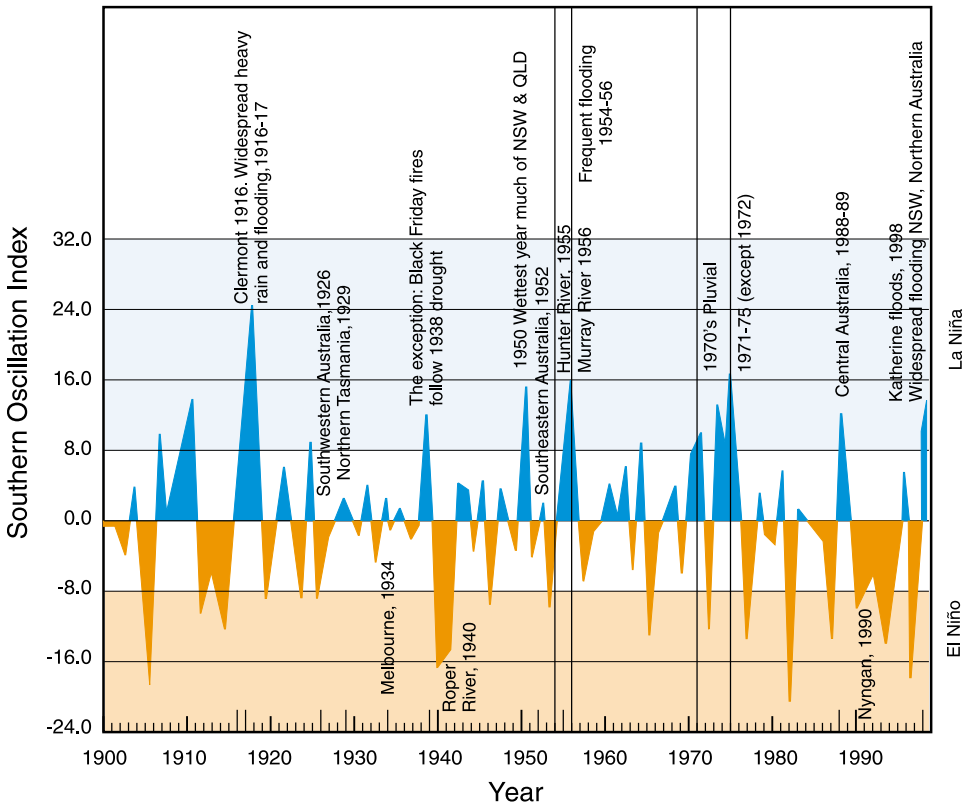


Figure 3: Annual variations in the Southern Oscillation Index.

Major floods associated with La Niña events since 1901 are also shown.

Source: BoM.

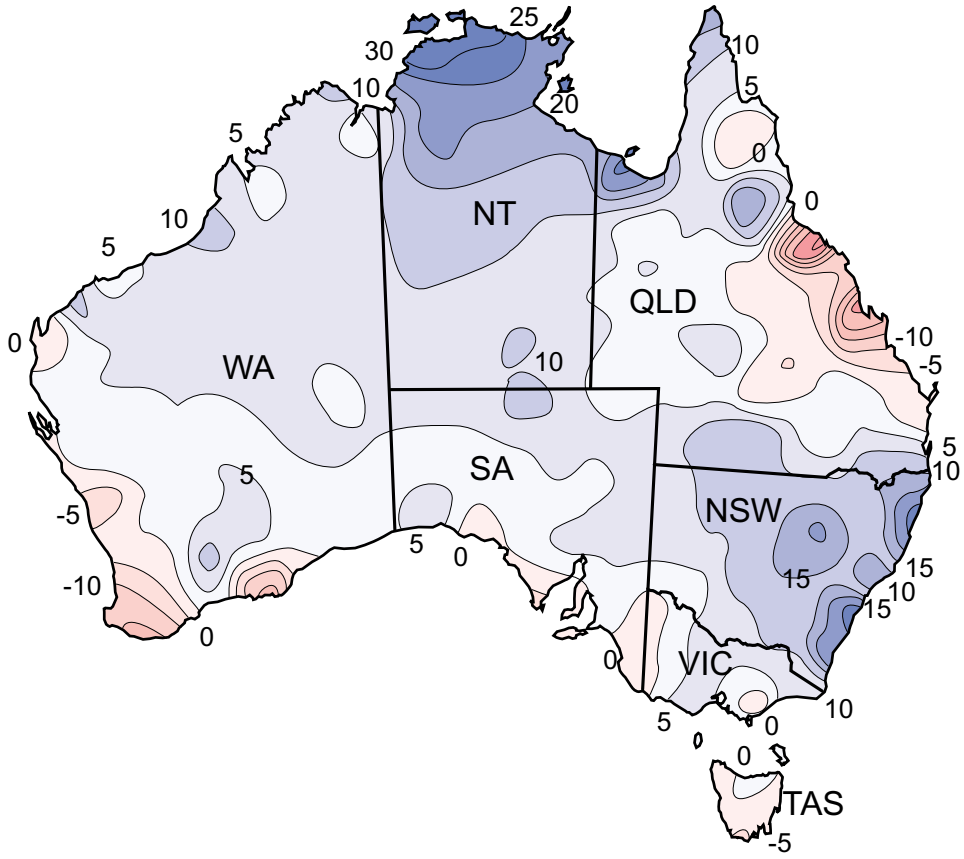


Figure 4: Rainfall trends in Australia from 1910 to 1999.

Trends are shown as millimetres per 10 years.

Source: BoM.

Australian average surface temperature follows global trends and has increased by 0.76°C since 1910 (Figure 6) with the minimum up by 0.96°C and the maximum by 0.56°C. The increase is largest over western and northern Australia. The number of extreme warm days and nights has increased while that of extreme cool days and nights has decreased, along with the annual number of frost days and the length of the frost season.

The sea around Australia appears to have risen an average of 12 to 16 cm over the last 100 years, compared with the IPCC estimated global average increase of 10 to 20 cm. However, tectonic action causes both falls and rises in local sea level observed around Australia. These changes, documented by the National Tidal Facility, Flinders University, confound the changes relative to the whole continent. Year-to-year variations around Australia also exist, strongly linked to ENSO. IPCC projects a global increase in sea level of 9 to 88 cm by 2100 (IPCC 2001).

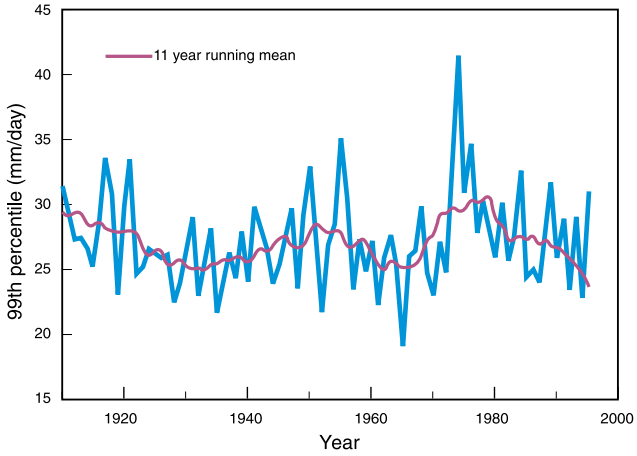


Figure 5: Interannual variations in the annual extreme rainfall (99th percentile of daily rainfall) for Australia.

Source: CSIRO Atmospheric Research.

Extreme weather causes considerable damage and losses. Tropical cyclones cause the most damage overall, with severe thunderstorms associated with hail and strong winds second. The largest cost for a single event, an estimated $1.6 billion, was the Sydney hailstorm of 1999.

Droughts result in fewer exports and lower tax receipts from primary production. Drought relief payments from 1992 to 1999 have averaged $100 million per year but the direct cost to government is only a part of the overall cost to the individual, communities and businesses. Coping with extreme events may require considerable changes in management practice to minimise cost and ensure sustainability, whether or not predicted long-term changes in climate occur.

Enhanced greenhouse effect

Carbon dioxide (CO_2), methane and water vapour in the atmosphere provide a natural greenhouse effect. These gases, together with clouds and aerosols in the stratosphere, maintain the earth's energy balance. Human activities and natural events can upset the balance by discharge of additional greenhouse gases into the atmosphere. Carbon dioxide is the most important greenhouse gas and its increase has accelerated since the mid-1800s. Methane shows a similar increase to carbon dioxide. Methane largely derives from the biosphere, particularly from livestock, rice cultivation, organic waste and landfills, as well as oil and gas production, gas distribution and coal mining.

Under the Kyoto Protocol developed countries are committed to reducing their greenhouse gas emissions by at least 5 per cent below 1990 levels by the first Kyoto commitment period (2008–12). However, at Kyoto, Australia negotiated an 8 per cent increase in emissions. According to the National Greenhouse Gas Inventory (NGGI) Australia's estimated emissions are already more than double this amount (although it should be noted that the NGGI methodology does not directly equate to the Kyoto Protocol accounting requirements).

Australia has very high greenhouse gas emissions per capita, although the total amount emitted is still small compared with other developed countries. Our total annual emissions, excluding land clearing, increased by 16.9% between 1990 and 1998 (Table 2) using the NGGI methodology. The increase of 16.9% compares unfavourably with Australia's target of an 8% increase above 1990 levels during the 2008–12 commitment period. Recent NGGI figures show that for 1999, total emissions increased by 17.4% from those in 1990.

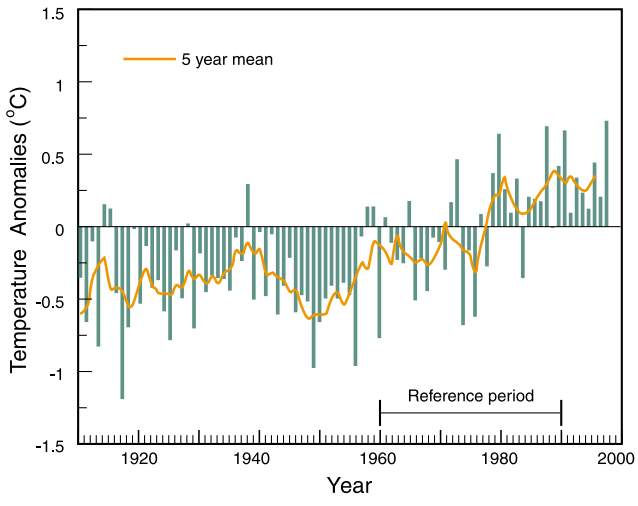


Figure 6: Annual mean temperature anomalies for Australia.

Source: BoM.

Table 2: Change in total carbon dioxide equivalent (CO_2-e) emissions by gas, 1990 to 1998
Totals and percentages may not correspond exactly due to rounding.

	1990 (Mt CO_2-e)	1998 (Mt CO_2-e)	Changes (Mt)[B]	Change in emissions (%)
Carbon dioxide	250.0	312.1	62.1	24.8
Methane	112.9	114.9	2.0	1.8
Nitrous oxide	22.1	27.5	5.4	24.3
Perfluorocarbons, etc.[A]	4.8	1.4	–3.4	–70.6
Total CO_2-e	389.8	455.9	66.1	16.9

[A]Includes sulfur hexafluoride (SF_6) from metal production; [B]Megatonnes.

Source: AGO (2000).

The main Australian sources of greenhouse gas emissions are:

- electricity and heat production, 56.8%
- agriculture, 20.2%
- transport, 15.9%
- fugitive emissions, 6.9%
- waste, 3.4%
- industrial process, 2.2%.

However, carbon dioxide removal relating to forestry and other subsectors reduced CO_2-e total by 5.4%. Therefore, any strategy that aims to reduce greenhouse gas emissions substantially should focus on energy production and use.

There is some evidence that Australia is being successful in decoupling its economic growth from its greenhouse emissions. The recent NGGI data showed greenhouse emissions increased by 1.1 % during 1999 while the economy grew by 5.4%.

The current best estimate of total gross emissions from the land use and forestry sector is 134.7 Mt of CO_2 or CO_2 equivalent (CO_2-e), while total removals (absorption of CO_2) in 1998 were estimated to be 95.2 Mt CO_2-e, a deficit of 39.5 Mt CO_2-e. The AGO reports that these estimates are unreliable because of uncertainty and gaps in the data.

Commonwealth and state governments, local councils and many businesses and industries have taken measures to respond to global warming by reducing greenhouse gas emissions. Measures include planting trees and managing land use to enhance greenhouse sinks, improving energy efficiencies, developing renewable energy and integrating transport systems.

Global models of climate are used to predict the potential effects of increasing concentrations of greenhouse gases. For Australia, the Commonwealth, Scientific and Industrial Research Organisation (CSIRO) has developed a range of temperature and rainfall projections that also take into account the uncertainties in such projections (Figures 7 and 8).

To the year 2030, most of Australia could warm by anywhere from 0.4 to 2.0°C. For 2070, the potential warming is about 1 to 6.0°C with regional and seasonal variations within both sets of projections.

In most locations, annual average rainfall relative to 1990 could either increase or decrease around the years 2030 and 2070. Changes are biased towards decrease in the south-

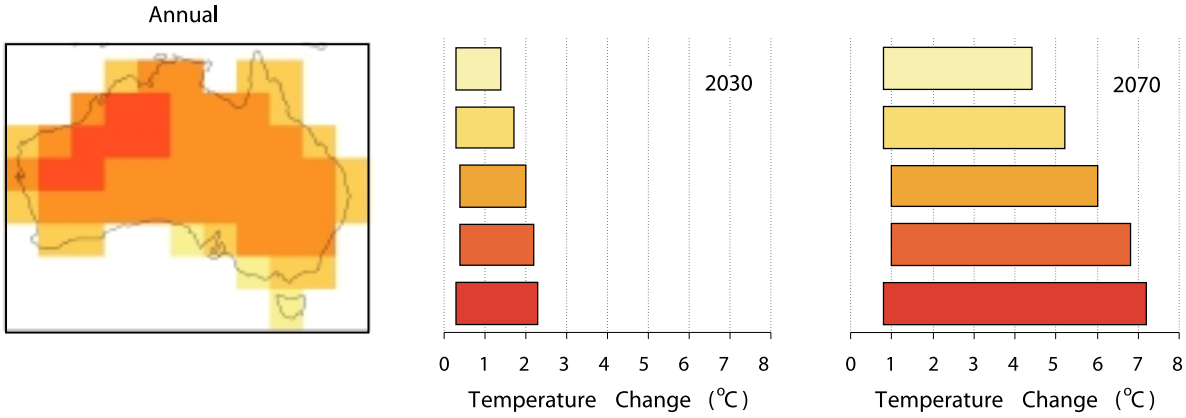


Figure 7: Projected mean annual temperature changes for 2030 and 2070.

Source: CSIRO Atmospheric Research.

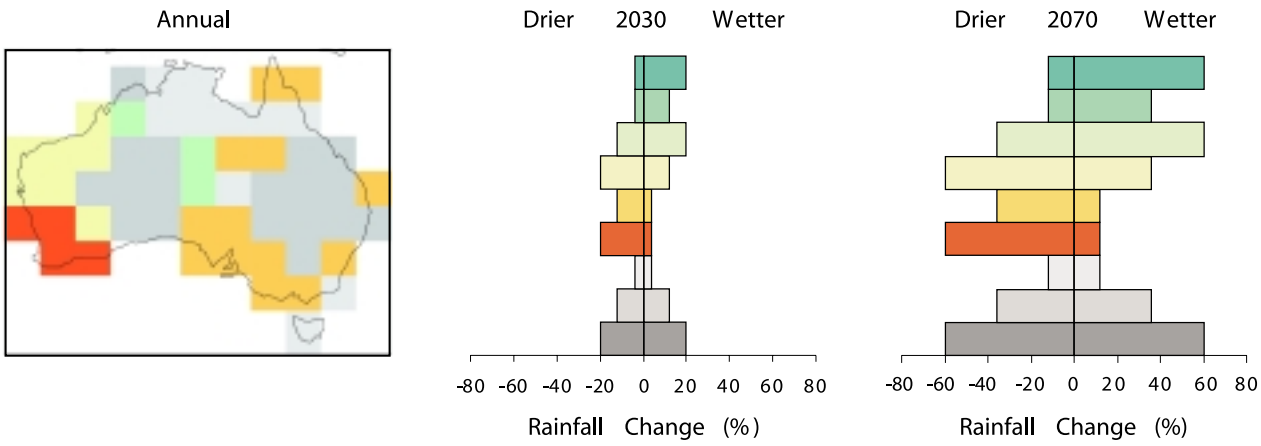


Figure 8: Projected rainfall changes for 2030 and 2070.

Source: CSIRO Atmospheric Research.

west and parts of the south-east and Queensland. For most other locations, predicted changes are around –10% to + 10% by 2030 and –35% to +35% by 2070. Despite their uncertainties, such models will continue to be an important means of anticipating the future (for details, see http://www.dar.csiro.au/publications/projections2001.pdf).

Stratospheric ozone

Ozone in the atmosphere prevents most of the sun's harmful ultraviolet (UV-B) radiation from reaching the earth's surface. It is produced in the stratosphere by the action of energetic UV radiation on molecular oxygen, and in turn destroyed by UV photolysis and by reaction with other oxygen species. Ozone destruction is assisted by trace levels of chlorine and bromine compounds released from the earth's surface.

The major ozone-depleting substances include chlorofluorocarbons (CFCs), halons and methyl bromide, used in many industries. Global consumption of these substances is now limited by the *Montreal Protocol on Substances that Deplete the Ozone Layer* to which Australia is a signatory. Accumulation of ozone-depleting substances is now declining slowly (Figure 9). This is a significant development since SoE (1996).

Ozone levels over Australia and New Zealand fell by 3 to 4% per decade from the 1960s, but may not decline much further. The largest ozone depletions, a drop of 60%, have occurred over Antarctica, where ozone removal has been enhanced by ice nuclei in polar stratospheric clouds and weak Antarctic sunlight.

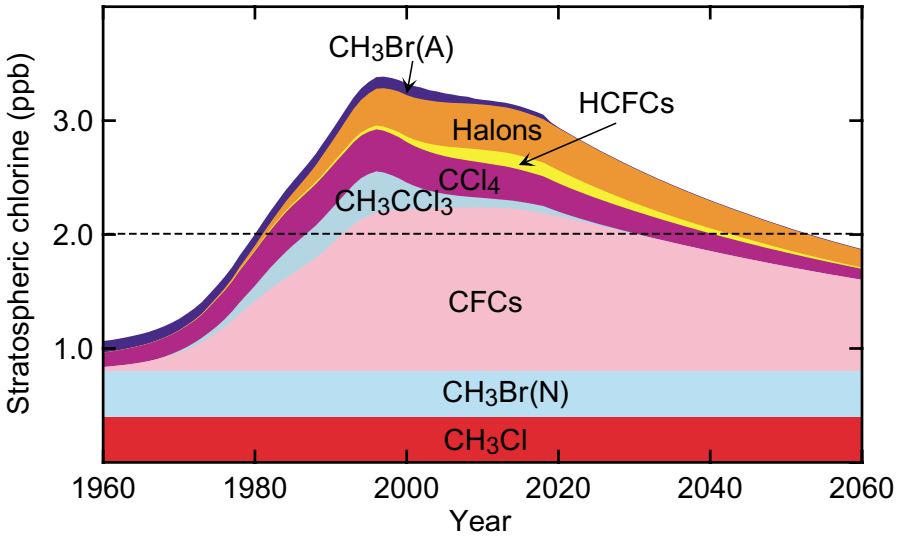


Figure 9: Stratospheric chlorine levels (ppb, cumulative) based on global atmospheric observations (1980–2000), historic (1960–1980) and projected emission data (2000–2050) of the major ozone-depleting substances.

The line at 2 ppb corresponds to when ozone depletion was first detected (about 1980) and when ozone recovery is anticipated (about 2050).

Source: Madronich & Velders (1999).

Australia has high levels of UV radiation and the highest per capita incidence of melanoma in the world, 28 per 100 000 persons in 1990. Since 1980, UV exposure in tropical regions of Australia has increased by 20% as a result of simultaneous depletion of ozone and decreases in cloud cover. At mid-latitudes, no significant net increases per year were found because of increasing levels of cloud cover but clear day levels of UV radiation rose. Human behaviour in avoiding excessive UV exposure is likely to have more than compensated for the increases in the UV levels. To assist the public the Bureau of Meteorology has recently added UV forecasting as one of its products (see http://www.bom.gov.au/weather).

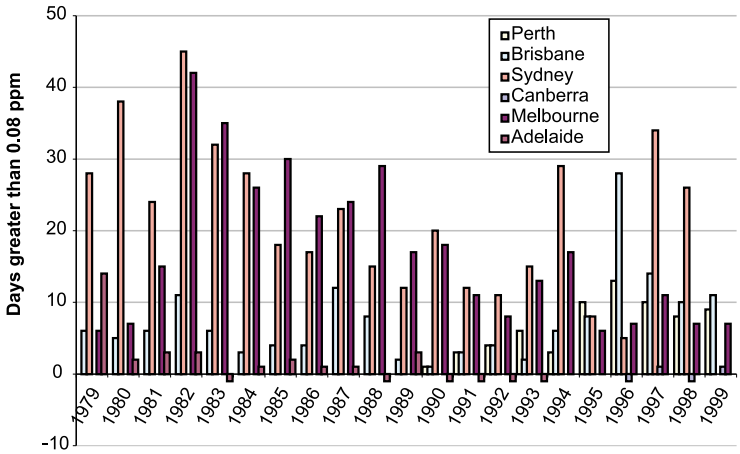


Figure 10: **Maximum four-hour ozone concentrations in selected cities.**

Source: Commonwealth, state and territory environment authorities.

Urban air quality

Over 60% of Australians live in coastal capital cities. High radiation levels, high summer temperatures and location in coastal basins surrounded by hills, make Australian urban areas susceptible to photochemical smog and to its recycling or concentration over areas of the airshed. Australian cities have air quality comparable with the better performing American, European and Asian cities.

Motor vehicles are the major emitters of air pollutants in urban Australia, contributing more than 75% of the carbon monoxide emissions and most of the oxides of nitrogen and organic compounds. Emissions include very fine particles that contribute to urban haze and adverse health. The phase-out of leaded petrol (complete by 2002) means that lead in air is no longer a concern for any major urban area. During 1980 to 1999, the eight-hour Air NEPM Standard for carbon monoxide has been exceeded in areas of high traffic density and low traffic flow, but the problem is not widespread. For nitrogen dioxide, only Sydney has shown exceedences and then on only one day per year.

In urban Australia, ambient sulfur dioxide concentrations rarely exceed Air NEPM values except near petroleum refineries, or petrochemical or chemical industries. Emissions of oxides of nitrogen and hydrocarbons react with sunlight to eventually form ozone, whose concentrations provide an estimate of photochemical smog. Since the 1980s, the maximum value of hourly ozone concentrations has declined steadily in the biggest cities. However, for the maximum amount averaged over four hours (Figure 10), there has been no decline, and hence no real drop in the level of photochemical smog. This indicates that the stricter vehicle emission limits proposed for the future will be needed to reach and maintain the Air NEPM standards.

Given that motor vehicles emit most of the pollution in capital cities (with power stations and heavy industry still a contributor in Perth and Brisbane), vehicle emission standards and their implementation are of major importance.

The present standard for new cars is Australian Design Rule 37/01 (ADR37/01). Starting in 2002, progressively tighter standards (ADR79, in harmony with European emissions standards Euro 2, 3 and 4) will be introduced and will become fully effective in 2005 (Tables 3 and 4).

The values for Melbourne in Table 3 reflect the 10-year average age of the Australian vehicle fleet. The 10% rate of replacement results in a long lag between the introduction of new standards and actual reductions in pollution.

Motor vehicle numbers and VKT continue to rise (Table 5). Fortunately, the stricter emission limits that will be introduced, together with the *National Fuel Quality Act 2000*, which will commence fully on 1 January 2002, should continue to maintain the quality of

Table 3: **Comparison of Australian Design Rules for motor vehicle emissions and observed emissions for Melbourne**

Emissions standard	Year first introduced	CO[A] (g/km)	NO_x[B] (g/km)	Hydrocarbons (g/km)	Evaporation (g/test)
ADR27	1974	24.2	1.9	2.1	6.0
ADR37/00	1986	9.3	1.93	0.93	2.0
ADR37/01	1997	2.1	0.63	0.26	2.0
Melbourne observations	1999	12.0	1.51	1.04	—

[A]CO, carbon monoxide; [B]NO_x, nitrogen oxides.

Source: Beer (1995), FORS (1996); Melbourne observations from EPAV (1998, 1999a).

Table 4: **Emission limits and timing for vehicles to meet Euro standards in Australia**

	Fully in force	CO (g/km)	NO_x (g/km)	HC (g/km) [exhaust][A]	PM (g/km)
Passenger cars and light commercial					
ADR37/01 (petrol)	1997–99	2.1	0.63	0.26	NA[B]
ADR79/01 (Euro3) (passenger, light commercial: petrol, LPG[D], CNG[E])	2005–06	2.3	0.15	0.2	0.05[C]
ADR79/01 (Euro4) (light diesel)	2006–07	0.5	0.25	0.3 (NO_x + HC)	0.025
Heavy duty diesel					
ADR70/00	1995–96	4.5	8.0	1.1	0.36
ADR79/01 (Euro4)	2006–07	4.0	3.5	0.55	0.03

[A]HC [evaporative] 2 g/test, [B]NA, Not applicable; [C]Applicable to light diesels, [D]LPG, Liquid petroleum gas, [E]CNG, Compressed natural gas.

Source: http://www.dotrs.gov.au/land/Environment/emission-requirements.htm.

urban air. Modelling by the Bureau of Transport Economics estimates that, with the new standards, particulates in urban areas from diesel vehicles will be 26% less in 2015 than in 2000, even with an expected growth of 60% in VKT. If urban vehicle usage increases substantially beyond projected estimates, alternative transport systems and even stricter emission controls may be required.

Although photochemical or smoke haze occurs, visibility in all Australian cities is substantially greater than 20 km. Seasonal pollens and dust, however, make Australia the worst country in the world for hayfever, contributing to over 40% of young adults suffering allergic symptoms.

Despite the importance of pollen counts as a health indicator, little monitoring occurs outside Melbourne. This is in marked contrast to the United States of America where local pollen counts are available (see http://www.weather.com/health/allergies/).

Emissions of a pollutant and exposure to it are not always directly linked. Most benzene emissions come from automobile exhaust and industrial emissions but these contribute only modestly to people's exposure (for emissions in urban areas see Table 6). Benzene released by cigarettes, petrol fumes and consumer products poses a much greater threat. The exposure of Australian urban populations to air pollutants can be defined by a characteristic concentration to which 37% of the population is exposed at least once per year. Such data indicate that most urban Australians are not exposed to the maximum values that individual monitoring stations may record. Therefore, PM10 concentrations in Sydney can reach maximum values of 60 to 90 µg/m^3 but the characteristic concentration which typifies the exposure for most of the population is only 15 µg/m^3.

The main respiratory health risk for Australians arises from particulates and hydrocarbons. Since 1979, death as a result of respiratory diseases and respiratory cancers has been falling for males but rising for females, which mirrors cigarette smoking patterns. Peaks in death rates also arise from influenza outbreaks. Therefore, studies to relate air quality and health variables need to allow for these major effects before determining the more subtle effects induced by air pollution.

Most air pollution complaints to EPAs involve odours from a range of sources. Odours from diffuse sources are often difficult to identify and control. There is no consistent and

Table 5: **Growth in Australian passenger car numbers and distance travelled**

	Cars (thousands)	Cars per thousand people	VKT (billions of km)[C]
1979	5652[A]	389.3[B]	84.8
1982	6290[A]	415.6[B]	96.1
1985	6926[A]	438.6[B]	106.6
1988	7381[A]	446.8[B]	116.6
1991	8012[A]	463.6[B]	114.3
1995	8628[D]	478.8[D]	113.0
1998	9315[C]	496.8[E]	134.3

[A]BTCE (1996: Table I.1, p. 331); [B]BTCE (1996: Table II.5, p. 356); [C]ABS (2000b: Table A3, p. 24); [D]ABS (1997: Table 1.4, p. 9); [E]ABS (2000c: p. 77).

Table 6: Peak values of urban benzene and toluene concentrations in Australia
Values given in µg/m^3 have been converted to ppb.

	Benzene (ppb)	Toluene (ppb)	Location and year	Benzene (ppb)	Toluene (ppb)	Location and year
Melbourne	14.9	20.2	CBD[A] 1990	7.9	13.0	CBD 1997
Sydney	2.6	8.9	1979–1980	2.5	6.9	1992–1993
Perth	5.0	9.1	Perth Traffic 1993–1994	1.44	2.56	1997–1998
Brisbane	5.3	10.7	1992	2.7	10.2	1998 Maximum
Adelaide	10.3	11.5	Hindley St 1989	8 .0	37 .0	North Tce 1994

[A] CBD, Central business district.

Source: EPAV (1998, 1999a, 1999b); DEPWA (1999a).

agreed objective method to measure and assess the strength and responses to odours. Odour criteria, if defined, vary among the states and territories but some states are now working on these issues and management approaches with the release of public discussion papers. No agency exists to coordinate a national approach to issues such as assessment methods, remedial measures and preventative strategies.

Regional air quality

In rural and regional Australia, levels of pollutants are generally well below actual or proposed standards. Carbon monoxide levels produced by vehicles, wood fires or other combustion sources can produce local effects but these are limited. Nitrogen dioxide and ozone are not of concern except for occasional transport from one region into another region. Benzene, where monitored, is well below any proposed standards. Airborne insecticides can be a local problem.

Airborne dust is often the only significant air quality issue in regional Australia. Strong winds influence levels of dust which can be attributed to natural sources as well as wind-blown erosion in cultivated or stocked areas and to mining. Particulates also arise from bushfires, burning off and domestic wood fires.

Maximum PM10 concentrations vary greatly. The Air NEPM allows five exceedences per year of the 24-hour average of 50 µg/m^3. Most regions comply, but wood burning in Launceston (Tas.) and Armidale (NSW) results in obvious exceptions. In Armidale, there were many days in 1997 and 1999 when 'local visual distance' was below 2 km (Armidale 2000).

The implementation of the Australian Minerals Industry Code for Environmental Management has helped reduce dust loads in mining areas. However, in New South Wales, a value of 4 g/m^2 per month of dust deposition is set for coal mining areas and until 1996, dust deposits in Wollongong remained close to or above this limit. In the Port Kembla area, deposition rates were generally higher.

In South Australia, dusty days are common, frequently due to wind erosion. As much as 20% of the state's asthma problems are possibly due to windborne dust.

With a 30% overall reduction in sulfur dioxide emissions since 1996, most of regional and rural Australia is now unaffected by sulfur dioxide pollution and there are only a few regional localities still of concern. In Port Pirie, maximum concentrations are presently unacceptable. Pollutants may be trapped close to the ground in atmospheric inversions at night, and mixing of plumes to the ground can occur during days with intense solar heating.

Mount Isa continues to meet its licence levels with the company's predictive control strategy in operation. However, the one-hour Air NEPM Standard is evidently a much bigger challenge (Figure 11) even with sulfur removal into the new sulfuric acid plant.

The copper smelter at Port Kembla used to have very high ground level concentrations of sulfur dioxide and of

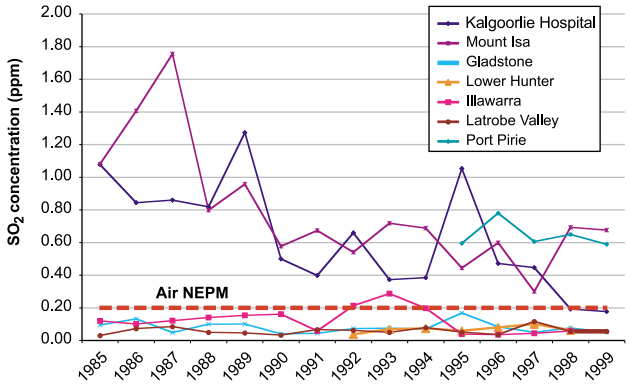


Figure 11: Highest one-hour averages of sulfur dioxide since 1985 in regional centres of Australia.

Lower Hunter from 1992; Port Pirie from July 1995.

Source: Data from State EPAs; DEPWA (1999b).

Table 7: ANZECC goals for ambient concentrations of fluoride
Values are presented in µg/m^3.

Goals	12 hour	24 hour	7 day	30 day	90 day
General land use	3.7	2.9	1.7	0.84	0.50
Special land use	1.8	1.5	0.80	0.40	0.25

Source: ANZECC (1990).

lead. After extensive community action and court appeals, the smelter was rebuilt in 2000 with a new sulfuric acid plant to remove much of the sulfur dioxide (see http://www.pkc.com.au/).

Mineral extraction and processing activities at Kalgoorlie have recently drastically reduced the one-hour and annual averages of sulfur dioxide and no exceedences of the Air NEPM have occurred in recent years for Gladstone, Lower Hunter and Latrobe Valley (power generation areas using coal).

Lead is of concern in rural or regional Australia only near smelters. At Mount Isa, ambient lead concentrations in the town are well below the Air NEPM Standard, even though stack emissions are large. Other significant industrial sources, notably Port Pirie and Cockle Creek, have committed to the Australian Minerals Industry Code for Environmental Management but substantial effort is still required in these locations before it can be said that all of Australia complies with the Air NEPM for lead.

Gaseous fluoride compounds cause damage to plants at concentrations about one thousand times lower than those that affect human health, and grapevines are particularly sensitive. The Australia and New Zealand Environment Conservation Council (ANZECC) has recommended ambient levels based on damage to plants (Table 7).

Fluoride concentrations are not a cause for concern around any of the aluminium smelter locations. At sensitive vineyard sites in the Hunter Valley (NSW), data from 1990 to 1995 show annual maximums of 0.1 to 0.3 µg/m^3, well below the guideline for sensitive vegetation of 0.8 µg/m^3, and there are consistently low atmospheric fluoride concentrations near the Alcoa smelters in Victoria. Major reductions in emissions of fluoride from smelters operated by Comalco Ltd have occurred over the past five years and these smelters are now comparable with new smelters at Tomago and Portland.

Gaseous fluorides are emitted in significant quantities from power station stacks, and investigative monitoring of these would be prudent.

Conclusion

Australia's climate is highly variable both in the short term and long term, and is dominated by major ocean and air circulation systems. Average temperatures have risen by 0.76°C since 1910, consistent with global increases. Rainfall averages have increased somewhat over most of the continent, although there have been decreases in some areas. Extreme events (drought, cyclones, floods and hailstorms) may have slightly increased in number or intensity, but also show cycles of decades in length.

Australia's greenhouse gas emissions per capita are high by world standards, and continue to increase, with energy production and use the greatest contributors.

Ozone loss from ozone-depleting chemicals has stabilised with reduction in their use, but ozone levels may not recover for many decades. Concomitant UV radiation levels have increased, but human behaviours to avoid excessive exposure have outweighed these increases.

Urban air quality has generally improved over the last two decades although episodes of high ozone levels still persist. Most other urban air pollutants—lead, sulfur dioxide, nitrogen dioxide, carbon monoxide and fine particles—are now less than set by the recent Air NEPM standards. Woodsmoke and pollens are a significant seasonal problem in some cities.

Motor vehicles remain the major source of urban air pollution. New emission standards, similar to those in Europe, and fuel standards should outweigh the projected increases in VKT.

Australia has the highest number of hayfever sufferers in the world attributed to pollen and other nasal allergens. There is insufficient regular, ongoing monitoring of pollen counts.

Most air pollution complaints to EPAs involve odours from a range of sources. There is no consistent and agreed objective method to measure and assess the strength and responses to odours.

Regional air quality is generally good. The exceptions are sulfur dioxide near some smelters, and in some locations, airborne dust or woodsmoke. Fluoride levels outside all Australian aluminium smelters are below the required limits, but may still be an issue for coal-fired power stations.

Coasts and oceans

Australia's marine area extends about 16 million square kilometres, from Antarctic to near equatorial latitudes. It includes one of the largest Exclusive Economic Zones in the world (11 million km^2), and the high degree of endemism (numbers of species found only in a particular region) in the south and the rich tropical diversity of the north create unique opportunities and challenges for Australia.

Australia is highly dependent on its marine resources in a range of ways such as the benefit of marine industries including shipping, tourism, fisheries and offshore oil and gas (see *Antarctica* box on page 37). The value of our marine resources has been appreciated by Indigenous Australians for thousands of years and their cultural associations remain strong. Many people cherish the clean beaches, the tourist destinations such as the Great Barrier Reef and the picturesque southern coastlines. Millions of Australians appreciate the pleasures of recreational fishing.

SoE (1996) raised the awareness of Australians to the state of their environment (as did *The State of the Marine Environment Report* in 1995). SoE (1996) found that coastal development had degraded near shore and estuarine habitats and water quality, particularly in the south-east and south-west. Many fisheries were fully or overexploited; and introduced marine pests were a threat to marine ecosystems. These findings are largely reinforced in SoE (2001).

In general, the states and territories have jurisdiction over marine areas to 3 nm from the baseline, and the Commonwealth has jurisdiction beyond those waters to the outer boundaries of the EEZ. The Offshore Constitutional Settlement established jurisdiction between the Commonwealth and the states over marine areas in 1983. Most of Australia's marine area is under sole Commonwealth jurisdiction.

In considering the condition of the coasts and oceans, there are eight key issues:

- degradation of habitats
- threats to marine species
- effects of increased coastal settlement
- coastal water quality
- fisheries and aquaculture
- introduced marine pests
- marine industry development
- marine resource management.

A summary is presented in *Key findings* (page 5).

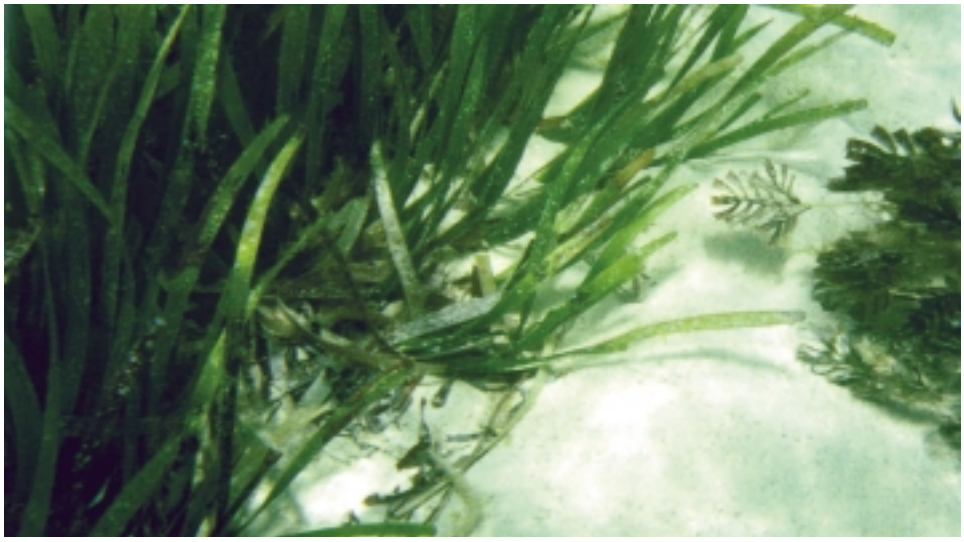
Key issues

Continued degradation of habitats

Mangroves are our marine forests. Australia has 43 species representing 58% of global diversity. No mangrove species is considered threatened, and indeed, net mangrove area may be increasing. Reasons for the increases include growth in areas of accreting mud banks, and incursion into salt marsh systems. Mangrove forests are being destroyed locally through urban expansion, or through changes to drainage systems. Loss of mangroves represents loss of fish habitat and changes to the flows of nutrients and sediments. The consequences are lowered fish productivity and loss of water quality.

Seagrasses are not robust ocean 'weeds': they are flowering plants and represent productive, shallow marine pastures. They support nursery areas for fish, prawns and other species. They provide food for dugongs. Seagrasses are vulnerable to pollution from chemicals and smothering by mud.

Seagrasses populations may not recover after loss. In the tropics, many species are seasonal and regrow quickly. However, in temperate waters, the dominant *Posidonia* species may take many decades to regrow so their recovery is not practically achievable. The recent discovery of



Seagrass bed, *Posidonia australis* and *Amphibolus antarctica*, near Rockingham, WA.

Source: M Waycott, James Cook University.

deepwater beds in the Great Barrier Reef World Heritage Area indicates that our knowledge of seagrasses is still expanding.

Dunes and beach habitat represent about 50% of the coast, yet they are among the most poorly studied coastal habitats. They are under localised pressures from urban development around population centres.

Intertidal mud flats are species rich, and important in the routes of migratory bird species, but as with dunes and beaches, they are not particularly well studied.

Rocky reefs are found in intertidal and subtidal areas. They are important as a base for productive macroalgae, sponges and fish. About 50% of Australia's fisheries are supported by rocky reef habitats. The principal human pressures on rocky reefs come from land-based pollution and from fishing pressure.

Trend: Key habitats

The condition of key coastal habitats has not changed significantly since 1996, pressures have remained constant and responses have been adequate in some respects.

Estuaries were the preferred site for European settlement. In an assessment of 972 estuaries, the National Land and Water Resources Audit found that almost half are degraded in some way, usually owing to land-use practices or human settlement pressure. For the other estuaries, pressure is assumed to be light owing to low levels of human use.

Trend: Estuaries

The condition of estuaries has deteriorated since 1996, pressures are increasing and responses have been adequate in some respects.

Gulfs and bay habitats are robust because they are open to the ocean but are still vulnerable to sediment deposition which carries adsorbed nutrients and pollutants. In Hervey Bay, Queensland, there was a major loss of seagrasses (1000 km^2) after a large flood in 1992 carried greater than normal amounts of eroded sediments into the Bay. For bays and gulfs near coastal cities and towns, habitat degradation occurs through enhanced nutrient and toxicant inputs and the introduction of pathogens to the water through sewage outfalls and septic tank overflows.

Coral reefs are exceptionally diverse marine systems that thrive in relatively low nutrient tropical waters. The Great Barrier Reef in north-east Australia is well known, but is not our only coral reef. Ningaloo Reef in Western Australia is Australia's largest fringing reef,

stretching for 230 km along a very lightly populated coastline. Cocos (Keeling) atoll is Australia's only true atoll.

Coral reefs are under great pressure globally. The Global Coral Reef Monitoring Network 2000 assessment indicated that about 20% of the world's reefs are seriously degraded or lost. A dramatic 'bleaching' event in 1998 accounted for the damage of 16% of the world's reefs within one year. Of the 16%, 50% will recover quickly. Coral bleaching occurs when the water temperature exceeds a certain threshold, usually just over 30°C. Symbiotic algae in the coral tissues are expelled, allowing the white calcium carbonate skeleton to show through the clear animal tissue cover. If the temperature remains high for more than a few weeks, the coral dies. Australia was fortunate in that only 3% of reefs were significantly affected by bleaching in 1998.

Australian coral reefs have been degraded by sediment and nutrient runoff at certain coastal locations in Queensland's wet tropics, and brought under pressure from increasing recreational and commercial fishing at others. The Crown-of-Thorns Starfish (*Acanthaster planci*) is reducing living coral over very large areas of the Great Barrier Reef, and could be the worst of the three recorded episodes since the 1960s. Yet the precise triggers for the outbreaks of this 'boom and bust' species remain uncertain, although high levels of freshwater runoff has been implicated as a possible cause.

Trend: Coral reefs

Coral reefs show signs of degradation in some areas, pressures have remained constant and responses have been adequate in some respects.

Australia's continental shelf and slope cover a huge area, some 2.5 million square kilometres, yet it remains poorly known. Soft sediments predominate over vast areas. Diverse communities of fish and sponge gardens occur and some of these may be very long-lived and slow to recover from disturbance. Our seamounts off southern Tasmania harbour unique long-living ecosystems.

Threats to marine species

Over 1000 species of echinoderms (seastars, sea urchins, sea cucumbers and brittle stars) have been recorded in the shallow coastal or reef waters of Australia. Some 10 000 species of marine molluscs known to science have been described.

Stalked Crinoid or Sea Lily.

Scale in cm.

Source: CSIRO Marine Research, Hobart.

Green Turtles eat algae and seaweed.

Source: G Carter, Great Barrier Reef Marine Park Authority.

A variety of invertebrates are exploited by fisheries with Australia's prawn, lobster and abalone fisheries representing very high value for relatively low volumes of harvest. Human effects on invertebrates come from coastal development and land-based pollution, and from some methods of trawling such as dredging.

In the past five years, there has been an increasing adoption of marine protected areas (MPAs) as a means of conserving marine invertebrates and protecting them from extractive industries. The MPAs rely less on precise knowledge of species population status and more on maintenance of areas of habitat types. However, not all attempts to establish MPAs at a state level have been successful.

The conservation status of fish species, as listed under the EPBC Act, shows one fish species is endangered (the Derwent River Spotted Handfish, *Brachionichthys hirsutus*); five species of shark are listed as vulnerable (including the Great White Shark, *Carcharodon carcharias*). The practice of setting nets for sharks near swimming beaches has affected shark populations, particularly the Grey Nurse Shark (*Carcharias taurus*), which has been reduced to about 1000 individuals and is listed as vulnerable under the EPBC Act. Shark mesh-netting around beaches has also killed many dolphins and dugongs.

Six of the world's seven species of turtles breed in Australia. The eastern Australian stock of the Loggerhead Turtle (*Caretta caretta*) is considered to be endangered, with a 70 to 90% decline in the nesting population in the last 30 years. Other species also show declines. The Hawksbill Turtle (*Eretmochelys imbricata*) is recognised internationally as critically endangered, and relies heavily on breeding sites in the northern Great Barrier Reef region. About 10 000 turtles are caught accidentally by trawl fishing each year in northern Australia. However, an estimated 90% of these are released alive. About 2000 to 4000 Green Turtles are caught by Indigenous peoples each year.

The vulnerability of turtles has led to a heightened international profile and national and state action plans to conserve turtle species. Fishing trawlers in most northern areas now use turtle excluding devices that prevent turtles being caught in trawl nets. Indigenous councils have implemented management plans to control their take of dugongs and turtles at several locations.

Seabirds and shorebirds are a highly visible and important component of our marine and coastal ecosystems. There are 73 species dependent on coastal habitat, even though many are migratory. Disturbance to seabird populations and their habitat come from a wide variety of sources, including urban development, airports, mining and minerals exploration, off-road vehicles, tourism at nesting sites, longline fishing, discarded fishing gear, and rats and feral cats

on offshore islands. There are a few examples of population reduction through Indigenous harvesting of seabird eggs (e.g. in the Torres Strait).

There have been several new developments aimed at reducing pressures on seabird populations (e.g. the Commonwealth's Threat Abatement Plan of 1998 to reduce effects from longline fishing vessels, where seabirds, such as albatross, are attracted and caught by baited hooks as they are cast into the water). Longline fishing operators are now trialing a bait chute-launcher that will prevent bird losses. Nesting areas are being protected in the Great Barrier Reef region, and in southern Australia there are programs to reduce disturbance from feral animal predators. Australia also has 32 coastal wetland areas declared as protected under the international Ramsar Convention, and 16 of these sites are significant for migratory birds.

Trend: Seabirds and shorebirds

The populations of seabirds and shorebirds has thought to have declined since 1996, pressures such as habitat loss remain constant and the overall response is adequate in some respects.

Cetaceans (whales and dolphins) are visible and valued by Australians as charismatic species deserving maximum protection (Figure 12). Public concern at the decline of the great whales has led to measures through the International Whaling Commission. There are still some countries that regard whales as harvestable species (Japan and Norway). The Commonwealth government continues its fight to protect whales.

Conservation efforts have helped the numbers of Humpback Whale (*Megaptera novaeangliae*) recover. In 1998, the status of the species changed from endangered to vulnerable, and available evidence points to an increase in populations of about 10% per year. Other species such as the Blue Whale (*Balaenoptera musculus*) and Southern Right Whale (*Eubalaena australis*) remain at critically low numbers.

Whale watching is rising in popularity and is subject to state controls and national guidelines. The aim is for people to view cetaceans and learn about them without interfering with their migration, feeding and breeding. Several coastal towns have improved their economies by fostering whale and dolphin watching (e.g. Merimbula and Eden, NSW).

So little is known about some species, such as the inshore dolphins, that the population status cannot be categorised.

There are 10 species of seal occurring in Australian waters, all in southern temperate Australia and sub-Antarctic regions. Their population dynamics are complex,

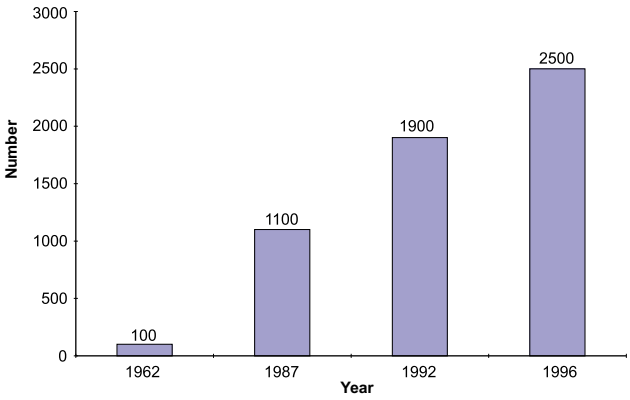


Figure 12: Estimated number of humpback whales migrating up the East Coast.

Source: EPA (1999).

Drowned albatross caught on a pelagic longline.

Source: G Robertson, Australian Antarctic Division.

Antarctica: Cool science for global systems

Antarctica and the Southern Ocean are critical to the global environmental system. Interaction between the atmosphere, oceans, ice and biota affect the entire global system through feedbacks, biogeochemical cycles, circulation patterns, transport of energy and pollutants, and changes in ice mass balance.

The Antarctic Treaty, signed in 1959 by 12 countries, applies to the area south of 60°. The Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol) which entered into force in 1998, designates the Antarctic as a natural reserve devoted to peace and science, and forms the foundation for the comprehensive protection of the Antarctic.

The Australian Antarctic Territory comprises 5 896 500 square kilometres, equal to 77% of the land area of Australia and 42% of Antarctica. It is the coldest, driest, windiest and most remote continent. Antarctica is also the continent least affected by human activity, making it an ideal location for studying human effects and global background levels of anthropogenic agents such as PCBs.

Antarctica has many biological surprises. The biomass of krill rivals that of the human population while Crabeater Seals (*Lobodon carcinophagus*) may be the most numerous of all the world's larger animals apart from humans. At the other size extreme, Antarctic microbes (algae, protozoa and bacteria) can be abundant and diverse in the marine terrestrial and lake environments. Marine algae in Antarctic waters have a major role in the absorption of atmospheric carbon dioxide and some produce chemicals that induce cloud formation that can influence global climate.

The catch of krill and fish harvested in Antarctic waters by member countries are regulated under the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) utilising an ecosystem approach. Illegal fishing for Patagonian Toothfish (*Dissostichus eleginoides*) in the Southern Ocean is, however, estimated to exceed the legal catch.

While fishing in the Southern Ocean may affect other Antarctic species, the Antarctic continent itself is unlikely to come under direct threat in the short term from resource extraction. Antarctic tourism is, however, an emerging environmental issue. Although the number of expeditioners associated with national operators is relatively constant, tourist numbers have doubled over the last eight years and tourist activities in the Antarctic continue to diversity. Hundreds of scientists and thousands of tourists visiting some Antarctic sites over a short summer season are drawn by very high expectations of Antarctic wilderness.

Source: Australian Antarctic Division (2001).

Moonrise over Matherway Island, Antarctica.

Source: G Dixon, Australian Antarctic Division (10-3435B6).

Tourists near Bunger Hills, Antarctica.

Source: R Ledingham, Australian Antarctic Division (1614-C2).

and it is thought that declines in Southern Elephant Seals (*Mirounga leonina*) at Macquarie Island may be related to rises in Fur Seals (*Arctocephalus pusillus*) and King Penguins (*Aptenodytes patagonius*) (both of which are rapidly becoming more numerous).

The dugong (*Dugong dugon*) is Australia's only strictly marine herbivorous mammal. Australian dugongs constitute a significant percentage of the world population. Some populations of Australian dugongs have declined dramatically since European settlement, largely as a result of human activities, but others do not appear to be currently threatened. Dugongs are vulnerable to mesh nets in shallow coastal waters and to loss of their seagrass feeding habitats. Commercial harvesting ceased many years ago, but they are legally hunted in northern Australia by Aborigines and Torres Strait Islanders. Dugong habitat is protected by legislation in Queensland and includes 16 Dugong Protection Areas declared in 1997.

Trend: Marine mammals

Whale and seal populations seem to be recovering while dugong populations remain stable. Pressures remain constant and responses have been adequate in most respects.

Effects of increased coastal settlement

The Australian coastline is lightly populated when measured against more highly populated countries, but about 80% of our population lives close to the coast. The trend to move to the coast is continuing (Figure 13).

Development of Australia's coastal strip is one of the major strategic issues confronting the conservation and management of the coastal zone. Effects of human activity cause the loss or degradation of specific habitat types, alter tidal water flows in wetlands and streams, cause erosion of beaches and dunes, and degrade water quality through stormwater runoff, sewage and litter. Developments may cause loss of familiar and loved landmarks and seascapes, obliterating cultural heritage and changing land use patterns (e.g. subdivision of farmland for housing).

Marine tourism is a significant part of Australia's economy. There is a tremendous range of activities including boat cruising, whale watching, visits to the Antarctic, bird watching, recreational scuba diving and snorkeling and exploring historic shipwrecks.

Environmental aspects of marine tourism are dealt with by regulations controlling discharges from vessels, island resorts and tourist pontoons, and the establishment of moorings for tourist vessels to minimise anchor damage and improve safety. These regulations are managed by the states and the Northern Territory with varying degrees of effectiveness.

A survey in 1996 found that 73% of beach litter was from land-sourced plastics, and a further 13% was debris from fishing. The disposal of plastic waste at sea is prohibited under the MARPOL Convention (International Convention for the Prevention of Pollution from

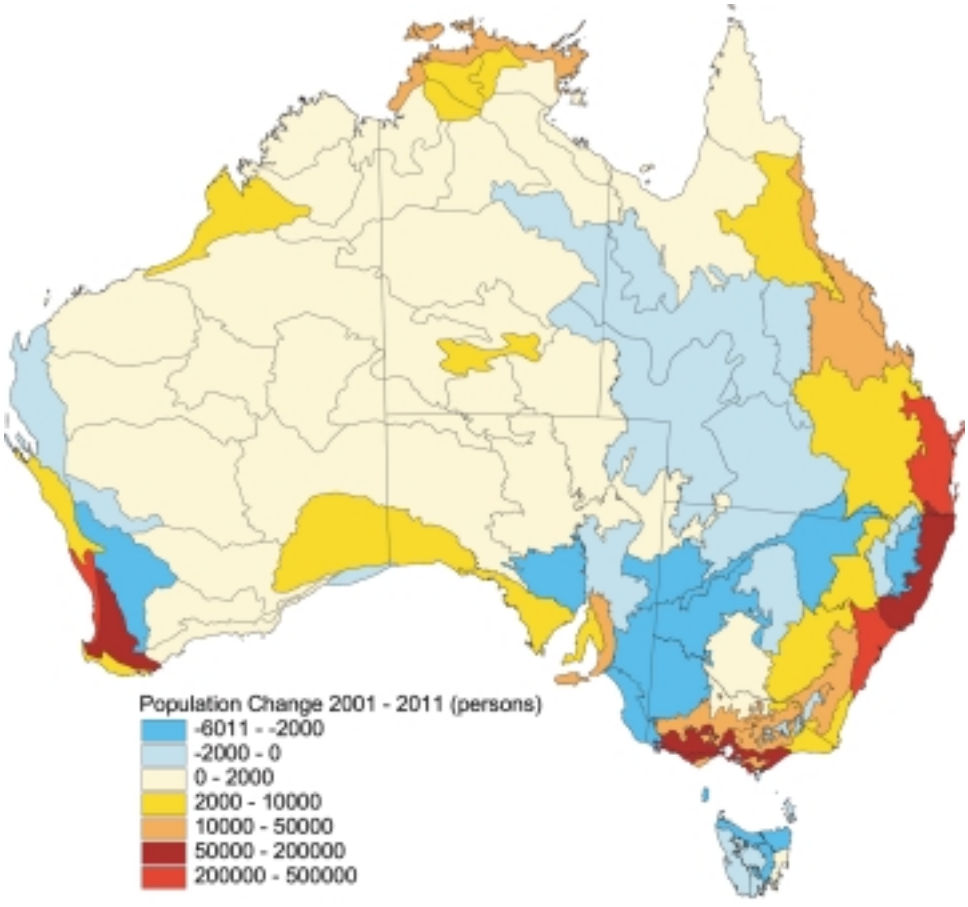


Figure 13: Projected changes in population density by Interim Biogeographic Regionalisation for Australia (IBRA) region.

Units are persons per square kilometre. Data are derived through simple difference between 1997 and 2006 ABS projections. IBRA version 5 used.

Source: after ABS (1996).

Tourists leave Port Douglas to visit the Great Barrier Reef.

Source: J Jones, Great Barrier Reef Marine Park Authority.

Ships) (Annex V) and enforced in Australia through legislation. In addition, there are national and fishery specific codes of conduct designed to minimise all discards and waste associated with fishing. Beach litter continues to be a problem in Australia despite community interest in 'Clean Up' days.

The creation of acid runoff through disturbance of acid sulfate soils in coastal areas has already had a major effect and this damaging phenomenon might expand. These soils underlie large tracts of the populated coastal zone, where alteration to drainage and the excavation of the soil creates very acidic runoff that causes fish kills and corrodes metal structures. Fortunately, acid runoff can be managed, and in some areas, water quality is improving. Recognition of the phenomenon by local, state and Commonwealth governments since 1996 has been an essential step.

Decline in coastal water quality

Maintenance or restoration of water quality, particularly in coastal margins, is arguably the most critical marine environmental issue confronting Australia in 2001. Water quality is essential for ecosystem maintenance, for industries such as fishing and tourism, and for recreation and aesthetics. The incremental decline in quality makes it difficult for regulators to achieve the community support needed to reverse negative effects.

The appeal of the Antarctic wilderness attracts growing numbers of tourists.

Source: R Ledingham, Australian Antarctic Division.

Table 8: Total nutrient emissions for selected coastal regions (1000 kg)

		Phosphorus		Nitrogen	
Coastal region	Land use	Point[A]	Diffuse[B]	Point[A]	Diffuse[B]
Peel-Harvey (WA)	Agriculture	NA[C]	260	NA	1 800
Esk/Tamar (Tas.)	Agriculture	150	360	390	1 600
Dawson River (Qld)	Agriculture	20	1 700	28	6 400
Latrobe–Thomson (Vic.)	Agriculture	18	410	44	3 800
Richmond River (NSW)	Agriculture	5.8	250	NA	1 700
Darwin Harbour (NT)	Mix	68	47	270	590
SE Queensland (Qld)	Mix	1 300	1 500	3 300	7 000
Water Catchment Adelaide (SA)	Urban/industrial	210	64	920	550
Port Phillip Bay (Vic.)	Urban/industrial	2 500	190	8 500	2 300
Botany Bay (NSW)	Urban/industrial	1 300	48	7 600	280
Lake Illawarra (NSW)	Urban/industrial	190	25	970	170

A Point sources: Emissions of Total Phosphorus and Nitrogen from reporting facilities (e.g. industry or wastewater treatment plants) 1999–2000.
B Diffuse sources: Emissions of Total Phosphorus and Nitrogen to water from aggregate sources: 1999–2000. Diffuse source pollution represents aggregated data for which there may be significant error of estimation, ranging up to +/– 50% for data for Western Australia and 3 to 13 times for diffuse source estimates in Tasmania. There are significant qualifications to the National Pollutant Inventory estimates and information on the website should be consulted before quoting and/or interpreting these figures.
C NA, none reported.

Source: http://www.environment.gov.au/epg/npi/ (accessed October 2001).

Although many coastal areas have excellent water quality, there are also many that do not. The negative effects can come from land use practices occurring in catchments hundreds of kilometres from the coast. For example, deforestation, agricultural chemical use, poor cropping or grazing practices cause enhanced erosion and increased turbidity and nutrient supply to estuaries and coastal waters. Nutrient loads from different land use mixes in selected parts of Australia are shown in Table 8.

Individual jurisdictions are working on improving the situation. Point source pollution is increasingly subject to regulation. Cities such as Sydney are spending millions of dollars in managing the effluent contained in stormwater overflows.

There is no national overview of the extent and levels of toxicants found in coastal waters and sediments. Neither is there national-scale information on the emission of toxicants from diffuse pollution sources. It is the job of 'nobody' yet 'everybody' to do this. The degradation caused by diffuse sources remains largely unchecked and even identifiable, and local degradation is often not well managed.

Coastal water quality in areas of major river runoff from broad agricultural catchments, are of concern. Overgrazing during droughts can markedly increase the amount of erosion and subsequent runoff of sediment. This sediment is deposited from flood plumes close to the coast placing added pressure on nearshore ecosystems that may be sensitive to smothering in mud, or loss of plant growth through increased water turbidity. A review of the effects of river runoff in the Great Barrier Reef region has shown that effects of human activity onshore can be seen in sections of coast between Mackay and Port Douglas as far offshore as 20 km. The catchment-scale approach to understanding and managing the problem is the most logical approach and implementation should be encouraged wherever possible.

Overall, the quality of estuarine and coastal waters has not improved, although there are some locations where signs are positive, for example around Sydney's beaches and parts of the Harbour. But these improvements have required massive infrastructure investments by various authorities, for example Sydney Water and the Western Australian Water Corporation.

Trend: Coastal water quality

Nutrient and sediment loads are causing deteriorating conditions in some coastal waters, pressures are increasing, while responses are adequate in some respects.

Commercial prawn trawl fishing on the Great Barrier Reef is important to the Australian economy.

Source: A Elliot, Great Barrier Reef Marine Park Authority.

Fisheries and aquaculture

Many Australian fisheries are fully or overexploited. None is pushing species towards extinction, to the best of current knowledge, but clearly sustainable development demands much more than this benchmark. Many types of fishing gear have unwanted effects on the environment, taking species that are not the target of fishing operations. The effect of trawl nets on species such as sponges and other benthos remains a significant issue in some areas.

Commonwealth fisheries are developing Bycatch Action Plans. Plans have been developed for eight of the 21 Commonwealth fisheries with another six expected to be completed by the end of 2001. The longline fishing industry is addressing the problem of accidental capture of seabirds, although the problem is not yet under control.

Government regulators and the industry have recognised the need to accelerate sustainability into all aspects of the seafood industry. Since SoE (1996), a program has been underway with support from Commonwealth and state agencies and research and development (R&D) agencies. The ESD Framework Project aims to include environmental, economic and social indicators into fisheries management, and to address the effect of fishing on the environment beyond the immediate target species. As Commonwealth fisheries develop management plans they have to do a strategic assessment under the EPBC Act. There has been progress in implementing sustainable principles in some areas such as the Great Barrier Reef Marine Park where there is a plan to reduce the amount of trawling in the region.

The level of uncertainty in scientific assessments of the status of fisheries remains relatively high, although recent information shows a trend to fewer fisheries classified as 'underfished' and slightly more as 'uncertain'. Sustainable development of Australia's fishing industry may involve making greater returns for industry by increasing quality or value-adding to the wild-caught product rather than by increasing total tonnage of the catch.

About three-quarters of Australia's fisheries are under state jurisdiction. Western Australia, Queensland and New South Wales produce regular reports on status of fish stocks

Turtles being monitored by fishers before release.

Source: C Robins, Bureau of Rural Sciences.

with all reporting stocks either at or near their sustainable limits. There are few examples where fisheries management can claim clear success in achieving regulatory goals. An example is the Western Australian Western Rock Lobster Fishery, recently acclaimed as the first fishery to be accredited under the Marine Stewardship Council. In the early 1990s, scientists identified dwindling parent stock at a time when catches remained high. Management restrictions were introduced and subsequently there has been an increase in parent stock.

It is unknown whether the Eastern Gemfish (*Rexea solandri*), found in deep water off southern New South Wales, will recover from its depleted state after overfishing in the 1970s and 1980s. Orange Roughy (*Hoplostethus atlanticus*), taken off Tasmania and the South Tasman Rise, is also under strong management controls to restrict the catch of this long-lived species.

Trend: Commercial wild capture fisheries

The status of many fisheries remains unchanged since 1996 while responses to the pressures have been adequate in most respects.

Recreational fishing is a popular sport in Australia. The best estimate indicates that 30 000 t of seafood is taken per year by about five million people. About 73% of recreational fishing activity is in saltwater. Controls on recreational fishing are usually through size limits, gear or bag limits, and closures by season or area. However, the precise status of most species taken by recreational fishing is unknown. Since SoE (1996), several States have introduced angling licences to include marine recreational fishing and a national survey was instigated in 2000 to gather information on the extent of recreational fishing and fishing by Indigenous peoples. The evidence is not yet available to determine whether species taken in recreational fisheries are overfished.

The value of aquaculture production has been growing at 14% per year since 1989 (Figure 14). Until the 1990s, most commercial aquaculture was for oysters (edible and pearl), and a limited amount of fish and prawn culture. Pearl culture yields about $200 million, making pearls a sea gem rather than a sea food. Recently the cage culture of fish has grown rapidly. Atlantic Salmon (*Salmo salar*) in Tasmania and the fattening of caged Southern Bluefin Tuna (*Thunnus maccoyii)* in South Australia account for about one-third of Australia's $600 million production. The growth of aquaculture has brought new environmental management issues under scrutiny. For example, The Great Barrier Reef Marine Park Authority introduced water quality standards for prawn farm discharges into the Marine Park. New South Wales has just introduced a State Environmental Planning Policy (SEPP) to provide guidance and control over an industry which is being encouraged as a state priority.

Threat of introduced marine pests

Australia is highly dependent economically on the export of bulk commodities such as minerals, agricultural products and oil and gas. The vessels that carry these products usually arrive on our shores empty, except for massive volumes of ballast water, which when dumped in Australian waters can carry unwelcome hitchhikers. There have been some 200 species introduced unintentionally in ballast water. Many of these species slip quietly and unnoticed into our marine systems, forming small populations that do not interfere with the ecosystem. However, some species cause dramatic changes and threaten entire habitat types, and some cause toxic algal blooms that threaten oyster and mussel fisheries and the health of those who eat affected shellfish.

The Northern Pacific Seastar (*Asterias amurensis*) and the Giant Fanworm (*Sabella spallanzanii*) are having a major effect on waters on our southern coastline. The exotic Seastar eats oysters, mussels and other sedentary species. The Fanworm is a filter feeder, but covers existing habitat to the exclusion of other species living on the sea floor.

In 1999, specimens of the Black Striped Mussel (*Mytilopsis sallei*) were found in three marinas in Darwin Harbour during a harbour resurvey. Having witnessed the

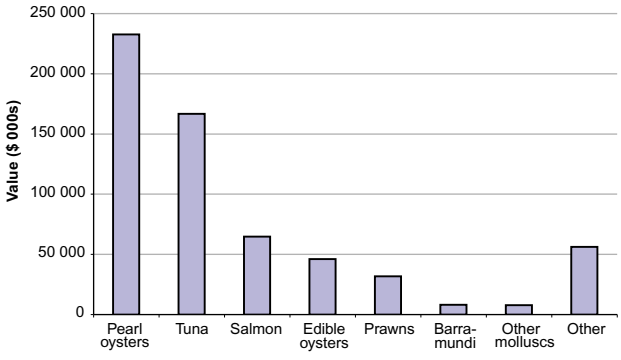


Figure 14: Value of aquaculture sectors.

Source: O'Sullivan and Dobson (2000).

The fouling caused by Black Striped Mussels.

Source: Centre for Introduced Marine Pests, CSIRO Marine Research.

ecological and financial disaster caused in the Great Lakes region of North America by its near relative the Zebra Mussel (*Dreissena polymorpha*), the Northern Territory and Commonwealth governments mounted a major effort to eradicate this pest. The effort involved 300 people and cost $2.2 million, but was successful and is thought to be the first eradication of a population of a marine pest species.

The Consultative Committee on Introduced Marine Pest Emergencies was established in 2000, and a program of port survey is underway through the Australian Association of Ports and Marine Authorities and the CSIRO Centre for Research on Introduced Marine Pests. However, these surveys are not yet organised as a routine, repeated procedure across all ports.

Concerns about translocated organisms extend beyond ballast water transport. Exotic organisms may enter Australian waters on the outside of ship hulls (hull fouling) or through trans-shipment of live or frozen seafood products. Quarantine restrictions apply to normal importation of products and some products are excluded on the basis of risk assessments. There is no restriction on movement of the hundreds of species that are attached to ship hulls.

The largest recorded fish kill in Australian waters occurred in southern Australia between late 1998 and early 1999. Dead pilchards on the south coast of Western Australia were estimated at 28 000 t. The origin of the infectious agent that caused the massive kill is still unknown although scientists have hypothesised that the herpes virus may have been introduced via ballast water, seabirds or imported baitfish.

Trend: Introduced marine pests

Pest species are continuing to cause deterioration of habitats and species; the risk of new introductions is constant and significant, while responses have been adequate in most respects.

Marine industry development

Australia is an island that depends heavily on shipping, and the infrastructure for this industry includes ports and navigation channels that require dredging. Disposal of the dredged material can be of concern to environmental regulators. In 1998, guidelines to assist applicants for dumping permits were released and the Commonwealth government has updated appropriate legislation.

Antifouling paint is, by definition, toxic to animals and plants. The phasing out of tributyl tin (TBT), the most common antifoulant, is still some years away. Concern over its effect remains high. In late 2000, a container ship was grounded on Sudbury Reef near Cairns,

and left a thick coating of antifouling paint on the seabed. Since then, a major cleanup program has removed paint flakes from 1500 square metres to allow more rapid recovery of the coral reef.

The possibility of oil spills in offshore waters remains a concern and four incidents with environmental effects have been recorded in the past six years. In 1999 in Sydney Harbour, 250 to 300 t of light crude oil were spilled during a cargo transfer, harbour foreshores were affected by oiling and people were affected by the odours. Since that incident, all vessels carrying oil are protected by a boom while in port. While the ocean can disperse oil, the visual effect of oil spills may be more problematic than their overall environmental impact. Offshore oil drilling effects have been restricted to the local impact of drill cuttings and drilling muds deposited adjacent to wells.

As knowledge of our marine biodiversity increases, the prospects for discovering biologically active compounds have also grown. Some useful molecules have already been discovered. Corals contain chemicals that are natural sun-blockers. Sponges and other sedentary plants and animals have chemical defence mechanisms that may find application as human drugs and herbicides. There have been concerns that discovery of a valuable compound may lead to overharvesting of the organism concerned. Current biodiscovery programs emphasise the need to protect natural biodiversity and synthesise, or grow by aquaculture, any valuable molecules or organisms rather than harvest them from the wild.

The largest recorded fish kill (pilchards) in Australian waters.

Source: South Australian Research and Development Institute (Aquatic Systems).

Marine resource management

There are some 80 international agreements relating to the use of the oceans, and half of them relate to managing the marine environment, including fisheries. Some prominent ones include the UN Convention on the Law of the Sea 1980, the Convention on the Conservation of Antarctic Marine Living Resources 1980, the MARPOL Convention and the World Heritage Convention.

Rights of Indigenous peoples to the use of marine resources have been acknowledged in several court decisions relating to harvesting of traditional food species, and in legislation in the case of Torres Strait Islander use of the marine environment. The High Court decision establishes that the *Native Title Act 1993* recognises native title rights in relation to the territorial sea. The decision also establishes the primacy of the public rights to fish and navigate. (*The Commonwealth v Yarmirr, Yarmirr v Northern Territory* [2001] HCA 56).

Australia's Oceans Policy was released by the Commonwealth government in 1998, the International Year of the Ocean. This policy includes support for some innovative approaches to integrated oceans management, including the concept of regional marine plans. These acknowledge the need to take an ecosystem approach to natural resource management, striking a balance between environmental, economic and social objectives.

Australia has continued to pursue the establishment of MPAs. There are now about 194 protected areas covering 60 million hectares. Since 1996, 17.6 million hectares of marine reserves have been added to the reserve system in both state and Commonwealth-managed waters. Progress has been made in planning in most states, and declarations of new protected areas have been made in the Great Australian Bight, Macquarie Island, Solitary Islands, Jervis Bay, Lord Howe Island, Tasmanian Seamounts, extensions to the Great Barrier Reef Marine Park and Cartier Island. However, it is the implementation of management plans that will determine whether ecosystems and threatened species will benefit from the establishment of MPAs.

Trend: Marine resource management

There has been a very slow improvement in the state of marine resource management, pressures have remained constant and responses have been adequate in some respects.

Ecosystem-based management is ill-defined at the operational level of management but nevertheless creates a framework for policy development and decision making. Its key attribute is the recognition that the effects of any activity in a region should be assessed in light of the linkages and interdependencies within the whole ecosystem. A good example is Integrated Coastal Zone Management. This aims to overcome the fragmentation of management arrangements and the 'tyranny of small decisions' that lead to incremental degradation through the negative effects of many small decisions that seem, on their own, inconsequential. This principle is being embraced by some states in their coastal policy or strategy and being reinforced by proactive coastal councils (e.g. in Victoria and NSW).

Catchment management is a key response, and this has been recognised in most parts of Australia, and in all tiers of government. Implementation requires community involvement, cooperation of industries and governments, and alignment of regulatory regimes between Commonwealth, state and local government. There is still no nationally applicable coastal zone policy, and delivery of effective catchment management across all jurisdictions is still some way off.

The Coasts and Clean Seas Initiative of the Natural Heritage Trust (NHT) (see http://www.nht.gov.au), comprises 11 major programs. For example, the Coastcare program has funded over 1750 projects involving restoration of habitats, development of local management plans, education and training. How these programs will evolve under the Extension to the Natural Heritage Trust remains unresolved.

Conclusion

Where human settlement and land use is light, Australian coastal waters are often in excellent condition. However, in some areas there is threat of, and actual loss of, shallow marine and coastal habitats through poor catchment management and development, and invasive species such as the Northern Pacific Seastar and the Giant Fanworm, and tropical pasture grasses in coastal lagoons in the north. Landowners, when land use is poor, are often unaware or apathetic of the downstream consequences. The damaging effects of acid soil runoff in some estuaries is a good example of both negative downstream consequences, and of how improving land use practices can remedy the problems.

Mechanisms for resource allocation remain poorly developed in most areas among commercial, recreational and Indigenous users of fisheries resources (e.g. the allocation of fishing rights). As the national capacity to measure use of these resources is poor, it is difficult to assess the achievement of equitable allocations and sustainable use. Measurement of resource use is most advanced for the commercial fishing sector.

How much information is readily available on the general state of the coasts and oceans environment? Unfortunately, not much, and it is 'nobody's job' to coordinate and deliver such information. An effective institutional solution would require specific resourcing and a mandate, and would probably involve Commonwealth, state and territory organisations, possibly through a Ministerial Council.

SoE (2001) has shown that developing indicators is necessary but not sufficient. Many of the important indicators require a national approach to the development of data collection and reporting systems, which is yet to occur. The effort to gather and publish high quality information on the state of the coastal and marine environment should be continuous and be integrated through the Commonwealth, state and territory, and local governments.

Land

The word 'land' carries strong emotional overtones. Land is territory; it is what peoples and nations have always fought for. Land means food, security, wealth and power. Societies have a powerful need to feel and express a sense of place in the art, song, poems, pictures and fables of their culture.

At the end of its first century of federation, Australia is in the process of redefining its cultural identity through changing attitudes to land and landscapes. Nowhere is this more evident than in the increased recognition of the significance of what land means to Indigenous Australians since the passing of the *Native Title Act 1993*.

In many parts of Australia, the historical predominance of agriculture as the economic driver and user of land, water and vegetation is being challenged by new economic activities and different values. Native title rights, service industries, tourism and recreation are already important. However, emerging new attitudes are placing increased value on landscape

Table 9: Summary of geomorphic and biological natural processes and parallel human interventions

Geomorphic processes	Human interventions	Biological processes	Human interventions
Wind erosion-deposition	Clearing, overgrazing, cultivation	Carbon cycling	Fossil fuel burning, vegetation planting and clearing, cultivation, animal herding, grazing
Water erosion-deposition	Clearing, overgrazing, cultivation	Nutrient cycling	Manufacturing, fertiliser additions, vegetation changes, animal herding, cropping, bacterial manipulation
Chemical weathering	Altered hydrological regime, changed vegetation types, fertiliser use	Essential nutrient cycling (P, K, S, Ca, Fe, Mg, Mn, Zn, Cu, Co, Se, Mo and B)	Vegetation planting and clearing, animal herding and grazing, manufacturing, mining, landfill and wastes
Mechanical weathering	Surface soil changes (mulches, loss of cover)	Chlorophyll production	Plant domestication, change to plant organs, grass, cereal and crop monocultures, synchronous ripening
Fluvial processes	Dams, weirs, levees, canals, drains	Carbon reducers (soil biota)	Clearing of litter and top soil, fertilisation of farm soils, N and P microfloral inoculations
Fire	Deliberate firing for grass production, forest and human property protection and ecological management, and arson	Carnivorous consumers (humans and carnivores)	Exotic herbivores cultivated, permanent vegetation changes, reduction in non-human predators

Source: after Hamblin (1998).

aesthetics, water quality, native vegetation and fauna. At the beginning of the 21st century, Australia is a continent in transition.

The three levels of government in Australia have traditional roles in land management. These roles have evolved and changed as Australia's constitution has been tested and interpreted over the last 30 years. Today, Australia is at a threshold as the states and the Commonwealth come to terms with the necessity to manage our continent at local and regional scales for continental outcomes. The EPBC Act has set the stage and this report is presented as the NAP for Salinity and Water Quality is being put in place (see the *Inland Waters* thematic findings section on page 57).

In considering the condition of land, there are six key issues, also discussed below:

- accelerated erosion
- altered habitats
- invasive species
- secondary salinity and acidity
- nutrient and carbon cycling
- soil and land pollution.

A summary is presented in *Key findings* (page 6).

SoE land indicators were developed to reflect the extent to which ecosystem functions are maintained (Hamblin 1998). Six geomorphic and biological processes that support such functions have been used as criteria (Table 9). Threatening processes are interpreted as those processes of human origin that distort or disrupt natural processes (see http://www.ea.gov.au/biodiversity/threatened/tssc.html). Much of the terrestrial biodiversity of Australia depends heavily on landscape function and integrity (see the *Biodiversity* theme report). For this reason, SoE (2001) focuses more on the functioning of ecosystem processes and the services that ecosystems provide than did SoE (1996).

SoE (2001) attempts to understand how well ecosystem integrity and function are being maintained in Australia. However, the responses to the condition of our lands depend on the value system of that society. Also the evaluation of condition is itself value-laden, implying as it does a specified end use.

This section can be divided into two: a snapshot of the continent and a review of the six issues. Where conditions are improving at the continental scale, the influence of better seasons has been the greatest influence. Elsewhere, conditions are often deteriorating because the scale is so large and the resources that can be brought to bear are inadequate. Pressures are tending to increase in most cases. This occurs because of increasing economic activity, greater population pressures, inappropriate land uses and lack of resources to counteract long-term persistent pressures. However, government and community responses are increasing in

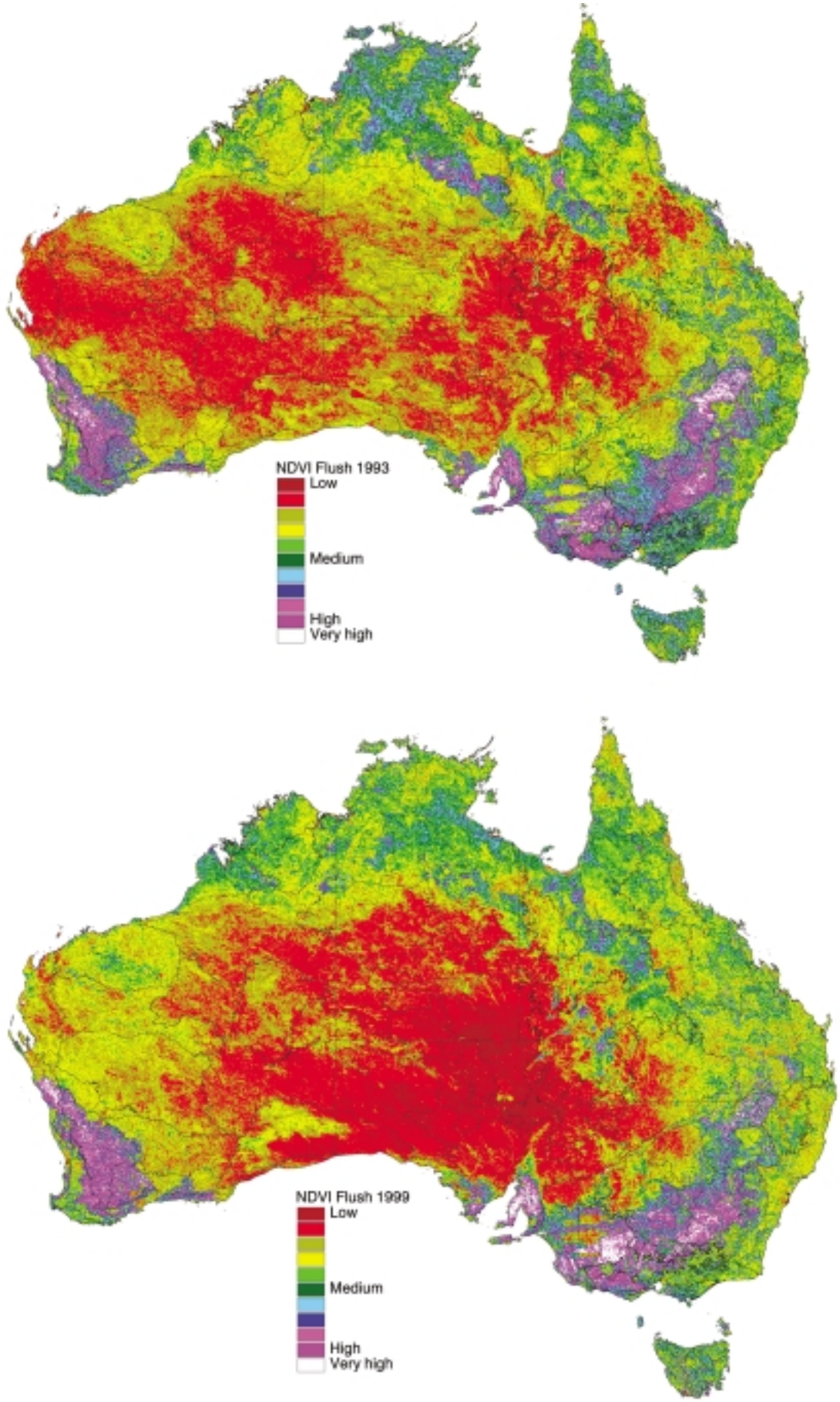


Figure 15: NOAA images of 'flush difference' for 1993–94 and 1989–99 showing the difference in amount of seasonal greening between El Niño and La Niña years, respectively.

Source: Environment Australia (2001) using National Oceanic and Atmospheric Administration (NOAA) data.

number. In many cases, these responses are more relevant than a decade ago, but in some, the responses are not consistent, and have conflicting results.

Snapshot of the continent

Variable seasonality drives Australian ecosystems. The website of the Environment Resource Information Network (ERIN) provides a satellite view of the alternating but erratic flushes of green and brown that is Australia (Figure 15) (see http://www.ea.gov.au/land/monitoring/index.html).

Since SoE (1996), Australia's land ecosystems have had less arid seasons than the first half of the decade, culminating in a very wet (La Niña) period in 1999 to 2000 (see the *Atmosphere* thematic findings). As a result of good rainfalls, many parts of the arid interior have more vegetation growth than at any time in the previous decade. In the central and southern interior, this has been further assisted by the up to 90% reductions in rabbit numbers following the escape and natural spread of rabbit calicivirus in 1995. In parts of the two-thirds of the continent that are used for grazing, there has also been some reduction in total grazing pressure following the drop in sheep numbers in response to low wool prices.

Regionally, there have been big differences in the net effect of rainfall, total grazing pressures, clearing, effect of fire and vegetation growth. Much of Queensland is still recovering very slowly from the effects of low seasonal rainfall between 1991 and 1994. Over the same period, western and much of southern Australia were little affected by low rainfall in the early 1990s and differences in vegetation growth have been smaller over the decade. However, in 2001, south-west Western Australia is experiencing an exceptionally dry period.

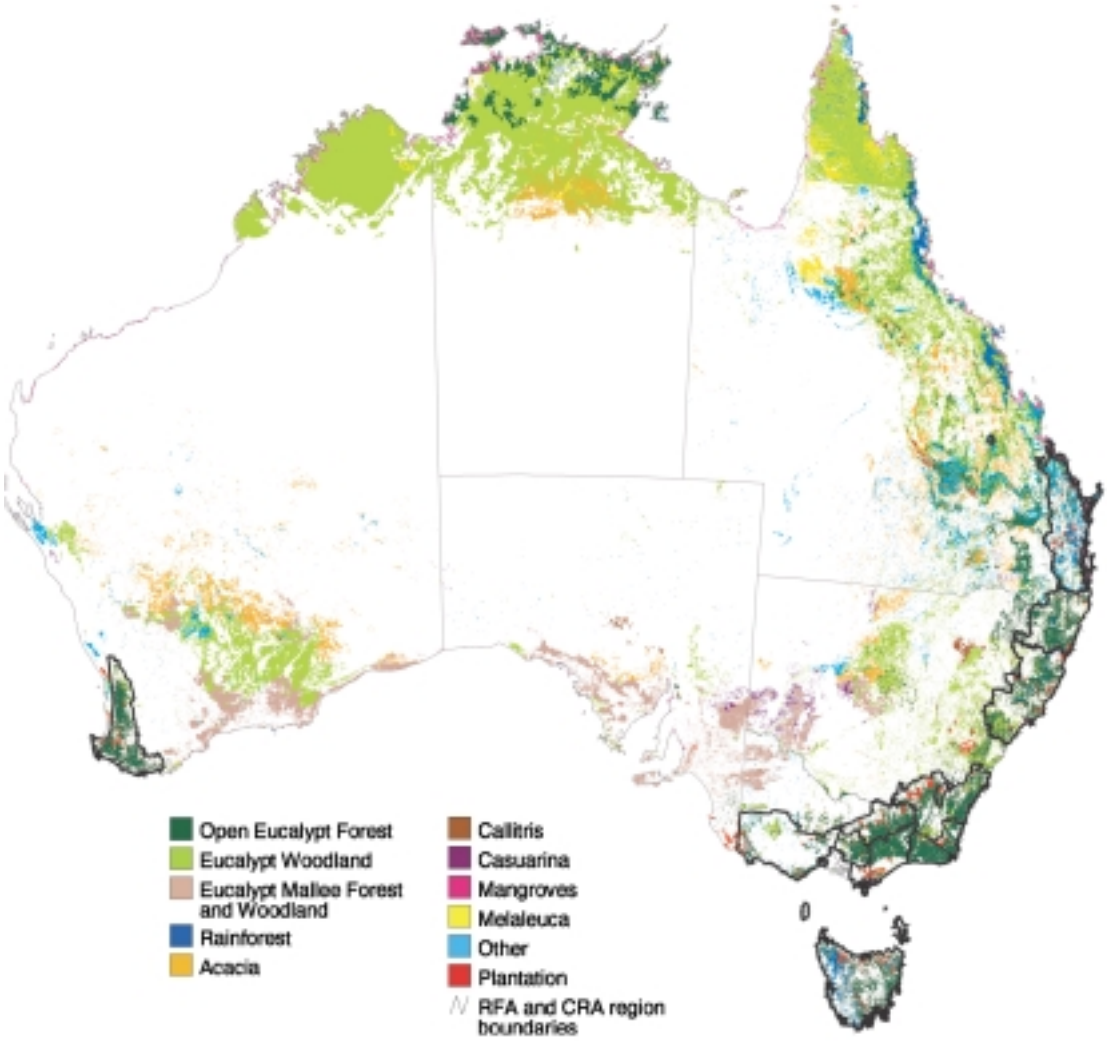


Figure 16: **Location of forests, according to type, showing regions covered by RFAs.**

Source: National Forest Inventory (2000).

Agricultural holdings continue to influence 61% of Australia. Depending on the season, between 20 and 25 million hectares are sown to crops, and 94 million hectares of improved pastures are grazed (35 million hectares are sown to introduced legumes and grasses). There has been no clear trend in proportional land use, but annual fluctuations reflect changes in commodity prices, seasonal conditions and options for diversification. In the rangelands, however, there has been only a very small reduction of 3.7 million hectares (or 1.4%) in the total area of grazed leases.

Other land use changes have been similarly conservative, apart from an increase in the proportion of old-growth forests that have been added to the conservation estate. Australia has 16% of its 164 million hectares classified as native forest, set aside (Figure 16) in conservation reserves.

In response to both government and market forces, there has been an increase (30 000–90 000 ha/y) in new tree plantations. A net loss of native trees and woody species has continued, with probably more than 1.2 million hectares cleared over the past five years (1995–2000). However, estimates of tree loss for 1997 to 2000 are varied depending on the method of estimation. Knowing how much clearing is actually occurring is hugely problematic. The most reliable figures are provided by state and Commonwealth research agencies using remotely sensed data of tree cover changes adjusted for fire and drought. Despite this, conservation organisations continue to use licence permit numbers adjusted on past years whereas the Australian Bureau of Agricultural Resource and Economics (ABARE) uses surveys to ask landholders for area cleared. There is a pressing need to establish agreed national standards for measurement of land cover changes.

Since 1997, there has been substantial government investment in Landcare and Bushcare programs funded under the NHT. Landholders and community groups plant many millions of trees annually. In 1999, more than 80% of farmers said they had participated in some type of Landcare activity. However, the effect of this massive volunteer effort is still relatively small and the beneficial effects will not become apparent for a long time. The scale, both temporally and spatially, of the problems dwarf the noble efforts of the volunteers.

Intensification in land use is characteristic across most of the more densely settled regions of Australia. This has been formally characterised for state of the environment reporting purposes in a suite of indices for degrees of disturbance. The initial map coverage (in SoE 1996) has been progressively revised, and today less than half of the continent has a level of naturalness equivalent to that of pre-European occupation. In Victoria, less than 5% of the land is in this category, and Tasmania, often considered a wilderness destination for trekkers, has only 35% of land classed as remote and highly natural.

Key issues

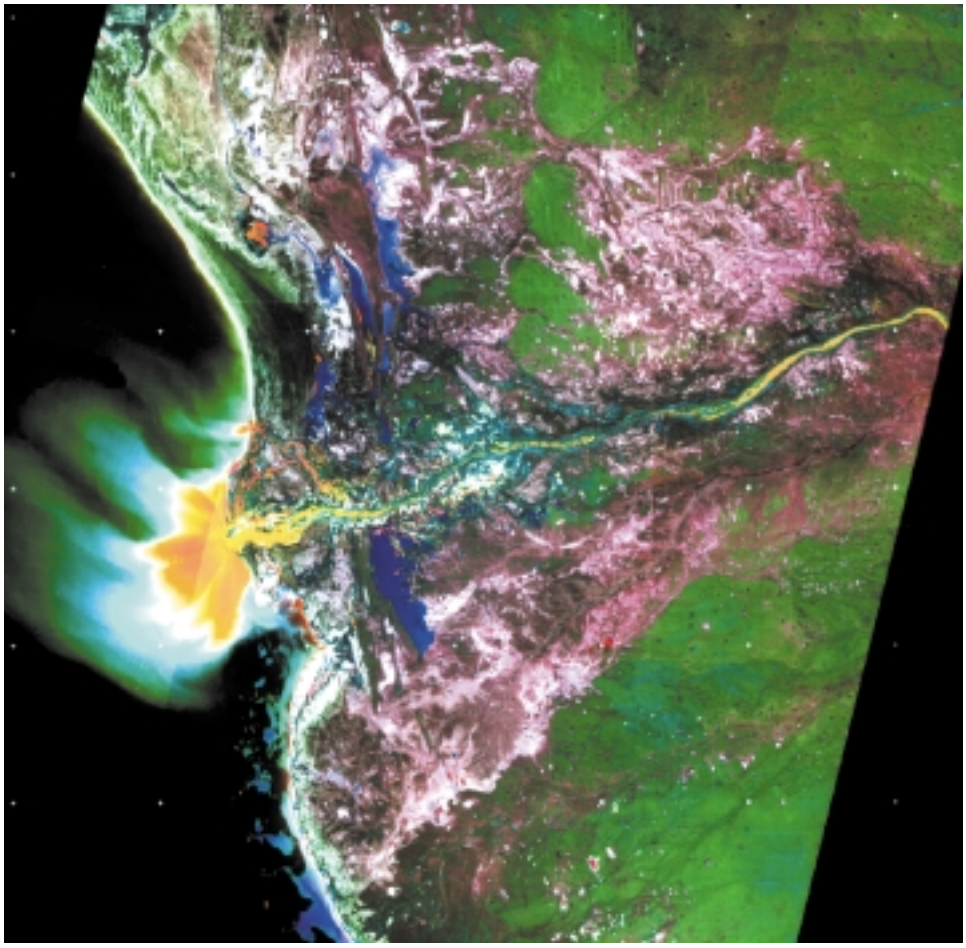
In SoE (1996), it was not possible to set baselines in many instances. However, there is sufficient information from that Report and other sources for SoE (2001) to assess whether there are any detectable trends for significant issues. No previous estimates are available for land pollution, and much of what is available is preliminary.

'Condition' indicators for land depend upon the prevailing seasonal conditions. Consequently, short-term changes in condition must not be interpreted as longer term trends, unless there are good historical data or modelling. Trends in social responses and, to some extent trends in human pressures, can be verified over shorter times.

Accelerated erosion

Since 1996, over 66% of grain farmers have adopted some form of minimum tillage, direct drilling and stubble retention for at least some of their crops. Membership of Landcare groups has increased steadily. Current activities, however, cannot halt or quickly restore the extensive land degradation that has occurred. Many of these problems had their origin in the late 19th and early 20th century when the effects of overgrazing, exacerbated by severe droughts in the 1890s to 1900s, had a severe but not well-recorded impact. In Western Australia, New South Wales and Queensland, land degradation was accelerated by further extensive clearing after World War II. Secondary salinity becomes apparent only after lag phases of between 15 years (sandy regions of Western Australia) and 150 years (dense clays in riverine plains of the Murray–Darling Basin).

Although accelerated soil erosion (i.e. above that expected from natural erosion) continues to affect much of the arid interior and northern regions, 1995 to 2000 has seen some significant improvements (Figure 17). This is particularly marked where pastoral grazing



Satellite image of sediment plume extending 50 km from the mouth of the Gascoyne River two weeks after a major cyclone.

SPOT image of 2 March 1995 showing the sediment plume from the flooding Gascoyne River, WA. Seriously degraded inland areas can also be seen in this image.

Source: WA Department of Land Administration, Remote Sensing Services.

management has been modified to allow natural restoration to take place. However, accelerated erosion continues to occur through the action of intensive storm events, with much of the erosion taking place in first-order streams that crisscross paddocks rather than in the more vegetated, larger stream channels.

Wind erosion remains a persistent feature of sandy soil crop lands, such as the Western Australian wheatbelt and in the mallee. The degraded mulga lands of south-west Queensland, western New South Wales, South Australia and south-east Northern Territory continue to be a source of windblown dust to southern and eastern Australia (Figure 18).

Findings from recent data in Lu et al. (2001) show that the extent of land decline by erosion is not as severe as estimated. However, the effects of hydrological imbalance and consequential salinity on the landscape are a cause of concern.

Trend: Accelerated erosion

Pressures are reducing, condition is improving and response is variable.

Altered habitats

People living in Australia's urban, southern and coastal regions continue to become concerned about a 'fragile and often degraded environment'. In these regions, the traditional pre-eminence of agricultural and mining land uses has been replaced by the competitive demand for urban land, tourism, recreation, aquaculture, service industries and retirement investments in rural-residential lifestyles.

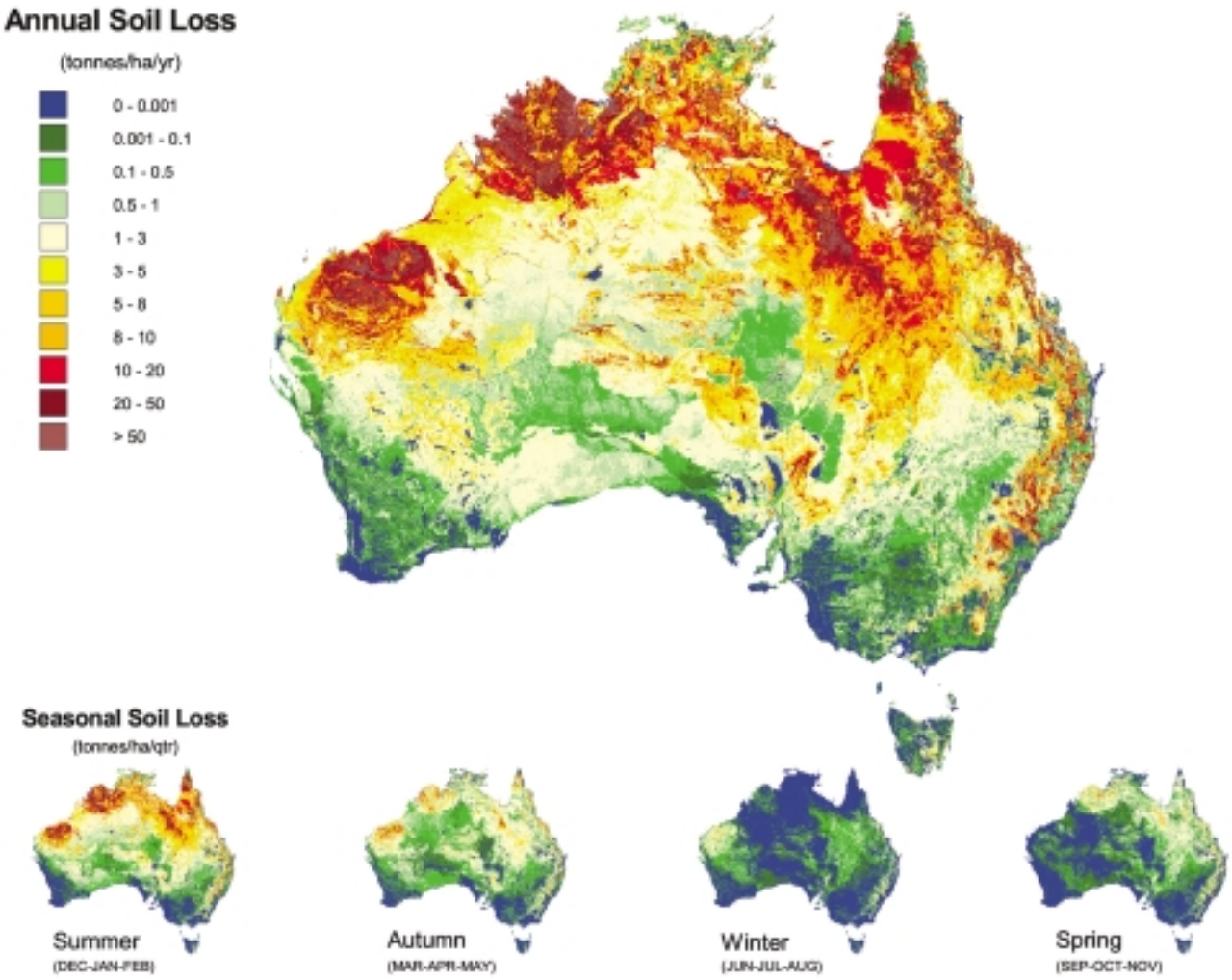


Figure 17: Estimates of continental sheet erosion based on 1997 land use distributions, 1990 to 1999 (normalised vegetation difference index, NDVI) seasonal greenness and rainfall regimes.

Source: Lu et al. (2001).

Throughout Australia, but particularly in the north and west, Indigenous interests in land have become a factor in land transactions. This has been through direct purchase of land and through native title and land rights processes. In northern Australia, increasing concern for biodiversity conservation is juxtaposed against those who still see the north as the last frontier of development opportunity.

Land use change has been rapid in areas where net migration of people to previously rural regions of coastal New South Wales and southern Queensland, and along the transport corridors from Melbourne to Sydney, has occurred at growth rates of over 5% over the period. In coastal Western Australia, south of Perth, the growth rate has been over 7% per annum. Elsewhere in rural Australia, people have migrated towards larger towns and coastal regions. Increases in population in some interior statistical local areas has occurred through expansion of mining and service industries. Projections for the present period (see *Human Settlements* theme report) show these trends increasing.

Fragmentation of native habitats is increasing in the areas of rapid population growth, with variable responses from local and state planning authorities. Some coastal environments have been increasingly protected by the creation of national parks and reserves, with 63% of Victoria, 33% of New South Wales and 25% of Queensland coasts now protected. Since 1995, 60 000 hectares have been added to New South Wales coastal parks. In addition, 96% of the Victorian coast is publicly owned, and a consent process for coastal Crown land provides an opportunity for governments to ensure appropriate use and development.

Forested regions have been the focus of new management arrangements under RFAs in Tasmania, Victoria, south-west Western Australia, east coast of New South Wales and parts of south-east Queensland (see http://www.rfa.gov.au/).

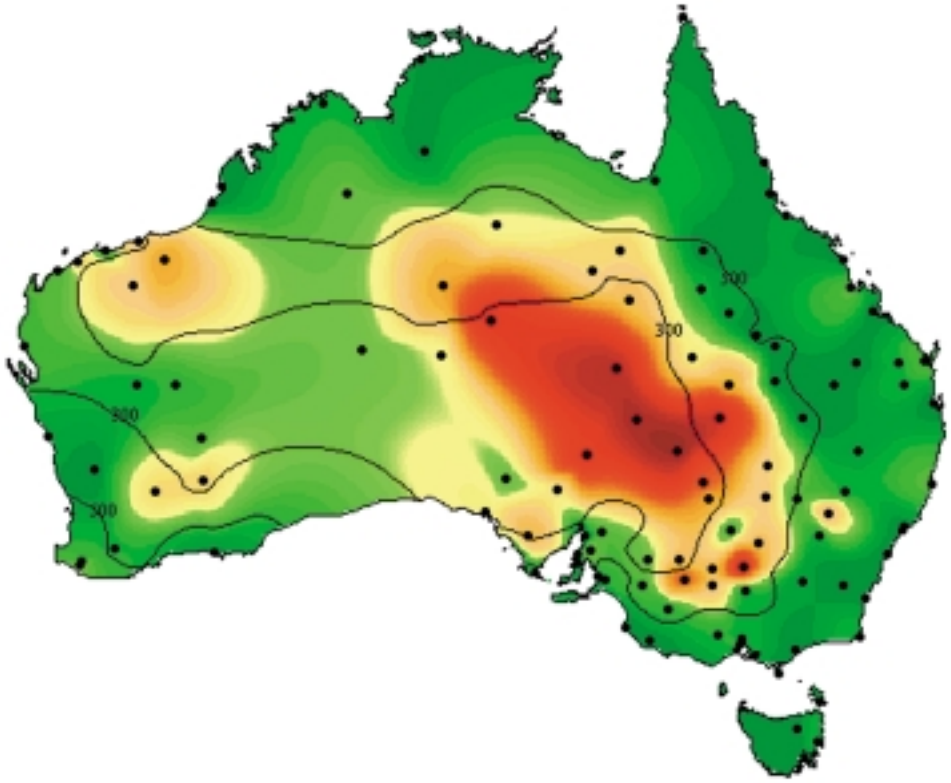


Figure 18: Dust storm index with 300 and 500 mm median rainfall lines, and accelerated erosion index for 1996 to 1999.

Source: McTainsh et al. (2001).

Surveys indicate that there is an increasing diversity of attitudes to land and to trees in the landscape. Farmers themselves plant or conserve trees on farms primarily for shade, environmental conservation or land rehabilitation, not for commercial purposes. Landcare group membership has had a strong effect on farmer attitudes to farm trees.

Trend: Altered habitats

Pressure is constant or increasing, condition is deteriorating and response is improving.

Invasive species

Although the geological and geographical isolation has endowed Australia with a unique and highly endemic biota, it has also made the continent's flora and fauna particularly susceptible to the effect of invasive species. During the 1990s, mounting air and sea traffic has increasingly challenged the Australian Quarantine Inspection Service (AQIS). Over 220 incursions have been reported, a further 90 species already arrived have spread to other states, while another 110 species initially detected and eradicated have been re-reported and need re-eradication. The eradication of the Fire Ant in Queensland, for example, is expected to cost $123 million.

Since 1996, the proliferation of Internet trading has added to the problem of introductions (e.g. seeds can now be ordered over the Internet and posted to Australia). The recent outbreak of foot-and-mouth disease in the United Kingdom has demonstrated the potential catastrophic effect of the incursion of an exotic disease. In response, the Commonwealth government has increased funding to AQIS to improve surveillance of incoming passengers and goods.

Australia has insufficient resources to tackle even those species of identified national significance, let alone the threat from new incursions, and spreads of 'sleepers' or existing known problems (e.g. Diamondback Moth, *Phytophthora* spp., Western Flower Thrips—which all attack hundreds of endemic species). The risk assessment protocols, strategies for containment are all very weak for exotic threats in non-agricultural species.

Dieback-affected native vegetation in south-west Western Australia.

Source: Environment Australia.

Trend: Invasive species

Pressures are constant or increasing, condition is deteriorating and response is constant or increasing.

Secondary salinity and acidity

In many regions, land managers today are paying the costs of land remediation as well as paying the conversion costs associated with more sustainable practices. Since 1996, for example, it is estimated that an additional 0.5 million hectares of secondary salinity has become evident with the common cause being hydrological imbalance. The National Land and Water Resources Audit (NLWRA 2001a) has indicated that 5.7 million hectares are at risk from salinity. This area could increase to 17 million hectares by 2050 (Figure 19). A major challenge is to develop agricultural systems that, as a minimum, restore hydrological balance (see *Drowning in a Dry Landscape* box on page 13).

Since 1991, the area of soils affected by acidification has increased by an estimated 13 million hectares. This has occurred because of draining of coastal acid sulfate soils and from the continued acidification of agricultural soils. Acidification could be halted with lime applications, but these are uneconomic for landholders faced with very low returns from extensive animal farming.

A similar situation occurs with sodic soils (heavy soils with a large amount of sodium in their clay), which swell and disperse in water. Such soils occupy nearly one-third of Australia. When used for agriculture, they infiltrate rain very slowly, and plant growth is restricted by both lack of water and high pH. These soils improve in structure when they are conditioned with gypsum, yet the amount of gypsum applied is similarly small relative to the extent of potential benefit. Integration of agricultural land management and conservation management into landscape management is complex. The mining of soil conditioners such as lime and gypsum can cause environmental problems where these materials are located in areas of high biodiversity value.

Trend: Secondary salinity and acidity

Pressures are constant or increasing, condition is deteriorating and response is increasing (salinity only).

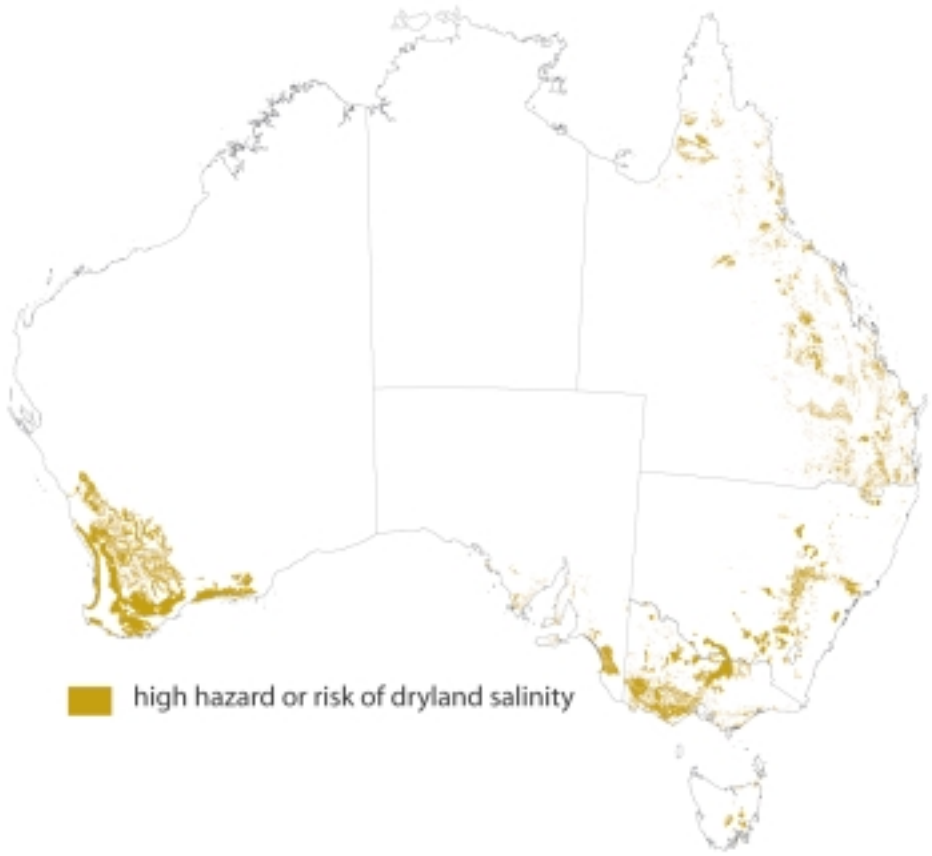


Figure 19: Forecasted areas of high risk (predicted) or hazard (estimated) of dryland salinity by 2050 in Australia.
Source: NLWRA (2001a).

Nutrient and carbon cycling

Fertiliser consumption has risen over the past two decades as farmers have altered agricultural production in response to the cost-price squeeze. Strategies for increasing the returns from agriculture include increasing yield per area, increasing the value of the product (e.g. from a low protein to high protein grain), changing the product to one of greater value (e.g. canola and grain legumes rather than barley or wheat), and developing controlled environment systems (glasshouses, intensive animal units, irrigated fruit and vegetables).

Nearly all such steps require higher use of fertilisers, pesticides, water and labour; they are much more demanding in terms of the management skills required. Horticultural crop production has more than doubled from a farm-gate value of $2.0 billion in 1987–88 to an estimated $5.1 billion in 1998–99.

Most improved pastures received annual dressings of phosphate fertilisers well into the 1970s and 1980s, but have had lower applications in the 1990s because of the lower returns from grazing industries. The phosphate bank built up in many such soils remains although it may not be available to plants. Soils are now often nutritionally deficient in potash and nitrogen. Low nutrient replenishment is as much a concern as overuse of fertilisers.

Fertiliser use increases the potential for nutrients to move through the landscape and enter coastal and inland water systems. This is a particular problem where soil erosion occurs and soil particles containing nutrients are mobilised. When combined with point-source pollution, this is a major concern (see the *Inland Waters* and *Coasts and Oceans* theme reports).

In 1998, when Australia became a signatory to the Kyoto Protocol, the reason for identifying gains and losses of carbon in landscapes became more urgent. The AGO is developing techniques to monitor woody and soil carbon through the use of geographical information system (GIS) remote sensing. This may provide sufficient data through a modelling approach on the result of land clearing in the 1990s.

Most Australian cropping soils have probably lost about half their original topsoil organic matter through repeated cultivation and resultant oxidation of organic materials. However, although it may be possible to reverse the decline in soil organic matter, the achievement of such a change depends on institutional, economic and social factors.

Typical patchwork of land uses across mid-rainfall regions of eastern Australia.

Source: A Hamblin.

Trend: Nutrient and carbon cycling

Pressures are constant or increasing, condition is static and response is increasing (carbon).

Soil and land pollution

Contamination can be separated into point sources and dispersed sources. Point sources are where pollution is focused (e.g. around a mine, factory, treatment works or intensive animal unit). Dispersed (or diffuse) sources are where chemicals have been widely dispersed across the landscape and are subsequently mobilised. From July 1998, industrial facilities using more than a specified threshold for fossil fuel combustion, specified chemicals, or total nitrogen and phosphorus emissions have been required to monitor and report to the National Pollutant Inventory (NPI). Thirty-six substances were selected for reporting in 1998 to 2001, and 90 substances have been selected for initial monitoring from 2001. Although the NPI as yet has only limited data, most emissions being monitored are released into the atmosphere, while only 5% are discharged to land. The most significant problems associated with land emissions are those that are likely either to move into groundwater and streams. These include petroleum-derived polycyclic hydrocarbons, heavy metals and acid soluble metal salts. Animal waste effluents from intensive feedlots, abattoirs and dairying activities are not yet all covered by NPI guidelines. Dairy produce factories are required to report emissions from 1999–2000 if reporting thresholds are exceeded. Agricultural activities such as irrigation, crop production, intensive animal grazing and other primary extraction processes such as logging are not covered by the NPI process.

Australia uses much lower levels of pesticides and fertilisers than other OECD countries (e.g. from the 1970s, average fertiliser use was one-tenth the amount in the UK). Environmental contamination from such pollutants is also less than in comparable developed countries. One view is that very low levels of agricultural subsidies in Australia has kept the use of agrichemicals efficient, compared with other OECD countries, where the average level of subsidy was 40% compared with Australia at 9%, and New Zealand, 4%. Australia also has more than 7.5 million hectares under organic management.

Since 1996, there have been several concerted actions to reduce agrichemical use in the horticultural, cotton, grain and sugar cane industries. Many weeds have become resistant to herbicides and some insects to insecticides (e.g. resistance of the Cotton Bollworm, *Helicoverpa armigera*). Integrated pest management, with less reliance on a single group of

Norwich Park mine in the Bowen Basin.

Source: BHP.

chemicals, and more reliance on suitable cultural practices, is now widely used. The use of genetically modified BT cotton has enabled substantial reductions in insecticide use, although the environmental effects of the use of such materials are not fully understood.

Total pesticide expenditure has grown from $670 million in 1995 to $920 million in 1999. This increase has been mostly for weed control, but dollars do not necessarily reflect their impact. Most new generation chemicals are so biologically potent that they need to be applied in a targeted manner at low rates. They are, however, between two and 10 times more costly than out-of-patent compounds. The rise in expenditure does not mean that the total amount of pesticides in the environment has increased.

Many of Australia's environments are little affected by pesticides. This single factor should be substantiated and used positively when marketing our goods as 'clean and green'. For those rural industries where pesticide use is heavy (and remains so to maintain levels of productivity and profitability), the most effective action is to provide the documentation on usage.

The number of pesticide violations in fresh food products is now almost nil in every category, according to the National Office of Food Safety. In addition, most agricultural land, comprising 90 million hectares of rough pasture and 442 million hectares of rangeland, has never had any pesticides applied other than for occasional locust control. However, environmental monitoring programs have found pesticide residues in surface water in regions associated with summer cropping.

There is a lack of a data on contaminated sites including industrial, urban, rural processing and orphan sites (i.e. where ownership and responsibility for remediation of a site is not clear) other than mining. The location of past contaminated sites and their management is a 'grey' area: regulation of small and medium enterprises that fall outside NPI are not well documented. In addition, a lack of scientific knowledge of effects on biota and pathways to groundwater and other water bodies still hampers monitoring and regulation. The cost of clean-up is often inhibitory except where high visibility leads to political pressure.

Trend: Soil and land pollution

No trends are assessable, no previous data are available for pressures, the condition is variable (some are improving, some unknown) and the response is increasing from a low base.

Conclusion

Since 1996, the pressures on Australia's landscapes have intensified and the condition of Australia's lands continues to deteriorate. The response, however, is gaining momentum, although it is too early to know if this growing response will result in a progressive improvement in land condition.

Inland waters

Water is a critical factor that has shaped the development of Australia. It is scarce in many parts of Australia, yet it is in increasing demand. Some of our water resources are becoming unusable as a result of past and current mismanagement. Australia's inland waters, as well as providing water for human uses (e.g. irrigation and drinking water), provide a diverse range of habitats for many unique native aquatic plants and animals and are important for the survival of many terrestrial species.

These key issues are not independent of each other. For example, increasing river salinity caused by dryland salinity can result in water becoming too saline for irrigation or drinking water and the death of riparian vegetation. In turn, the loss of riparian vegetation can increase the erosion of river banks which can in turn cause further deterioration in water quality and loss of aquatic species. This example highlights the important link between inland waters and their catchments. The health of inland waters often is directly related to land management practices and other human activities in their catchments. A challenge when managing water in Australia is unravelling the complexities of these linkages, which are often beyond the capacity of our management systems.

Another significant challenge in water management comes from our system of federalism where states and territories largely have the responsibility for water and catchment management. Each state and territory has different approaches to management, to defining environmental needs, and on deciding what is the acceptable health of an aquatic system. This is further complicated when a river, wetland or groundwater resource crosses state and territory boundaries. Cross border natural resource management authorities are striving to achieve more integrated processes and outcomes in the management of their respective inland waters and catchments. However, for some issues state or territory interests have overridden what is environmentally sustainable for the whole catchment.

The COAG Water Reform Framework aims to improve water management and to ensure that the extraction of water is sustainable. Governments have introduced a range of reforms to the water industry (see http://www.ea.gov.au/water/policy/coag.html). These have included charging for the full cost of supplying water, creating a market to allow the

Unstable stream banks resulting from clearing of riparian vegetation contributes to river silt loads.

Source: Robert Simpson.

The Paroo River is the last unregulated river in the Murray–Darling Basin.

Source: A Tatnell, Big Island Photographs.

reallocation of water to higher value crops or uses, and separating the regulatory and supply functions of water management agencies. Since 1996, there has been some progress in most states and territories. Reforms are not yet fully and equitably implemented, however. For example, users of urban water meet the environmental costs of urban water supply in most states and territories, but the costs of rural water generally do not account for the full environmental cost of extraction.

Successful examples of whole-of-catchment management include the management of the Lake Eyre Basin, part of Australia's arid zone that supports some unique ecosystems. The community decided that upstream–downstream tensions had to be managed effectively, and they established catchment committees that crossed state borders. The community and state agencies have been working together to manage river systems such as the Diamantina River and Cooper Creek (South Australia) in a more integrated way than has been achieved in the Murray–Darling Basin.

The Murray–Darling Basin covers most of inland south-eastern Australia. It includes much of the country's best farm land and nearly two million people. Outside the Basin another million people are heavily dependent on its water (http://www.mdbc.gov.au).

Australia's water resources are now better understood from integrated assessments undertaken by the NLWRA, SoE reporting programs, and state and territory water management agencies. Also since 1996, indicators for inland waters have been developed (see http://www.ea.gov.au/soe/envindicators/index.html and Appendix 2).

In considering the condition of our inland waters, there are three key issues, also discussed below:

- water resources
- water quality and pollutant sources
- aquatic ecosystems.

A summary is presented in *Key findings* (page 6).

Key issues

Water resources

Surface water resources

In an average year, after rainfall, about 391 700 gigalitres (GL) of water runs off Australia's catchments into rivers, streams and wetlands. The highest runoff occurs in northern Australia. As most runoff occurs after large rainfall events (e.g. rainfalls that cause flooding), only 32% of the total runoff can feasibly be pumped from rivers or stored in dams. Much of the water 'diverted' for human uses are the baseflows (see *Groundwater*) and low to moderate river flows

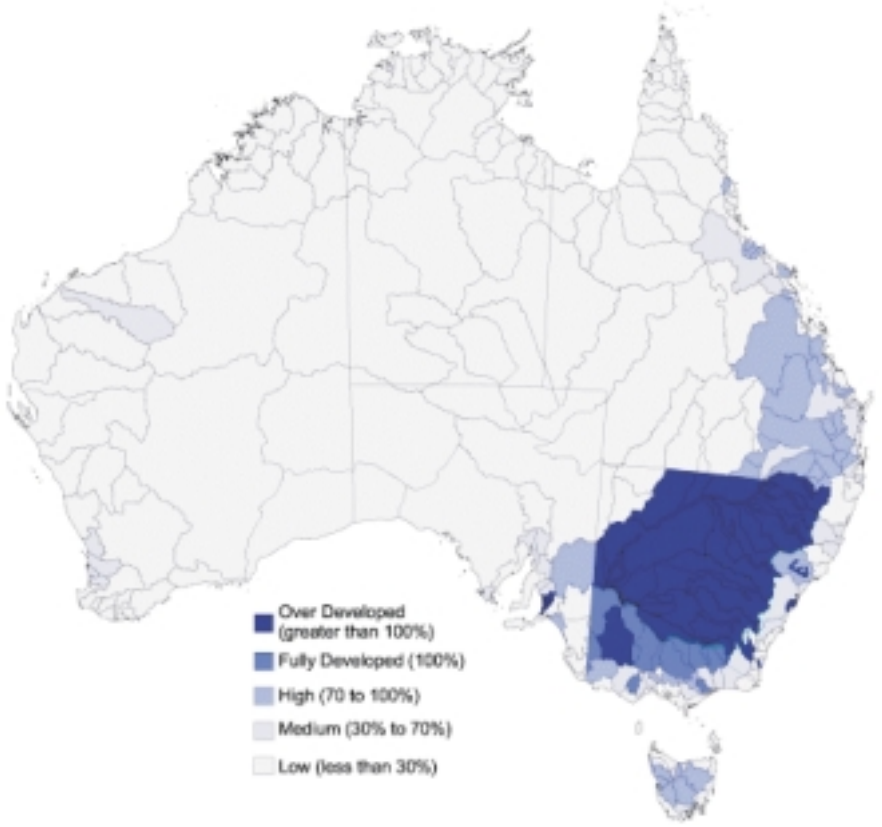


Figure 20: Indicative surface water development status.

Assessments were undertaken by the state and territory water resource management agencies. There are varying approaches to the assessment of sustainable flow regimes.

Source: NLWRA (2001b).

that are very important for river health. After considering environmental water needs, it has been estimated that only about 20% of Australia's total runoff can be sustainably 'diverted' for human uses. The water available for diversion or extraction may decrease if climate variability and change, such as the enhanced greenhouse effect, reduce rainfall and alter runoff patterns.

Only 7% of the total runoff from Australia's catchments can actually be diverted with the current system of dams, weirs, pumps and other infrastructure. Much of Australia's water resource development is concentrated in eastern and southern Australia, where many rivers have been dammed to provide secure access to water for agriculture and for urban areas. Although the construction of new government-funded dams has slowed over the past 20 years, there has been an increase in the number of large on-farm water storages that store water pumped from rivers and/or capture runoff from the land after rainfall.

About 26% of Australia's surface water management areas are close to or have exceeded sustainable extraction limits. However, this assessment is generally based on limited data and a limited understanding of what must be left in rivers to maintain their health. Many river systems in the Murray–Darling Basin and along the east coast of Australia are either overdeveloped or approach full development status (Figure 20). This indicates that that aquatic ecosystems in these river systems are under substantial pressure from water extraction, and the current level of extraction may not be sustainable over the long term. In contrast, the river systems and catchments of northern and western Australia have not been developed to the same extent, so the pressure on the aquatic ecosystems from water extraction in these areas is low. The river systems of northern and western Australia probably will be subject to increased pressure as these untapped water resources are developed for agriculture.

Where surface water is over-allocated (e.g. the Murray–Darling Basin) some states are attempting to reduce extraction. The increasing awareness of the value of water is leading to conflicts in how it should be allocated among different uses, including the maintenance of aquatic ecosystems. One mechanism in the Murray–Darling Basin is a Commonwealth and state/territory agreed limit on water extraction known as 'The Cap', developed after the 1995 audit of water use. The Cap is intended to hold the level of water extraction to that in 1993–94, and has certainly slowed the increase in water extraction. However, Queensland has not yet agreed to set their Cap levels, and New South Wales has not been able to keep

The Ord River dam.

The Ord River diversion dam in north-west Australia was completed and commercial-scale irrigation commenced in 1963. In 1972, the main dam was opened, providing a water storage capacity in Lake Argyle of 10.76 billion cubic metres, several times the capacity of Sydney Harbour.

Source: Cassia Read.

within the Cap in the Barwon River system. Capping extraction at 1993–94 levels may stop further deterioration, but will not be adequate to restore damaged river systems. The Cap may have to be reduced to halt the destruction of the Murray–Darling Basin inland river and wetland system.

Trend: Surface water

Pressures are increasing as surface water use continues to increase. The condition is deteriorating and the overall response is adequate in some respects but inadequate in others.

Water use

The extraction of water from rivers and groundwater resources reduces the amount of water available for dependent animals, plants and habitats, and also alters the natural patterns of high and low river flows. Since the last review of water resources in 1985, water use has increased dramatically (Table 10). In 1996–97, Australians extracted 24 060 GL from surface waters (79% of water extracted) and groundwaters (21% of water extracted). This is an increase of 65% in fewer than 15 years.

Irrigation now accounts for 75% of water used in Australia. The largest increase in water use was for irrigation in New South Wales and Queensland where the area of irrigated land has doubled. In 1997, 1.472 million hectares of land was irrigated in the Murray–Darling Basin, 71% of the total area irrigated in Australia.

Water use needs to be related to the capacity of the environment to assess whether current levels of water extraction are sustainable (i.e. an estimate of the volume of water that can be extracted without affecting other users and the environment). Preliminary estimates for most surface water and groundwater resources have been made for the NLWRA, but insufficient scientific data and knowledge were available to determine sustainable yields conclusively. More research and data are required urgently to assess the sustainability of current and future water extractions, the water requirements of the environment and the best ways to manage the needs of the environment while providing water for human uses.

Groundwater

Trend: Groundwater use versus sustainable yields

Groundwater available for allocation has reduced substantially in the last decade, and is now overused and over-allocated in many Groundwater Management Units (GMUs).

Table 10: Change in mean annual water use (GL) in Australia by water use category

Water use category	1985 review[A]	1996–97 review[B]	Percentage change
Irrigation	10 200	17 940	76
Urban/industrial	3 060	4 750	55
Rural	1 340	1 370	2
Total	14 600	24 060	65

[A]AWRC (1987); [B]NLWRA (2001b).

There has been a 90% increase in groundwater use across Australia between 1985 and 1996–97, to about 5000 GL/year. Overall, 32% of groundwater extracted is for urban–industrial use, 51% for irrigation and 17% for stock watering and rural use. South Australia, New South Wales and Victoria use more than 60% of groundwater for irrigation, while Western Australia uses 72% for urban and industrial purposes. Up to four million people in Australia depend totally or partially on groundwater for domestic water supplies.

The total volume of drinking quality groundwater (i.e. with less than 1500 mg/L Total Dissolved Solids) that can be sustainably extracted is estimated to be about 21 000 GL/year. However, many undeveloped groundwater resources are in remote areas. More importantly, most estimates of groundwater sustainable yields do not consider the impact of groundwater extraction on baseflows in rivers, streams, lakes and wetlands. Little is known about groundwater-dependent ecosystems (e.g. caves and aquifers) and their water requirements, although many contain unique or endemic species. Many land and water ecosystems depend on groundwater for at least some of the time, but the interactions between groundwater and these systems are poorly understood. In comparison with surface water, there is relatively little information on groundwater levels, use and quality and increased information is required if groundwater systems are to be managed sustainably.

Some groundwater resources are already overdeveloped, as the rate of extraction exceeds the rate of recharge (i.e. groundwater mining). These include the Great Artesian Basin, many

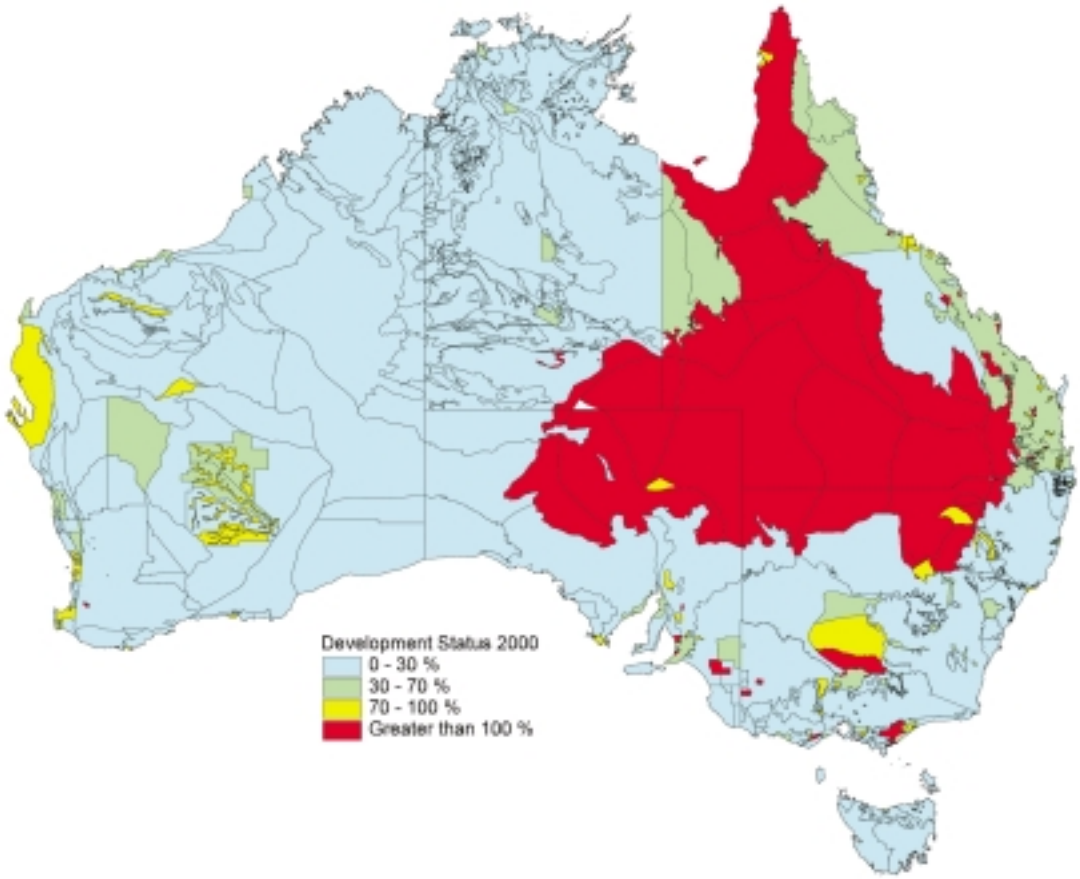


Figure 21: Groundwater development status.

Source: National Land and Water Resources Audit 2001b.

small aquifers in the Murray–Darling Basin, the Perth Basin and aquifers along the east coast of Australia (Figure 21). Although the National Water Reforms Framework include provisions for groundwater, groundwater reform is lagging behind surface water reform in most states and territories.

Water quality

Salinity

Trend: Water quality
Pressures are increasing, condition is deteriorating as more land is affected and the overall response is inadequate.

The effect of Australia's natural salinity has been exacerbated by changes in land use since European settlement. The increasing salinity of Australia's catchments and inland waters is one of the most significant threats to the health of aquatic ecosystems and to irrigation. Drinking-water supplies for most of South Australia and many inland towns in New South Wales are at risk from increasing salinity. Adelaide's drinking water is predicted to exceed guidelines for salinity on two days out of five by the year 2020 if there is no action to control increasing salinity in the Murray River.

Nationwide, 80 important wetlands are already affected by salinity and this is predicted to rise to 130 by the year 2050. Many riparian habitats (especially wetlands) can contain endemic species and communities at risk from salinisation. Loss of these communities will inevitably lead to a reduction in biodiversity in areas such as south-west Western Australia.

Dryland salinity, primarily caused by land clearing and rising saline groundwater tables, will be the major contributor to salinisation of the landscape over the next 100 years (see the *Land* theme report). River systems in south-west Western Australia and western Victoria have high salinities as a result of saline groundwater inflow from areas affected by dryland salinity.

In some catchments, irrigation-induced salinity caused by poor irrigation practices may be a major cause of increasing land and water salinisation (e.g. about 10% of the increased salinity of inland waters in the Murray–Darling Basin).

The Commonwealth, New South Wales and Victorian governments and the Murray–Darling Basin Commission released salinity strategies in 2000, but it is too early to judge their effectiveness. Specific salinity strategies have been developed for some individual river systems and catchments, but most river systems do not have an integrated management strategy for salinity (and other major problems). South Australia and Western Australia have had integrated salinity strategies for some river systems since 1996 and there have been reductions in land and water salinity in some catchments. In many catchments it will take decades for improvements in water quality to be measured (see the *Land* theme report).

Eutrophication and algal blooms

Trend: Algal blooms
Nutrient enrichment and reduced streamflow due to over-extraction of water have increased the frequency and extent of toxic blue-green algal blooms, with some reservoirs being unsuitable for recreation or drinking-water supply over 25% of the time.

Blue-green algae can produce toxins that affect humans, livestock and native aquatic flora and fauna. Blue-green algal blooms can occur in urban or rural areas and are most common in storages, lakes, wetlands and stretches of rivers that have still waters and are enriched with the plant nutrients, nitrogen and phosphorus. They are a significant problem in water storages because of increased costs of treatment, management and/or provision of alternative supplies. Algal blooms also reduce the recreational and visual amenity of water resources and cost Australian water users over $150 million annually.

Although the 1000 km toxic algal bloom that occurred in 1991 in the Barwon and Darling rivers in New South Wales has not been repeated, blue-green algal blooms are

common and persistent in many waterways. In Victoria, 30 to 50 blue-green algal blooms have been recorded each year since 1996. In New South Wales, persistent blue-green algal blooms occur in the Hawkesbury–Nepean River, in urban lakes and in many inland dams. In Queensland, blue-green algal blooms were present at least 25% of the time in 14 water storages between 1997 and 1999. The Blackwood, Vasse, Serpentine and Swan–Canning rivers in Western Australia have also been affected by regular blue-green algal blooms since 1996. Because of the variability in the occurrence of algal blooms and gaps in historical data, it is difficult to determine whether the frequency and size of algal blooms has increased in recent years.

Nutrient levels are high enough to support algal blooms in all river systems of the Murray–Darling Basin (except the Condamine River) and some coastal river systems in western Victoria, central and northern New South Wales, south-east Queensland, northern Queensland and Western Australia (Figures 22 and 23). Still water conditions are common in most regulated river systems and often coincide with warm water temperatures that are conducive for algal growth.

Based on an assessment of water quality undertaken for SoE (2001), there is no trend showing any broad-scale reduction in phosphorus or soil erosion since 1996, although there have been some improvements on a local level in some catchments. As long-term changes in land management are required to reduce soil erosion, changes would not be expected in the short term. In some catchments, other sources of nutrients such as runoff from fertilised land or intensive agricultural enterprises (e.g. cattle feedlots) may be major contributors to nutrient loads but information is not nationally available.

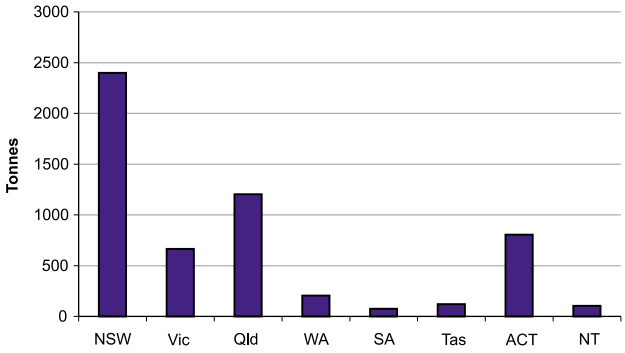


Figure 22: Tonnes of nitrogen discharged annually.

Source: Data for New South Wales, Victoria, Queensland and Tasmania were obtained from licensing databases supplied by state regulatory agencies. Data for Northern Territory, Western Australia, Australian Capital Territory and South Australia were obtained from the National Pollutant Inventory (2000).

Figure 23: Tonnes of phosphorus discharged by inland sewage treatment plants each year.

Source: Data for New South Wales, Victoria, Queensland and Tasmania were obtained from licensing databases supplied by state regulatory agencies. Data for Northern Territory, Western Australia, Australian Capital Territory and South Australia were obtained from the National Pollutant Inventory (2000).

Catchment plans commonly aim to protect the riparian strips along rivers and drainage lines which (along with wetlands) act as filters for soil and nutrients coming from adjacent farmlands and reduce erosion of river banks and drainage lines. Since 1996, the number and sophistication of catchment management plans and best management practices that have included measures to reduce nutrient enrichment of inland waters has increased markedly. However, there is no nationally available information on the success of these plans. Measures to reduce the nutrient enrichment of inland waters may take decades to have a significant effect.

Sewage treatment plants also contribute significantly to nutrient levels in some river systems. Wastewater reuse in most states and territories has increased from 4.7% in 1993–94 to 6.5% in 1996–97 of total volume of wastewater generated. In New South Wales, Victoria, Queensland and Western Australia, wastewater reuse has increased, while in the remaining states and territories, the reuse volumes have not changed substantially.

Since 1996, there has been a greater focus on managing urban stormwater to ensure that pollutants (e.g. sediments, nutrients and toxicants) do not affect rivers and estuaries. The use of pollutant traps to capture sediment and litter, and constructed wetlands to filter runoff, is now widespread and can reduce the amounts of contaminants entering waterways as long as they are properly maintained. The NHT and state and local government funds have also contributed to improving stormwater management in urban areas.

Trend: Pollutant sources

Diffuse source pollution and especially soil loss from catchments continues to contribute to the widespread nutrient enrichment and turbidity of inland waters. Soil washed into rivers and reservoirs will remain a source of nutrients for decades.

Gully erosion along a creek in Bathurst, NSW.

Source: J Williams.

Pollutants and acidification

There is little nationwide data on the extent and effects of pollutants entering inland waters. The National Pollutant Inventory (NPI) provides information on the relative contributions of nitrogen and phosphorus from both point and diffuse source discharges to inland and coastal waters. However, it should be noted that the data for diffuse source pollution is likely to be largely an estimate at this early stage of implementation of the NPI.

Pesticide monitoring is not routinely undertaken in Australia, although spot studies have shown significant contamination in many irrigation areas.

Cotton, rice, sugar cane and horticulture are the highest users of pesticides and pesticide use has increased significantly over the last 20 years (see the *Land* theme report). There are ongoing concerns with pesticides from agricultural land contaminating the water and sediments of inland waters (e.g. pesticides in high enough concentrations to kill fish have been found in rivers and streams draining agricultural areas in northern New South Wales). There is limited information available of the concentrations or loads of pesticides in inland waters.

Since 1990, at least 20 fish kills in New South Wales rivers have been attributed to pesticides. Integrated pest management and best management practices for pesticide use are gradually being adopted by farmers and a new generation of more selective, less toxic pesticides is also being introduced (see the *Land* theme report). However, based on the experience of the past 20 years, pesticide use is likely to continue to increase, potentially causing continuing pollution of inland waters. Although there are many laboratory studies on the effects of pesticides, there is little information about the ecological effects of such chemicals in the river systems.

Other pollutants (e.g. heavy metals) and hydrocarbons (e.g. oil) may have localised effects. Since 1996 in some states and territories (e.g. New South Wales), the management of these sources of pollution has improved. Stormwater management plans have been prepared for all urban catchments in New South Wales and the use of constructed wetlands and other stormwater treatment devices has increased throughout Australia together with improved pollution licencing systems.

Trend: Water acidity

This is an emerging issue in some catchments where increasing trends in water acidity and the area of land affected by soil acidity have been found. Higher water acidity may lead to increased availability and movement of pollutants as well as changes to the chemistry of rivers and streams.

Acidification of inland waters can directly affect aquatic flora and fauna and can increase the leaching of pollutants and nutrients from contaminated sediments back into the river water.

Acidification may occur as a result of disturbance of acid sulfate soils, acidic discharge from mine sites or the acidification of soils in agricultural areas. For example, the drainage and exposure of acid sulfate soils in coastal areas of New South Wales has caused high water acidity and localised impacts on freshwater biota. Acidification of inland waters is a localised problem (e.g. some rivers in Victoria have shown an increasing trend in acidity over the past 10 years). Since 1991, the area of land affected by acid soils has increased by 13 million hectares to 47 million hectares (see the *Land* theme report).

Catchments that have agriculture, industry or urban development increase the risk of contamination of drinking-water supplies. Pathogens of human origin (e.g. viruses, bacteria and protozoa) from sewage, and domestic and native animal wastes can have widespread health effects when poor catchment management allows contamination by these organisms.

In 1998, the *Cryptosporidium* and *Giardia* contamination of Sydney's drinking-water supplies followed extensive rainfall that washed pathogens into storage reservoirs (see the *Inland Waters* theme report). The subsequent independent inquiry recommended a 'whole-of-catchment' approach, with additional legislative and planning powers to ensure that activities in the catchments did not pose any risk to the safety of drinking-water supplies.

Groundwater quality

There is little information for many aspects of groundwater quality and the information that does exist is extremely localised. The most significant widespread pollutant of groundwater in Australia is nitrate. Groundwater resources in some rural and urban areas exceed nitrate guideline values for drinking water. Pesticides have also been detected in groundwater beneath many agricultural areas indicating that they have leached from the surface into the groundwater.

In urban areas, localised groundwater contamination has occurred as a result of leaks from underground storage tanks, industrial discharges, stormwater runoff and the movement of pollutants from contaminated sites. Although this has occurred in many urban areas, there are very few publicly available data to gauge the extent and effect of the problem.

Aquatic ecosystems

Trend: Aquatic ecosystems

Increasing salinity of inland waters is a major threat to many aquatic ecosystems, particularly in western Victoria and south-west Western Australia. Eighty important wetlands are already affected by salinity.

There has been an increased focus on protecting Australia's unique aquatic ecosystems. Drainage of floodplain wetlands to allow for agricultural development, and more recently urban settlement, has caused much damage. The building of levees to protect inappropriate development from flooding has often isolated the rivers from their floodplains. Irrigation development, and water-regulating structures (e.g. dams and weirs) also contribute to changes in flow regimes and water character (e.g. temperature) affecting aquatic ecology.

Key pressures on aquatic ecosystems include:

- changes in natural flow regimes as a result of water extraction and supply
- direct modification or destruction of important habitats
- barriers to the movement of plants and animals, for example within rivers and between rivers and their floodplain
- effects of poor water quality
- competition from introduced and exotic animal and plant species.

An example of changes in flow regimes can be found in the Murray River and its tributaries, where the cycle of seasonal flows has been reversed. The river now runs near bank-full in summer as it delivers irrigation water, and runs at low levels in winter as the dams are refilling. Weir pools help distribute water to the floodplain for irrigation and can be an ideal habitat for blue-green algae. The altered flow regime has also assisted pest species like European carp becoming dominant. In May 2001, Commonwealth and state governments introduced a 10-year program to implement water efficiency projects to benefit the environment along the Murray River, the Snowy River and key alpine rivers. One aim is to return flows to the Snowy system from present discharge of 1% of natural flow to 27% by

An aerial view of a lake in the Snowy Mountains.

Source: Environment Australia.

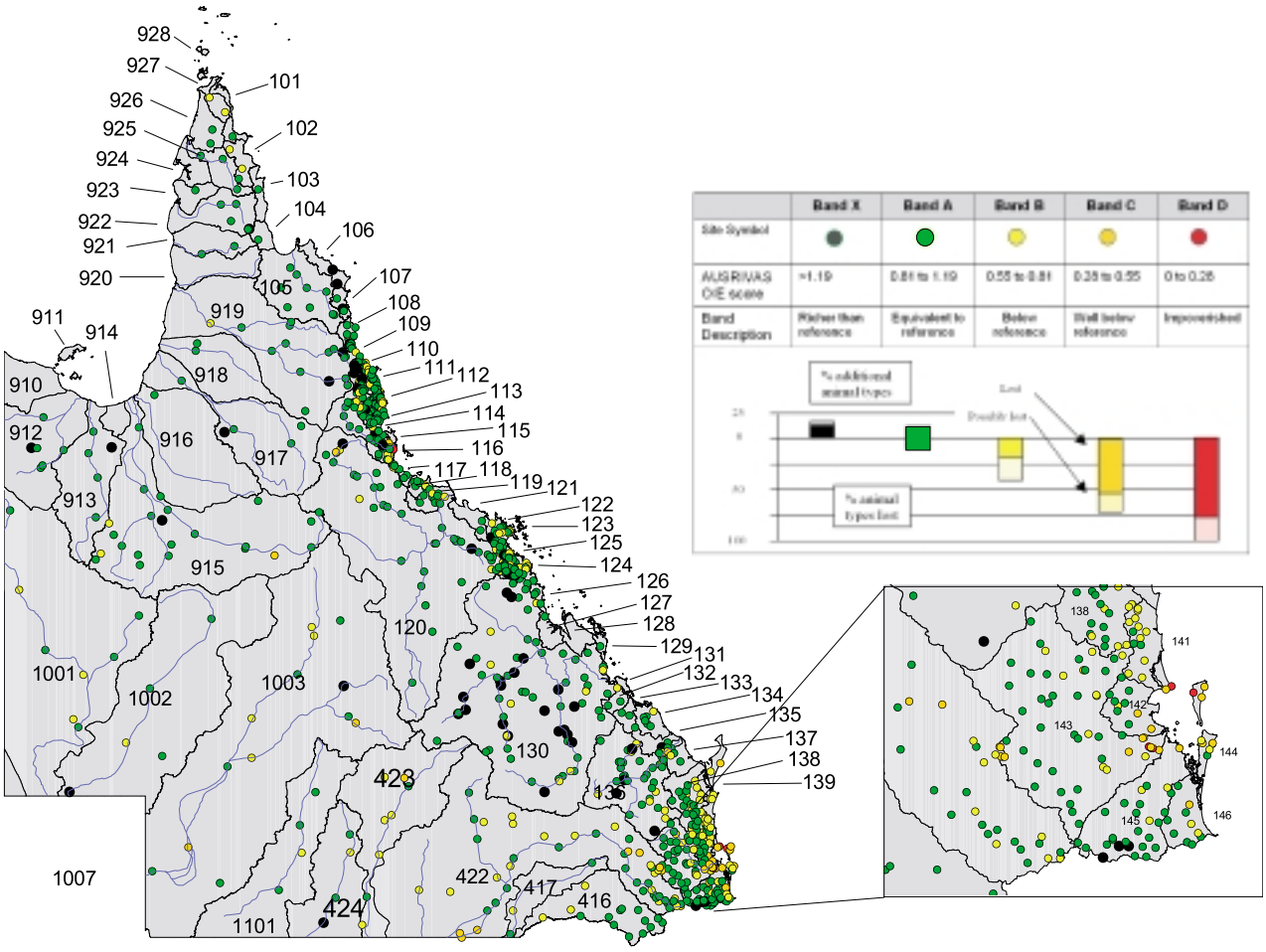


Figure 24: Summary of AusRivAS bioassessment results for all river sites surveyed in Queensland.

Numbers refer to AWRC basins. O, observed number of types of animals; E, expected number of types of animals.

Source: Cooperative Research Centre for Freshwater Ecology 2001, data supplied by relevant state authority.

Darling River minus riparian vegetation.

Source: Richard Norris, CRC for Freshwater Ecology.

2010. This plan will restore some of the former aquatic and scenic values of the once 'wild' river.

Only 13% of Australian river systems had agreed flow allocations for environmental purposes in June 2000, but at least preliminary environmental flow allocations will be established for many regulated rivers over the next five to 10 years. As well as allocating a volume of water to meet environmental needs (i.e. a sufficient flow of water for the species that inhabit the rivers), it is equally as important to time water releases to mimic natural flow patterns (or regimes). Much more research and monitoring is required to develop and assess environmental flow allocations.

Inland waters downstream of most major water storages are probably affected by cold bottom water discharges from dams. Effects on water quality from cold-water pollution may have significant impacts on ecosystem health in some areas. There are, however, only preliminary estimates of these impacts.

A national assessment of river 'health' using the AusRivAS monitoring assessment system found that at 31% of sites macroinvertebrate communities were significantly impaired, at 8% they were severely impaired and at 1% they were extremely impaired. The degree of impairment generally was related to land use in the catchment and disturbance of the river system. The AusRivAS results provide an important benchmark of river health (Figure 24).

Riparian vegetation is seriously degraded in many catchments as a result of clearing, grazing and salinity (e.g. in some areas of Western Australia over 50% of rivers and creeks have lost their native fringing vegetation and less than 10% of wetlands have healthy fringing vegetation). Riparian restoration and protection is becoming more commonplace, with successful outcomes being measured in some projects. However, these projects are only a small proportion of the total area affected. Resnagging of rivers such as the Murray River is also being undertaken to provide habitat for native aquatic species.

Wetlands are important in Australia's environment and often support high levels of biodiversity. Since European settlement, the condition and extent of many wetlands has decreased substantially. Since 1996, there is little new information on changes in wetland area. The area of many wetlands in the Murray–Darling Basin (and others) has declined significantly as a result of many physical and biological factors. Programs to better define and map changes in wetland extent and condition are underway. Another 13 wetlands have been Ramsar-listed since 1996 and the EPBC Act could provide additional protection to wetlands. Management plans for many wetlands have been or are being prepared.

Of the 18 waterbird species listed in the Action Plan for Australian Birds (see http://www.ea.gov.au/biodiversity/threatened/action/birds2000/), four species are listed as 'vulnerable' and five as 'near threatened', primarily as a result of habitat loss. Frog populations have been declining in Australia as in the rest of the world. For most species the cause of

Fishway in Victoria.

Source: Michael Shirley, Sinclair Knight Merz Pty Ltd.

decline is unknown, although the chytrid fungus has infected frog populations throughout Australia. Of the 208 frog species in Australia, 20 are considered endangered and seven are vulnerable. The Action Plan for Australian Frogs (see http://www.ea.gov.au/biodiversity/threatened/action/frogs/) details conservation measures to protect endangered frog species across Australia. Some states and territories have prepared conservation plans for individual threatened species.

Of over 200 freshwater fish species in Australia, 11 are considered endangered and 10 are listed as vulnerable under the EPBC Act. In New South Wales many native species have been reduced in range and abundance. Barriers to native fish movement (e.g. weirs, dams and bridges) have resulted in reduced reproductive success and access to suitable habitat. Fishways are being considered to overcome many major barriers but effective designs are still being developed. Restocking of mostly native fish is undertaken in all eastern states and territories with varying success. The loss of genetic diversity and introduction of diseases into wild populations have occurred as a result of restocking in some areas. Thirty-five exotic fish species have become established in inland waters, with eight identified as having a significant effect. Many exotic fish species continue to increase in range and abundance. Programs to eradicate exotic fish species are being attempted in some areas.

Some of the larger freshwater crayfish species are under considerable pressure from habitat loss and overfishing. There is only limited information on their distribution, however. Numbers of platypus have declined or disappeared in many catchments but reliable information on their health and abundance is not available.

Since SoE (1996), there have been some advances in the protection and restoration of aquatic ecosystems. Although most states and territories have legislation to protect riparian vegetation and threatened species and to provide for environmental water allocations, the application of the legislation is not consistent and not always legally binding. National conservation plans for frogs, water birds and fish have been prepared. There are still insufficient data on the condition and abundance of fauna to support or judge the success of these plans. All conservation plans recognise the primary need to establish 'healthy' habitat to support threatened fauna. Pest control programs are having limited success. There have been some localised successes in eradicating pest fish species (e.g. carp and trout), but many species remain a widespread and intractable problem.

Conclusion

Since 1996, there has been increased research and monitoring of Australia's inland waters and their health, although for many aspects there is still insufficient information to conclusively determine their condition and trend. The information available reveals that the pressures on

inland waters have increased and many water bodies in the developed southern and eastern areas of Australia are significantly degraded as a result of activities in the catchments and water extraction for agriculture and urban development.

The Commonwealth, state and local governments along with communities are now appreciating the linkages of river flows, aquatic ecosystems and their catchments.

Important initiatives in the 1990s that indicated that complex water issues needed to be addressed included:

- COAG Water Reform Framework
- ongoing work of the Murray–Darling Basin Commission
- recognition of the importance of environmental flows
- NHT commitments influencing the behaviour of land managers
- increased role for catchment boards and committees
- substantial information collected by the NLWRA
- NAP for Salinity and Water Quality.

Water use continues to increase across Australia. In the Murray–Darling Basin, the volume of water extracted for primarily irrigated agriculture has increased significantly over the past 15 years and is unsustainable in many river systems. Groundwater resources are also increasingly being developed as surface water resources become fully allocated. The effect of increased groundwater extraction on baseflows in surface waters, wetlands and other groundwater-dependant ecosystems is still unknown and requires urgent additional research to ensure that aquatic environment are not further degraded. Other effects of water extraction such as modifications in natural river flow patterns and the construction of barriers to fish movements are also resulting in a declining health of aquatic ecosystems. Although there has been some improvements in the management of water resources, proposed reforms are not yet fully and equitably implemented.

The increasing salinisation of land and water resources is one of the biggest threats to inland waters over the next 100 years. The potential effects are immense and widespread, and will affect both the environment and agricultural and drinking-water supplies in many areas. Many observers are concerned that measures presently in place might not be sufficient to reverse the degradation that has been observed.

Substantial structural changes in land management and use probably will be required in many areas to combat salinity. These changes must also be considered in the context of other issues such soil erosion and eutrophication/algal blooms to ensure that the most benefit is gained from the limited resources available.

Biodiversity

Concern for non-human life forms occurs throughout history and across many cultures. However, the level and nature of this concern changes, reflecting our understanding, the values we ascribe to it, the threats it is under and what might be done to conserve it. A vital challenge for all Australians in the 21st century is to put human development on a sustainable path by avoiding further biodiversity loss.

Many key threats defined in SoE (1996) continue to threaten Australian landscapes. These include land clearing, salinity, pollution, nutrient loading and sedimentation of waterways and coastal areas, urbanisation of land on the intensively settled coastal areas, climate change, diseases and invasive species.

Australia has a diverse and often unique environment that represents a priceless heritage and should be a source of pride to all Australians. The continent and surrounding seas support a significant proportion of global biodiversity. For example, south-west Western Australia supports the eighth highest number of endemic vascular plant species in the world (see Table 49 in the *Biodiversity* theme report) and the Great Barrier Reef contains around 2000 fish species and around 500 coral species compared with New Caledonia's 1000 fish species and 300 coral species (see Table 48 in the *Biodiversity* theme report).

Biodiversity is defined in Article 2 of the 1992 United Nations (UN) Convention on Biological Diversity as:

> the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.

Australians increasingly accept a share of the responsibility for biodiversity. The United Nations definition was repeated in the EPBC Act. The National Strategy for the Conservation of Australia's Biological Diversity expands on the three levels at which biodiversity occurs:

- genetic diversity—the variety of genetic information contained in all of the individual plants, animals and microorganisms that inhabit the earth. Genetic diversity occurs within and between the populations of organisms that comprise individual species as well as among species
- species diversity—the variety of species on earth
- ecosystem diversity—the variety of habitats, biotic communities and ecological processes.

The three levels of diversity are interrelated and interdependent. A population of a species depends on its habitat for survival, and a functioning ecosystem depends on the complex of species that comprises it. The significance of these interrelationships and interdependencies appears to be becoming more critical to avoiding further environmental, social and economic collapses within Australia.

Many fungi spend most of their life cycle in microscopic form hidden from view in the soil, until they emerge after rain to release spores and begin a new generation.

Source: JJ Bruhl, University of New England.

Trend: Ecosystems

There is little change in the condition, with ecosystems still being highly fragmented, pressure is increasing due to land clearing and other threatening processes and the overall response is adequate in some respects although there are still some major gaps.

One of the key threats to Australian vertebrate species remains habitat destruction and fragmentation, and the greatest disruption and loss has occurred in the mammals. There is, general acceptance of the need for protection at the species level. There is greater support for the conservation of 'soft and cuddly' species or for commercial species (timber, wildflowers or

Complex mesophyll vineforest, south of Cape Tribulation, Qld.

Source: VJ Neldner, Environment Protection Agency, Queensland.

Cushion plant community, Tasmania.

Source: JJ Bruhl, University of New England.

food). The ideas of ecosystem services and genetic values are less readily accepted and understood. These services are provided by biodiversity and they not only determine the health and condition of ecosystems, but also their productivity (e.g. food and water) that Australians rely on for their existence.

Trend: Genetic diversity

Genetic diversity is declining although information remains patchy.

Although 65 indicators were developed for SoE reporting at the national level, some could not be assessed in SoE (2001), as there were large gaps in either data or its availability. Data and its availability remains a key issue in planning for future SoE reporting. Because reporting occurs at local, state and national levels, data collections and information need to be integrated for maximum efficiency. Some changes in attitude to data gathering based on agreed standards may be required.

Australians are only beginning to understand the value and range of biodiversity in the Australian environment. For example, the difference between our knowledge of fungi and vascular plants is extreme—5% of fungi and 70% of vascular plants have been described. Similarly, more vertebrates than invertebrates have been described. Therefore, how much we know depends on the interest of scientists and other professionals, as well as the wider Australian community.

Trend: Species

The condition, although variable, is generally deteriorating, pressure is increasing and the response has been adequate in some respects.

Although the protection of biodiversity in Australia has increased, significant problems restrict further progress. These include: the dysfunctioning of State–Commonwealth arrangements, the level of community commitment (including resources to science), and cooperation between scientists on data standards and data exchange. The role of scientists, NGOs and voluntary groups needs to be clarified.

As the attitudes of Australian people to environmental issues change, so do those of industry. The mining industry, for example, employs biologists to study and evaluate biological values in many parts of Australia, for the purpose of codes and environmental

Biodiversity Month Patron, Sir William Deane, Governor-General of Australia (1996–2001), plants a local native plant in his backyard with help from children.

Source: Grant Ellmers, Community Biodiversity Network.

impact assessments associated with proposed developments. Previously only biologists from government departments and academic institutions collected the regional biological datasets.

Trend: Technical knowledge/data

Knowledge of biodiversity is variable, with less commitment to some areas and advances in others. There is an increasing public expectation. Research is focused but needs to address a range of data needs for SoE reporting.

The mining industry has developed codes of practice (http://www.minerals.org.au) on environmental management to help manage the small proportion of the environment affected by mining. In some sectors and industries, 'corporate Australia' is yet to fully recognise and fulfil its environmental obligations, especially to biodiversity.

How all Australians are to become involved in environmental issues remains paramount in biodiversity. As most Australians live and work within the urban and coastal areas, one mechanism may be to develop urban projects. The recent Bush Forever initiative by the Western Australian Government identified regionally significant bushland to be retained and protected (see http://www.wa.gov.au./planning, and http://www.environ.wa.gov.au). Bush Forever aims to protect a target of at least 10% of the 26 original vegetation complexes within the Swan Coastal Plain portion of metropolitan Perth, and to conserve threatened ecological communities. It combines the results of key research programs and consultation with the community over several years, ensuring that the recommendations incorporate the most up-to-date knowledge of the ecology of the Perth Metropolitan Region. This places Perth at the forefront of world cities conserving their biodiversity.

Local governments have recognised their roles and responsibilities in biodiversity. For example, the Biodiversity Report for Manningham City, north of Melbourne, is a program that developed from a conservation strategy and the 1992 Earth Summit. This illustrates the importance of involving people locally to achieve national and global needs in biodiversity. An important feature developing in urban biodiversity issues is the involvement of young Australians.

Another recent change has seen diverse organisations that historically would not have worked together (e.g. the NFF and the ACF) are now doing so. The diversity of people and organisations involved in protecting Australia's biodiversity is reflected in the range of organisations and groups involved with large programs such as Landcare, Bushcare, Land for Wildlife, Coastcare, NatureSearch Program, Friends groups associated with species,

ecosystems or places, Wildcare, Rivercare and many others. The NHT has funded many of these programs since 1997.

The EPBC Act came into operation in 2000 and covers a range of key areas of biodiversity conservation including Australia's obligations under the Convention for the Protection of World Cultural and Natural Heritage. In early 2001 land clearance was listed as a key threatening process, which allows a threat abatement plan to be developed. The next national SoE Report, which will appear in 2006, will be a timely opportunity to assess the effect of this legislation on biodiversity conservation, as well as the impact of NHT-funded projects on biodiversity. In 2000 the Commonwealth government reviewed the implementation of the National Strategy for the Conservation of Australia's Biological Diversity. The review identified some significant progress as well as areas where pressures on biodiversity continue and response remains inadequate.

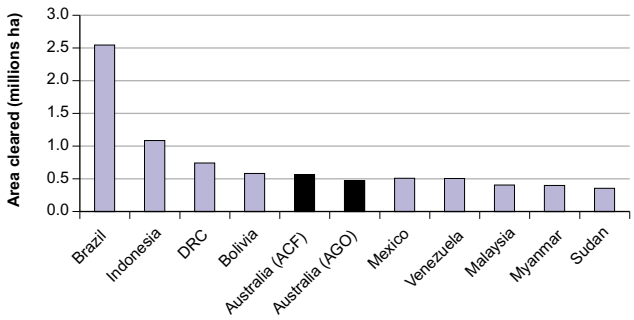


Figure 25: Countries with highest estimated rate of native vegetation clearance in 1999.

Source: after ACF (2000, 2001).

Key issues

Land clearing

Clearance of native vegetation remains the single most significant threat to terrestrial biodiversity. Based on estimates compiled by the ACF, over 564 800 ha of native vegetation was cleared in Australia during 2000; the AGO estimate for 1999 is 468 844 ha. The former area is exceeded by only four other countries in the world: Brazil, Indonesia, the Democractic Republic

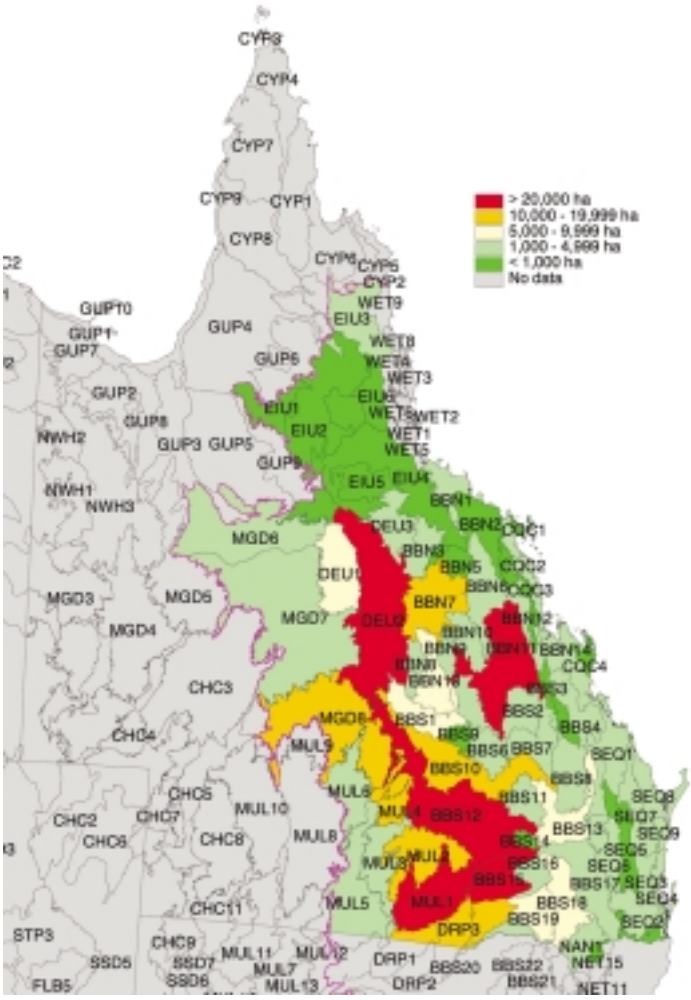


Figure 26: Area of native vegetation cleared in Queensland between 1997 and 1999 by subregion (indicative map only).

Source: EPA (1999); AGO. Compiled by: NLWRA, Landscape Health Project, Canberra.

of the Congo (DRC) and Bolivia (Figure 25). In the top 10 countries, Australia is the only developed nation.

The rate of land clearance has increased, with as much land cleared since the 1950s as in the 150 years before 1945. Although this issue was recognised in SoE (1996), there has not been a unified response within Australia or within various regions; for instance, the degree of land clearing by region within Queensland between 1997 and 1999 (Figure 26). Land clearing continues at different rates, despite apparently tight legislative mechanisms, within other regions of Australia apart from Queensland.

Trend: Land clearing

Land clearing has reduced in most states although it continues in some areas. Legislation and other controls have resulted in a variable response to date.

The loss and depletion of plants through clearance destroys the habitat for thousands of other species. For example, 1000 to 2000 birds permanently lose their habitat for every 100 ha of woodland that is cleared, while the clearing of mallee for wheat farming kills, on average, more than 85% of the resident reptiles and more than 200 individual reptiles per hectare.

Broadscale land clearance can fundamentally change the functioning of ecosystems, including regional climate, and in the medium to long term, undermine agricultural production and regional economies (see *Land* theme report). Invasive plants and animals can also markedly affect ecosystems.

By 2050, as another legacy of broadscale land clearance, up to two million hectares of remnant native vegetation are predicted to be at risk from dryland salinity.

Dryland salinity and water quality

Australia has critical dryland salinity and water quality problems that pose threats to not only native vegetation but also to sustainable agricultural and forestry. At least 2.5 million hectares (5% of cultivated land) is affected by dryland salinity. For example, WA has the largest area of dryland salinity risk in Australia (Figure 27). The costs of rehabilitating the biodiversity values of these land areas are enormous. Mapping distributions of major fragmented vegetation types in selected catchments and their likely response to projected hydrological changes has only just begun (Figure 28).

A comparison of the areas within Australia which are under threat from salinity and fragmentation highlight many of the issues related to the protection of biodiversity values in

Many vegetation types now exist as remnants along roadsides and railway reserves, such as this community near Bathurst, NSW.

Source: J Williams.

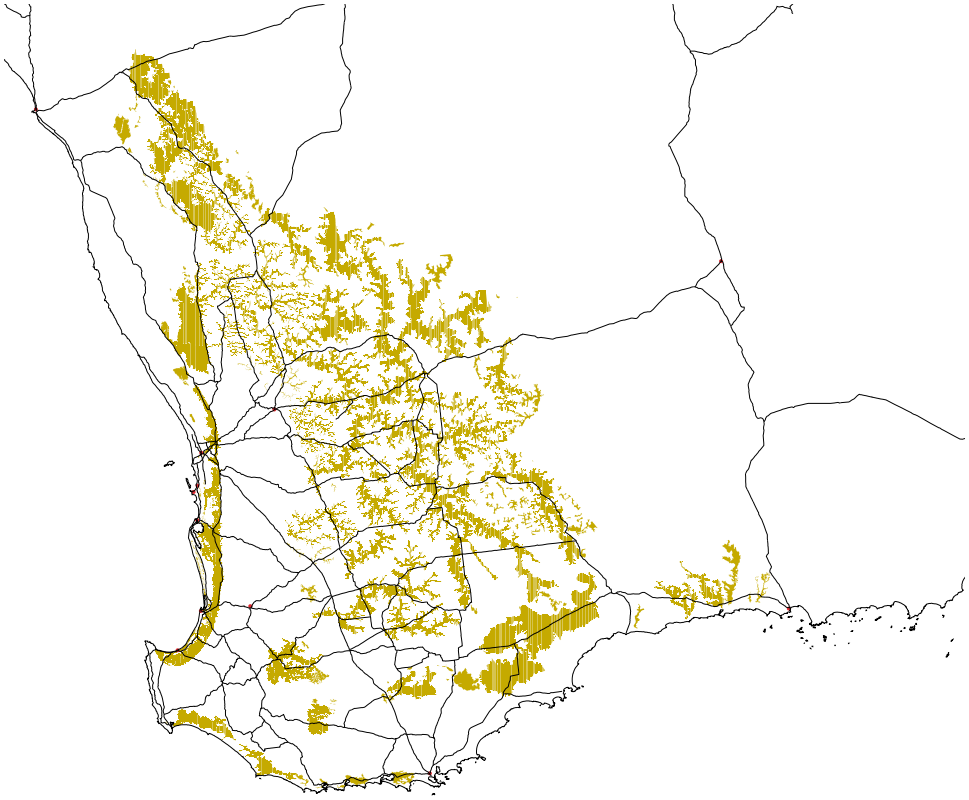


Figure 27: **Dryland salinity risk in south-west Western Australia 2000.**

Source: NLWRA (2001a).

these largely agricultural areas. The results of past effects of clearing appear difficult for some sectors of the Australian community to respond to.

Early research findings in the wheatbelt of Western Australia indicate that some 450 endemic plants are under threat of extinction from salinity. In addition, about 75% of the waterbirds are in decline and some 200 aquatic invertebrates are likely to become regionally extinct.

Trend: Dryland salinity and water quality

The condition of habitats is declining as a result of increasing pressures of salinity and changes in hydrological regimes. The response is sometimes adequate but on-ground action often is still not reversing the situation.

Ecosystem and land use change

Most biodiversity conservation has been focused in southern and eastern Australia where broadscale land clearing has been concentrated. Governments and the community are now beginning to appreciate the potentially significant effects of altered fire, grazing, hydrological regimes and invasive species on biodiversity in the extensive land use zone in central, western and northern Australia.

The pastoral industry covers about 70% of the continent. Grazing in arid and semi-arid regions is considered partly responsible for the extinction of many plants and continues to threaten around one-quarter of the plant species listed as endangered. The pastoral industry in these regions relies heavily on the production and diversity of native species. Native species are damaged by trampling or grazed to the extent that species and the industry suffer. Some species may not be under threat but if current stocking rates continue, then they may be.

The Commonwealth government developed a national approach to forest policy in 1992, which later was followed by a series of RFAs between states and the Commonwealth. The pressures on biodiversity in old-growth forests were identified as a major issue in SoE

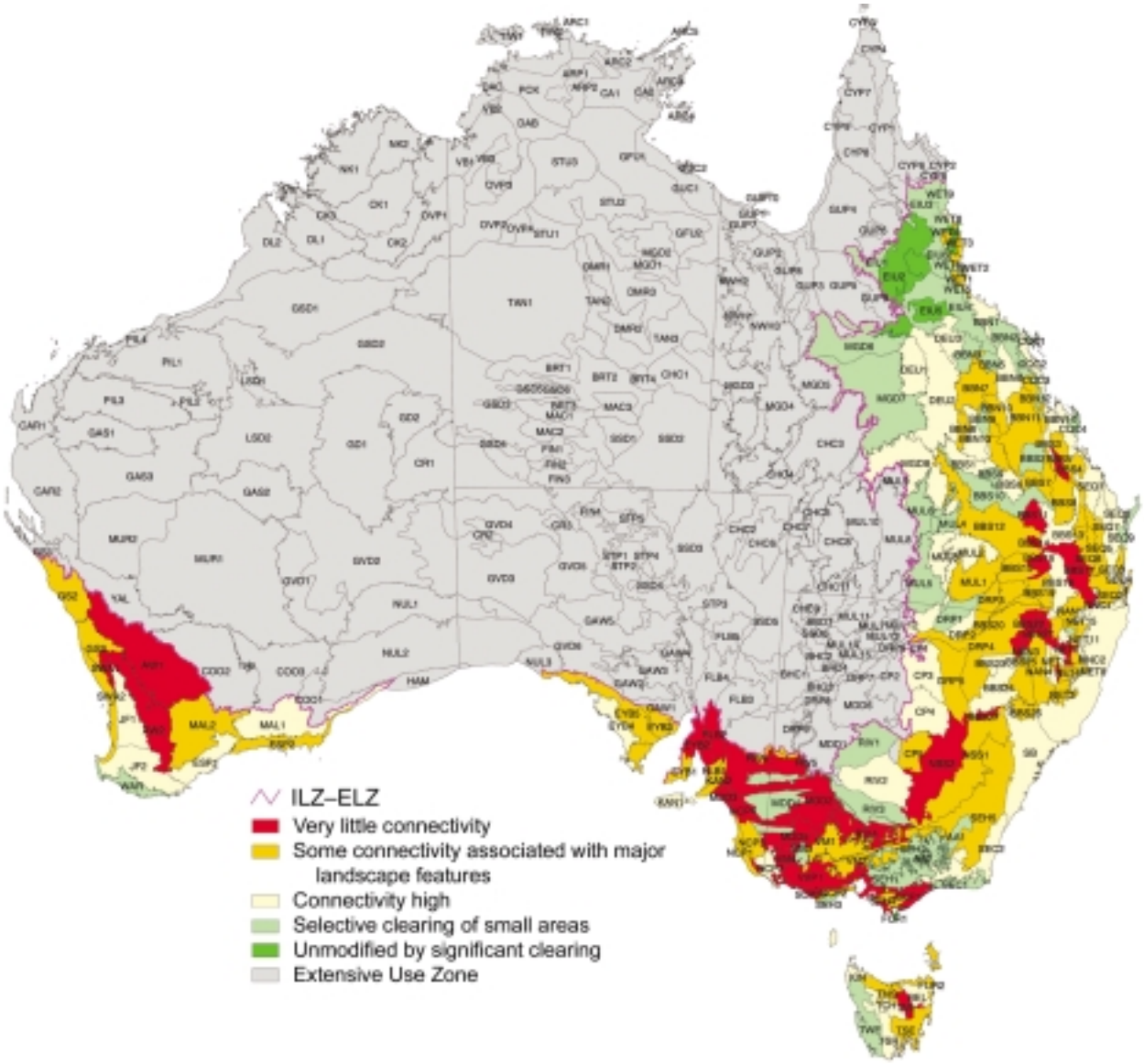


Figure 28: **Mapping of the degree of native vegetation fragmentation (indicative map only), by IBRA regions.**

Source: Specialist opinion based on State vegetation coverages. Data currency: land use—1999; vegetation—NSW 1986–1995, Qld 1997, SA 1985–1995, Tas. 2000, Vic. 1987, WA 2000, NT no data. Compiled by: NLWRA, Landscape Health Project, Canberra.

(1996). Since SoE (1996), there have been major changes in forest management in RFA areas (covering most of the production areas in Australia). Informed by regional assessments costing about $115 000 000, the RFAs generated comprehensive information about the environmental, heritage, social and economic values of forests. The RFAs were developed using extensive consultation with communities, industry and NGOs. Old-growth forests were, for the first time, mapped systematically and comprehensively. The RFAs have added 2.8 million hectares to forest reserves, protecting more than 60% of all public land in the RFA regions in a reserve system of 10.3 million hectares. The protection of old-growth forest increased by about 40%. Some claim that too much forest is locked away from commercial harvesting while others believe that all harvesting in native forests should be stopped.

Freshwater aquatic ecosystems also continue to be degraded. Numbers of several species of frogs, aquatic tortoises and lizards continue to decline. This is primarily the result of continuing declines in wetlands, riverine systems and water quality. The River Disturbance Index presented below reflects the large variation in condition of rivers systems within Australia (Figure 29).

For discussion of marine biodiversity, see the *Biodiversity* theme report and the *Coasts and Oceans Thematic findings* section (page 5) of this report.

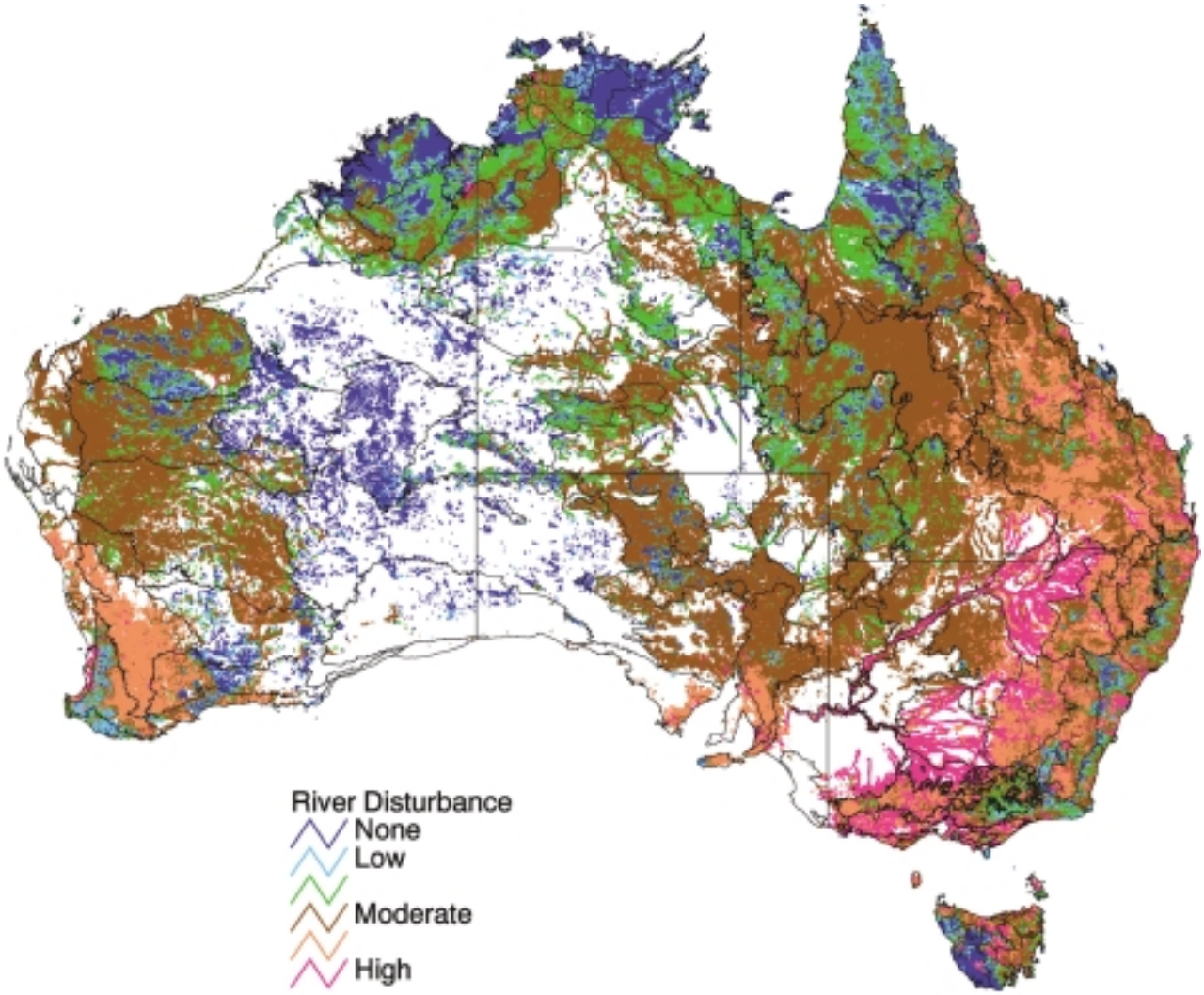


Figure 29: The River Disturbance Index.

The River Disturbance Index is the average of the Flow Regime Disturbance Index and Catchment Disturbance Index (from the Australian Rivers and Catchment Condition Database, ARCCD). Wild rivers are shown in blue (dark blue for rivers with no disturbance and light blue for rivers with a disturbance up to the 0.01, a threshold set by the Commonwealth Wild Rivers Program). All other rivers are shown with their respective disturbance levels (in order of increasing disturbance: green, brown, orange, pink).

Source: Environment Australia (2000).

Trend: Changes in land use

The condition is variable, pressures on biodiversity continue as a result of urban expansion and increasing population pressures. There has been increased attention from local governments on addressing biodiversity through local planning processes and land capability studies.

Altered fire regimes

Altered fire regimes were not listed as a key threatening process for biodiversity in SoE (1996). Today, however, there is much greater awareness, particularly in northern Australia, of the links between fire regimes (season, frequency, intensity and type) and the conservation of biodiversity. Satellite monitoring in northern Australia is building up a picture of changes in fire patterns, which are being used to improve management. With modest resources, monitoring could be extended Australia-wide to provide a long-term picture of fire patterns.

Climate change

Climate change and its potential to influence biodiversity remains a key issue. The present Australian government has emphasised mitigation of greenhouse gases emissions through

processes such as the Greenhouse Challenge (see http://www.greenhouse.gov.au). The direct and indirect effects of climate change on biodiversity has received much less attention. The potential effects of climate change on terrestrial (e.g. alpine and arid zones) and marine biodiversity need to be adequately researched, better understood and managed. Native vegetation assists in carbon sequestration and the mitigation of climate change. Despite this, some Australian jurisdictions continue to permit high rates of land clearance (see the *Land* and *Biodiversity* theme reports).

Summer wildfire in dry sclerophyll forest on Black Mountain, ACT.

Source: AM Gill, CSIRO Plant Industry.

Diseases and invasive species

Invasive species can include exotic organisms, introduced diseases, genetically modified organisms (GMOs), and native species whose range and/or abundance have changed because of human activities.

Invasive species were identified as a major threat to biodiversity in SoE (1996) and remain so (Figures 30 and 31).

Unlike in SoE (1996), 'sleeper' weeds (species that have established, but are yet to become a widespread problem) are now recognised to be of major concern, as are exotic organisms that might find their way through Australia's quarantine barriers as a result of trade, tourism and other human activities.

Some introduced animals that have been around for decades can also become pests. For example, the Crazy Ant (*Anoplolepis gracilipes*) was introduced to Christmas Island in the 1930s but has only recently become a major threat to biodiversity on the Island. The South American Cane Toad (*Bufo marinus*), introduced into Queensland in 1935 from Hawaii to control two insect pests of sugar cane, has spread north, west to 500 km south of Darwin and has been reported recently in Kakadu National Park. The potential costs of these species alone are enormous in terms of control measures, loss of biodiversity and loss of productive systems.

Resprouting eucalypts after a wildfire on Black Mountain, ACT.

Source: JE Williams.

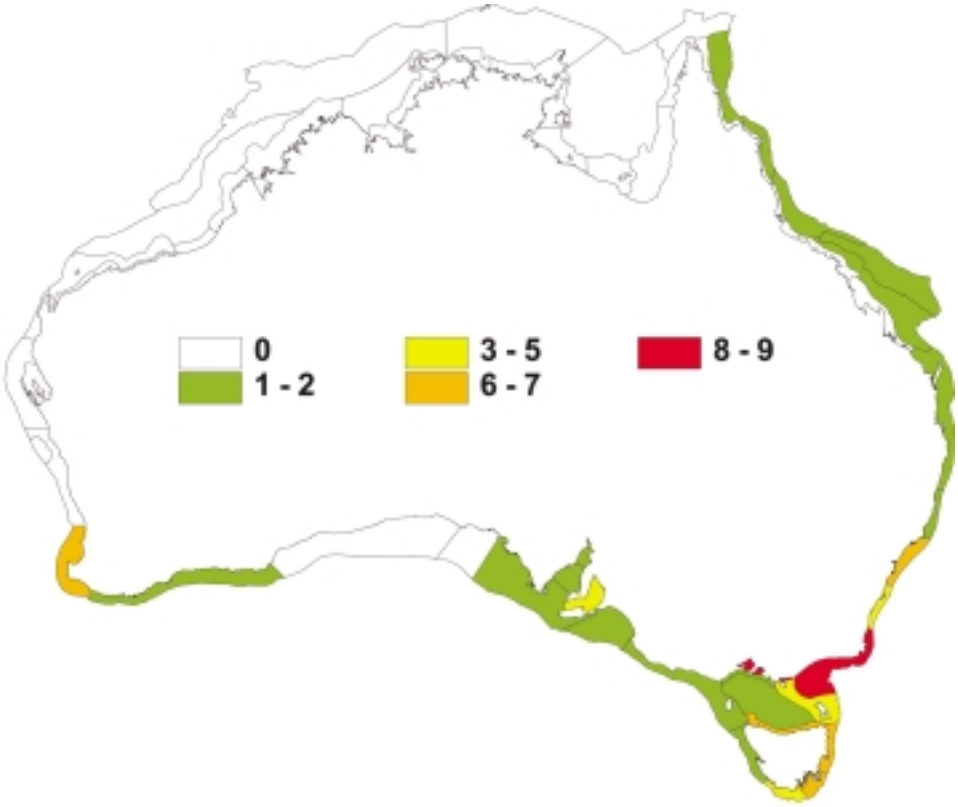


Figure 30: **Number of marine invasive species per Interim Marine and Coastal Regionalisation for Australia (IMCRA) including the endemic Crown-of-Thorns Starfish (*Acanthaster planci*).**

Source: Clarke et al. (2000).

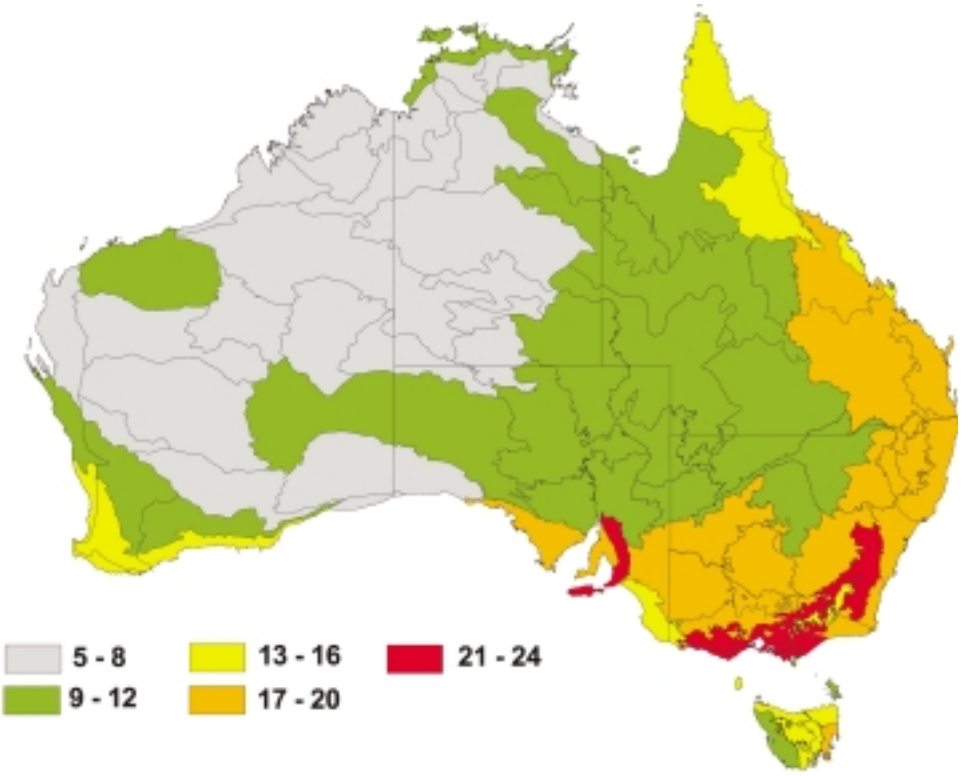


Figure 31: **Number of terrestrial non-Indigenous vertebrate and invertebrate invasive species per IBRA based on a list of around 30 species considered to have a major effect in Australia.**

Source: Clarke et al. (2000).

A Crazy Ant (*Anoplolespis gracilipes*) feeding on the honeydew produced by scale insects. The mutual relationship between these two species has been responsible for extensive canopy dieback on Christmas Island.

Source: Piper Films, Australia.

A National Weeds Strategy was released in 1996 with 20 Weeds of National Significance identified in 1999 and another 28 species listed that pose a potential threat to biodiversity. Threat abatement plans have also been developed for the fox, rabbit, cat and goat. In addition, Environment Australia, in cooperation with state agencies and scientists, have been developing a Threat Abatement Plan for the fungus *Phytophthora cinnamomi*, a major threat to biodiversity.

At the national level, two CRCs fund most research into the ecology and management of invasive plants and animals that threaten biodiversity.

The significance of these threats to Australia was recognised by the Commonwealth government in the recent additional allocation of funds to AQIS via the 2001–02 Budget.

Trend: Invasive species/diseases

There is an growing threat to terrestrial and marine systems through introduction of an increasing range of species. The response has been variable but awareness of the issues has increased.

Genetically modified organisms and biodiscovery

The effects of GMOs on biodiversity could also be significant if they become invasive. A systematic and comprehensive investigation of the potential effects of GMOs in Australia should be a priority (see http://www.health.gov.au/ogtr/index.htm).

Biodiscovery (the chemical prospecting for pharmaceuticals in natural organisms) is another recent development. Although the concept of developing drugs from natural organisms is not new, the need to maintain biodiversity values is now paramount.

Role of industries in biodiversity

The agricultural sector has a key role in conserving biodiversity and has adopted some important reforms. Farmers comprise the bulk of the membership of many community groups such as Landcare. Some parts of the sector now routinely integrate nature conservation objectives into their resource and landscape management strategies, and commercial programs (e.g. see *The Living Landscapes Project* box on page 81).

Integration of land disturbances and protection of the environment is already being practised in some other industries, such as mining. Mining has developed these planning

The Living Landscapes Project

The Living Landscapes Project is a community-based project to develop sustainable landscape management. The Project attempts to embed biodiversity conservation into catchment and agricultural planning in the wheatbelt of south-west Western Australia. This pilot planning process considers both agricultural production and broader landscape issues such as nature conservation and ecological health. The aim is to assist community groups to develop landscape management practices that protect biodiversity within an ecologically viable and sustainable land use system.

The Project involved an interdisciplinary team that used learning through experience as an overarching process. The other key process used was the focal species approach. By combining these two approaches, Living Landscapes has developed a set of guiding principles for nature conservation planning in the context of sustainable land management. The approach is now being considered in several regions in eastern Australia.

issues through capitalising on the need to undertake an environmental impact assessment of proposed developments. Particularly for larger proposed developments, the background data collected on geology, landforms, soils, hydrology, flora, vegetation and fauna have allowed a high degree of sophistication to enable the interpretation of potential direct and indirect effects.

The differences between industries and their approaches to biodiversity conservation are related to how well these values have been defined and determined. In general, the forestry industry has also evolved in its approach from collecting data on structure and dominant species to integrating some biodiversity values by addressing potential threats (e.g. developing soil-water controls to help reduce disease caused by the pathogen *Phytophthora cinnamomi*).

Involvement of Indigenous peoples in biodiversity

Today, there is much greater involvement of Indigenous peoples in land management, with repeated calls for Indigenous issues to be fully integrated into policy and program management. One example is the development of the Indigenous Protected Area Program.

Around 15% of Australia was managed by Indigenous peoples in 1996 and their involvement is essential to the future of biodiversity in this country. Their extensive ecological knowledge could be better used to improve our understanding of biodiversity and its management. The mining industry and other land management groups are already integrating Indigenous knowledge in rehabilitation and land management programs. Exchange of Indigenous knowledge and learning would be assisted by their more comprehensive and interactive involvement in land management across an array of tenures and ecosystems.

Protection of biodiversity values in reserves

Some new initiatives since 1996 have helped to increase the representativeness of the nation's system of conservation reserves (Figure 32). The comprehensiveness and adequacy of the reserve system has been improved.

The new initiatives include the National Reserve System Program and related state and territory programs, the RFAs, the Indigenous Protected Area program, Marine Protected Areas (see *Coasts and Oceans* thematic findings), new multi-tenure management schemes, and the enormous growth in contributions from the non-government sector (e.g. Trust for Nature and Bush Heritage Fund). Many anomalies exist and conservation cannot be covered in Australia without a range of tenures, land, water and marine management options. These options need to be in place for areas managed as reserves and off reserves. For example, some regions have relatively high levels of reservation (e.g. south-west Tasmania and the Australian Alps) whereas other regions that have been subject to extensive modification and/or species loss have relatively low levels of reservation (e.g. where agriculture dominates in southern Australia and in relatively productive regions of the Australian rangelands).

Changing roles and responsibilities

Land management and ownership remains a key issue in the context of property rights and responsibilities. Although the land may be in certain ownership, others in the community may consider it their responsibility or right to a say on how land and its biodiversity is managed.

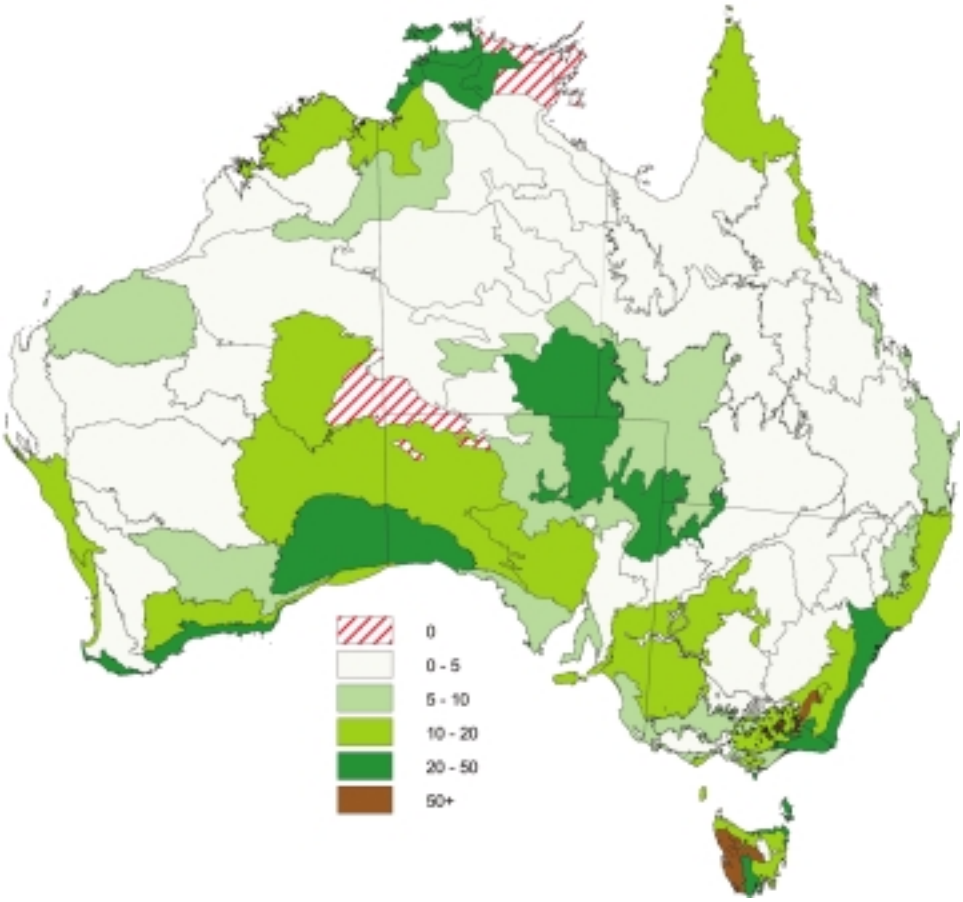


Figure 32: Conservation status of IBRA in 2000 showing the percentage area reserved in each region.

Source: Environment Australia (2000).

Most land in Australia is either freehold or leasehold, managed for commercial use. The significance of ecosystem services to humans and the 'value' of biodiversity is becoming more widely appreciated.

Conclusion

Many key threats to biodiversity identified in 1996 still persist. For example, clearance of native vegetation remains the single most significant threat to terrestrial biodiversity. Salinity and hydrological changes continue to threaten terrestrial and inland waters; sedimentation and nutrient loading threaten coastal waters; and arid and semi-arid regions are under threat from the effects of altered fire regimes, grazing and invasive species.

The protection of biodiversity values in Australia, however, has progressed significantly. There have been major changes in forest management and an increase in the representativeness of conservation reserves. Protection of biodiversity values now extends well beyond the reserve system and many Australians, including Indigenous peoples and corporate Australia, are now involved with biodiversity. Threat abatement plans and recovery plans are addressing many issues although it is often still too early to gauge their effectiveness.

Emerging issues include the potential effect of climate change, GMOs and sleeper weeds on biodiversity.

Natural and cultural heritage

Heritage defines our sense of place. Heritage places and objects provide cultural and physical links with the past, with the history of human habitation, and with the evolution of plants, animals and the physical landscape. Heritage helps define our identity, providing a context in which we find meaning and definition about who we are and who we might be. Heritage helps us express our values and aspirations about the world.

Australia is a land of unique heritage value. It is the home of the first Australians, the Aboriginal and Torres Strait Islander (Indigenous) peoples, who have owned and cared for the

Baltzar Lookout, Grose Valley in the new Greater Blue Mountains World Heritage Area, NSW.

Source: Andrew Morison, A.J. Morison & Associates Pty Ltd.

lands and waters for at least 60 000 years. It is where the first Australians have accommodated major environmental and social changes into their unique ways of life.

Australia has a rich and varied history of European settlement since 1788; and has more recently become the home of people from many countries with a consequent richness of tradition and cultural diversity. As an island continent, we can consider our heritage in an

The Wandjina figures—as depicted in this 1970 painting by Charlie Alyungurra—are creative beings of the Dreaming.

Unique to the Kimberley Region WA, the Wandjina made their world and all that it contains, and set down the rules and rituals that govern human behaviour and living with the land.

Source: National Museum of Australia.

holistic way as the natural and cultural boundaries are clear and unambiguous, not like that of Canada or South Africa.

In considering the condition of our natural and cultural heritage, there are 11 key issues:

- identification of heritage places
- conservation and management of heritage places
- Indigenous involvement in heritage protection and management
- Indigenous languages
- funding for heritage
- legislation and strategies
- data availability
- heritage objects
- role of professionals and volunteers in heritage
- effect of tourism on heritage
- threats to the sustainability of natural and cultural heritage.

A summary is presented in *Key findings* (page 8).

Key issues

Identification of heritage places

With the addition of Heard and McDonald Islands, Macquarie Island and The Greater Blue Mountains Area, the number of Australian World Heritage properties increased from 11 to 14 (Figure 33).

The absence of any World Heritage historic heritage site (e.g. the Sydney Opera House) is a noticeable gap in the representation of Australia's heritage places of outstanding significance.

RFA surveys and some large-scale regional studies (e.g. in the Murray Mallee, Paroo and Cumberland Plain–Outer

Springtime view of Big Ben, Australia's only active volcano, on Heard Island—one of Australia's new World Heritage properties.

Source: K Green, Australian Antarctic Division (2804D6).

The Sydney Opera House is an internationally respected example of modern architectural heritage.

Source: A Tatnell, Big Island Photographics..

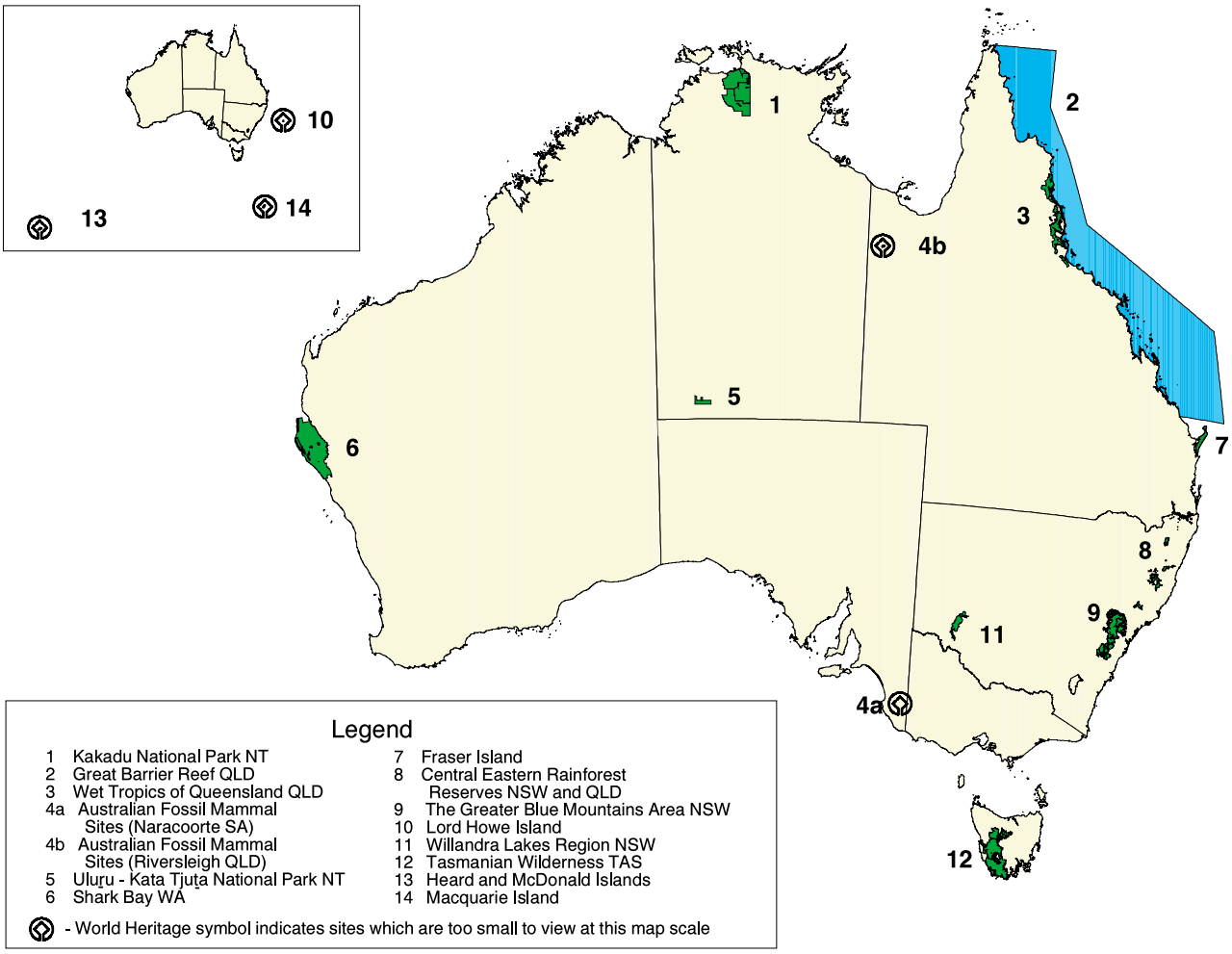


Figure 33: Location of Australia's World Heritage properties at December 2000.

Source: Environment Australia, http://www.ea.gov.au/heritage/awh/worldheritage/index.html.

Currawinya Lakes near Hungerford, Qld.

The Lakes are an important part of the Paroo River Region and form an important wetland in a semi-arid landscape.

Source: Australian Heritage Commission.

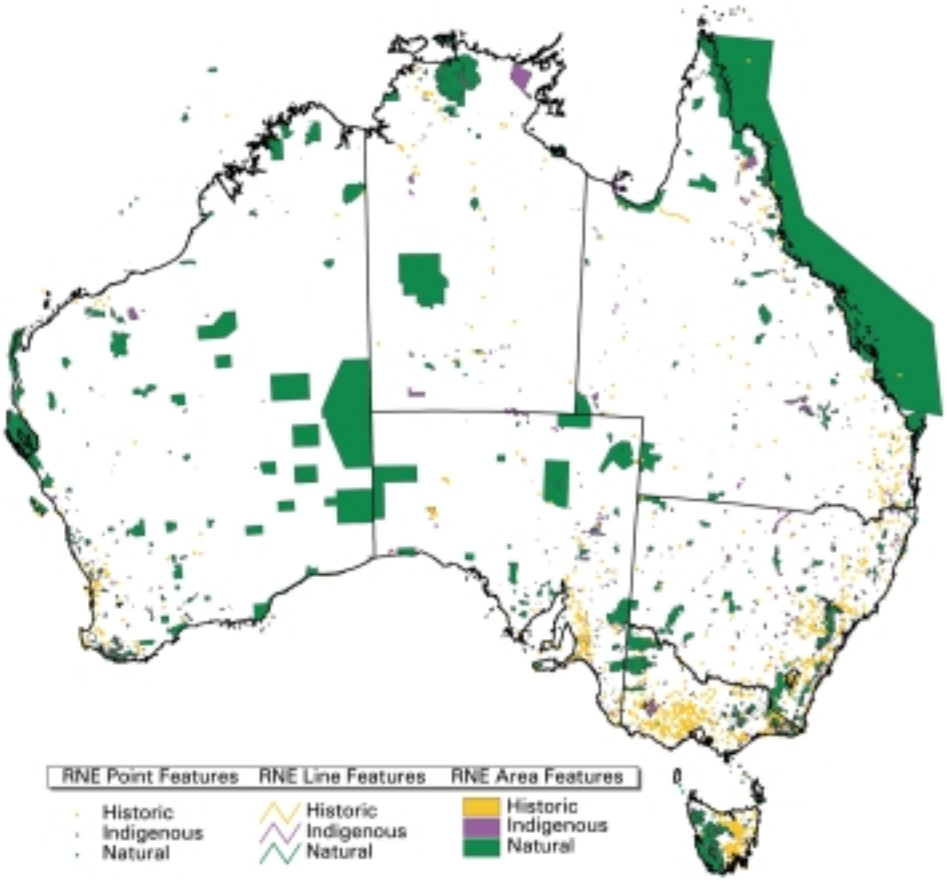


Figure 34: Distribution of all places listed on the Register of the National Estate 2000.

Source: Environment Australia; Register of the National Estate Data Base.

Sydney regions) have resulted in the further identification of heritage sites, although most have not yet been recorded in heritage registers. About 3000 heritage sites were identified through the RFA process. These surveys were important as the first large-scale attempts at integrated assessments of all heritage values.

During the reporting period, the number of places listed on the Register of the National Estate (recognised for their heritage values by the Australian Heritage Commission) rose from 11 000 to about 13 000. The list of Register places was made accessible over the Internet. Figure 34 shows all places registered or listed on the Register of the National Estate as at the end of 2000 and Figure 35 shows places added from 1996 to 2000.

Trend: Knowledge of heritage places

There is an increasing trend in the number of natural, Indigenous and historic heritage places being identified; however, gaps exist and responses are adequate in some respects.

Conservation and management of heritage places

Overall conservation of heritage improved during the reporting period of 1996 to 2001. The *Natural and Cultural Heritage* theme report describes these improvements but the balance sheet is not a cause for complacency. Components of Australia's distinctive natural and cultural heritage are still being lost due to the inadequate identification and protection of heritage places and associated objects or collections and Indigenous languages. In addition, there are uncertainties about future heritage management arrangements and how these will affect conservation regimes.

A survey of 12% of the historic heritage places listed in the Register of the National Estate found that 95% of places were in fair or better condition. However, the survey found:

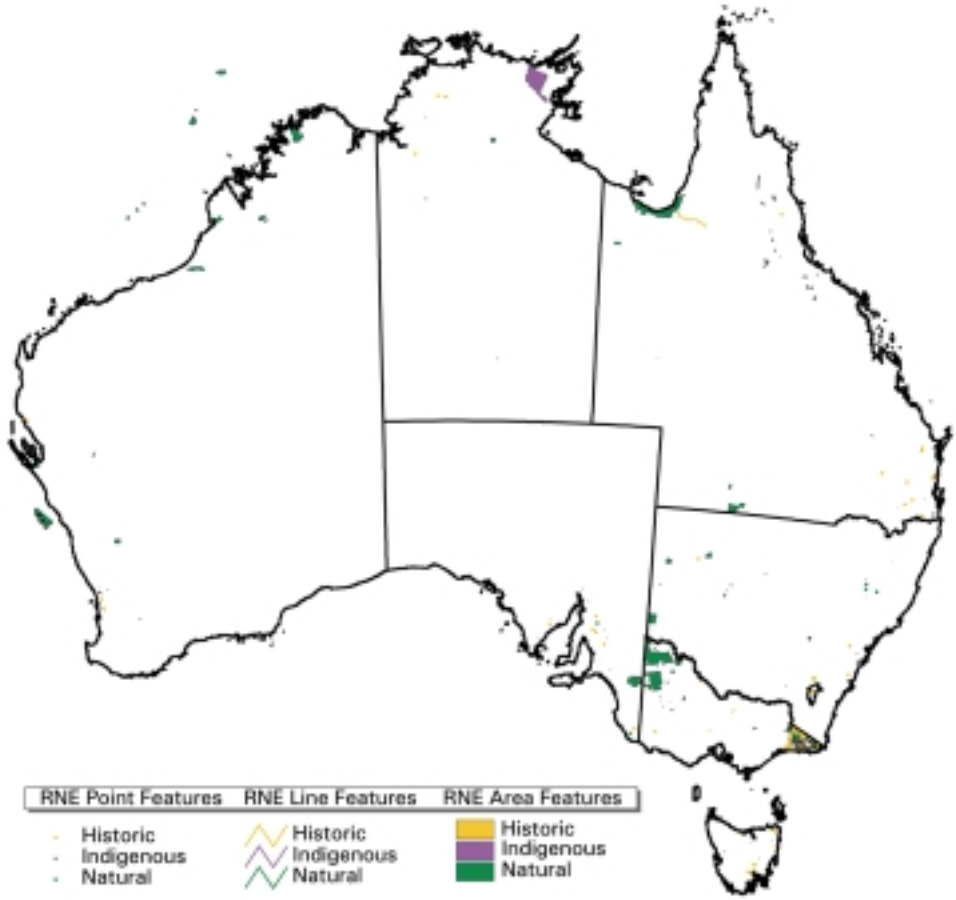


Figure 35: Places added to the Register of the National Estate from 1996 to 2000.

Source: Environment Australia; Register of the National Estate Data Base.

Woolmers Gardens, near Longford, Tas.

The gardens are in good condition and highly intact. They are part of an extensive historic rural estate now opened to the public.

Source: Duncan Marshall.

Naval Brigade Stores, Kangaroo Point, Brisbane, Qld.

The stores were built between 1886-87 for the Queensland colonial navy and taken over by the Commonwealth after Federation.

Source: Mike Pearson.

- continuing occurrence of vacant and deteriorating government buildings, demonstrating governments' lack of interest in funding heritage assets in the various jurisdictions
- growing ongoing and deferred maintenance for many churches will pose major conservation funding problems until 2010
- continuing low but steady rate of damage to heritage buildings by inappropriate works such as 'modernising' of shop fronts and interiors, and insertions of windows.

Management of heritage places has been affected during the reporting period by declining budgets allocated to public sector agencies for maintenance and conservation of heritage sites (with notable exceptions such as Victoria's Public Heritage Program). Cessation of the National Estate Grants program and the tax incentive scheme for owners of private heritage property and their replacement by a limited grants program has not helped. The trend is to support tourism infrastructure rather than conservation maintenance *per se* as exemplified by the range of funded heritage trails and localised grants for Centenary of Federation projects.

In many jurisdictions, there is still a lack of integrated management planning for the conservation of both natural and cultural heritage. This leads to unnecessary neglect of one or other aspect of heritage, even in conservation areas. This is despite some examples of this planning, especially in the RFA surveys.

Loss of historic heritage places continues at an uncertain pace as a result of:

- urban redevelopment due to main street redevelopments and loss of functions due to construction of shopping centres
- urban consolidation affecting the heritage character of older suburbs

The Norfolk Island convict-built pier being inspected for urgent repairs. It has been in constant use for more than 150 years.

Source: Jane Lennon.

- abandonment of rural structures due to changing technology and new markets and products
- public building redundancy due to movement of client population especially in rural areas, asset rationalisation and mergers
- loss of cultural landscapes through changing rural use.

These are difficult issues for people to respond to and it is hard to gauge community support for heritage issues statistically from the data collected. Media emphasis has been overwhelmingly on nationwide 'green' issues (e.g. forests or salinity), in comparison with local coverage of specific heritage places. These individual issues regarding heritage places have lacked coordination from peak interest groups because of the diffuse types and locations of heritage advocates. The exception has been the development of community interest in Centenary of Federation cultural heritage projects.

Surplus Mittagong (NSW) Railway Station building being offered for lease for alternative use.

Source: Ian Robertson.

Trend: Conservation and management of heritage places

Condition of heritage places has remained static; however, losses are continuing and responses are adequate in some respects. In particular, there are uncertainties about future management arrangements.

Indigenous involvement in heritage protection and management

Indigenous heritage issues seem to be increasingly handled and, to a certain extent, controlled by Indigenous peoples. This is demonstrated by, for example, the presence of Indigenous site officers in government, industry and community employment; and the general strength of concern expressed by Indigenous peoples for their cultural heritage.

Indigenous heritage issues have been at the forefront of the political debate during the reporting period. This has had some favourable results, but there has also been a strong polarisation of views especially in regional Australia, with some resentment of perceived favourable treatment for Indigenous Australians. Rejection by the government of significant aspects of the 'Stolen Generations' Inquiry Report (HREOC 1997) has led to public dispute about the facts of the treatment of Indigenous peoples since European settlement of Australia. Similarly, continued publicity (often inaccurate) about land rights and Native Title has made many country landowners suspicious of, or even destructive towards, Indigenous sites. These issues may have had some negative effect on Indigenous peoples contributing information about Indigenous heritage places. Several high profile controversial disputes concerning the importance of Indigenous sacred sites and their conservation versus other proposed land use demonstrate that there is still considerable disagreement and misunderstanding in the community about these complex issues and their resolution.

Work on Native Title and land claims is encouraging detailed research into Indigenous tradition and recent Indigenous history, with an increasing number of sophisticated and integrated studies which present a holistic

From redundancy to ruins—rural branch line railway, approaching Aramac in western-central Queensland.

Source: Jane Lennon.

Cobb & Co. Changing Station, Buangor, Vic. This coach and livery station dates from the 1860s. It has been modified for other uses but is now vacant.

Source: Mike Pearson.

view of Indigenous culture. The study and celebration of recent Indigenous history by Indigenous peoples is demonstrated by the healthy publication rate of memoirs and regional Indigenous histories, and by nominations to the Register of the National Estate of significant Indigenous historic sites like the Wave Hill Walk Off sites in the NT, the Cubbitch Barta National Estate Area (commonly known as the Holsworthy Military Training Area, NSW) and the Cyprus Hellene Club in Sydney, the site of the first Aboriginal Day of Mourning in 1938.

Major public events, cultural activities and media coverage, contribute to an increasing public awareness of Indigenous culture and heritage.

The active program through the NHT to augment the national reserve system in Australia continues to improve the conservation of Indigenous places conserved in natural environments. Since 1998, 13 Indigenous Protected Areas have been established as part of Australia's National Reserve System.

The number of heritage places and landscapes owned and managed by Indigenous peoples continue to increase above the 15.1% level that they held in 1996. The 1996 figure was an increase from 9.6% in 1983. This compares with almost 8% in National Park or conservation reserve tenures in 1996.

The Return of Indigenous Cultural Property Program instituted in 1998 is facilitating the return of cultural property to Indigenous peoples from Australian museums and other collecting institutions. There were increased efforts for the repatriation of Indigenous materials by Australian museums within the reporting period, especially for human remains and secret, sacred objects.

Although Indigenous peoples are involved in Indigenous heritage management, many of the protocols for consultation and involvement instituted by local Indigenous communities are not always recognised and used effectively.

Olsens Home Hardware Store, Warwick, Qld.

The store was built in stages from the 1870s to 1908. It is now covered with a hoarding that hides the facade—a common treatment in many towns.

Source: Mike Pearson.

Steel's Garage, Bolton Street, Newcastle, NSW.

Built in 1888 as skating rink, it was converted to a garage in 1939. Now it is mainly a pay car park. The facade is retained but the interior is largely modified.

Source: Mike Pearson.

Indigenous languages

The number of Indigenous languages and the percentage of people speaking these languages has continued to fall between 1986 and 1996 (Figure 36), the trend accelerating over the 10 years. By 1996, only 17 of the previous 20 strong languages were still strong and three had become endangered.

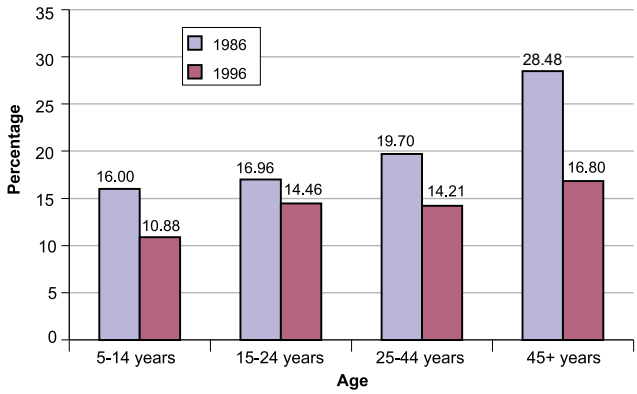


Figure 36: Comparison of 1986 to 1996 Census data on Indigenous language use in the home.

Source: ABS (1996) data, in McConvell and Thieberger (2001).

Funding for heritage

The NHT and the Centenary of Federation Fund provided substantial boosts to heritage conservation and management of heritage places and objects (e.g. World Heritage property management, the Queensland Heritage Trails Network and the new National Museum of Australia).

The NHT program contributes significantly towards improving the adequacy and representativeness of the conservation reserve system through its acquisitions program. However, it does not provide sufficient funding to reach the target percentage of reserved environmental types.

In contrast to the NHT's assistance for natural heritage places, there are no long-term national funding programs of similar magnitude specifically for Indigenous or historic heritage places.

School lesson in an Indigenous language being held at the Halls Creek District High School in the Kimberley, WA.

Source: Volodymyr Malanczak.

Legislation and strategies

In 1998, the Cultural Ministers Council released *Australia's Heritage Collections—National Conservation and Preservation Policy and Strategy*. A survey found that environmental conditions for storing heritage objects in the major collecting organisations appear to be reasonable across all sectors. The proportion of collections catalogued across all heritage sectors appears to be improving.

There were significant advances in heritage methodology and practice during the reporting period. The Australian Natural Heritage Charter was adopted in 1996. In 1999, a new version of the Burra Charter was released. The Burra Charter (see http://www.icomos.org/australia/burra.html) now addresses intangible aspects of heritage places such as understanding, meanings and use, in addition to its traditional concern with the

The new National Museum of Australia in Canberra, ACT, was created around the themes of land, people and nation.

Source: George Serras, National Museum of Australia.

Over three seasons, the AAP Mawson's Huts Foundation has conserved the historic 1911–14 Mawson's Huts in Antarctica.

Source: Rob Easter, Australian Antarctic Division..

physical fabric. There has been more regard for Indigenous heritage values other than the specifically archaeological, and this has led to integrated assessments in RFAs and other assessments.

Australia continues to be a leader in heritage practice. Within the reporting period, the Chinese government worked with the Australian Heritage Commission to adapt the Burra Charter to Chinese conditions. It remains the basic document from which all Chinese conservation policy is to be developed and implemented.

There is major challenge to the management of Australia's heritage presented by the proposed new Commonwealth legislation, which will close the Register of the National Estate and consequently leave a vacuum in measuring trends using existing information. The Register is the only source of national data across all environments and arguably assists Australians to think of their heritage in an all-encompassing way. Whereas the effect of the changes in legislation will be discussed in future reports, there is already concern that state, territory and local governments will not accept their responsibilities. At the heart of the matter are the lack of agreed national standards and the inconsistency of the heritage place legislation across different jurisdictions. This creates a barrier to bilateral agreements for funding.

The failure of the Commonwealth government to respond effectively to the Schofield Report on the condition of heritage stock in its possession is seen as a lack of leadership. It affects all Australians as, for example, post office buildings become redundant and are inappropriately reused or demolished. This remains a challenge and reminds us that what may be initially seen as progress can easily become a loss of familiarity and place in a local community. Similarly the Commonwealth government has failed to pass amendments to existing legislation to better protect Indigenous heritage places based on the recommendations of the Evatt Report.

Data availability

There is a problem of collection of data for heritage indicators across a diverse range of sources—natural, Indigenous, historic places, Indigenous languages, heritage collections and objects. Constant changes to the information collected, or not collected, and reported, means that it has not been possible to have a set of constant, robust indicators applied across Australia. In addition, there has been no organised collection of standard data between SoE Reports on which to base an analysis of trends.

No suitable data are available for assessing condition of natural and Indigenous heritage places, other than that for natural heritage places within World Heritage Areas.

Heritage objects

A survey of museums found that there is no coherent, agreed, national definition or shared view of what might constitute cultural heritage collections despite the presence of the National Conservation and Preservation Policy and Strategy. Most small museums have little idea of the significance of particular items in their collections, and despite the introduction of Australian Museums & Galleries Online (AMOL) database to collect this information, we do not know how many objects by category are held in these 2000 museums. Nor do we know their condition. Small and large museums generally have documentation systems that are idiosyncratic and inadequate to meet current demands of scholarly and public access. Many of the collecting institutions highlighted a shortage of storage space as an issue, thus affecting the condition of objects.

Heritage collections generally are not perceived as relating to heritage places in which they were located, yet that is a primary interest for SoE reporting. For museum curators, the object or collection may be significant for many reasons other than place of origin. The archival or scientific value is not related to their place of provenance but rather to their story, as can be seen for example with dinosaur fossils in a museum rather than *in situ* at Lark Quarry or Riversleigh.

Trend: Heritage objects

There is improving documentation of objects in collections, pressures remain constant and responses are adequate to some extent.

Role of professionals and volunteers in heritage

The role of the volunteer is an often masked issue in historic conservation. As heritage becomes more professional in its methodology and seeks to attract employees with professional education and training, there is an increased divide between the roles of the volunteer and the professional. It is a constant source of tension and remains unresolved especially as there is very little government funded or sponsored support for community involvement in historic heritage conservation. The lack of integration of effort or recognition of what we each have to offer has severely weakened the cultural heritage movement and may, in part, explain the discrepancy in funding between natural and cultural heritage. However,

Bicornial baskets with their distinctive pointed ends are only found in the Cardwell and Cairns districts of northern Queensland.

This basket was collected in the 19th century.

Source: National Museum of Australia.

The Hills Hoist has become an icon object of post-war suburban life in Australia. This rare 1955 model is part of the National Museum's extensive Hills Hoist collection.

Source: National Museum of Australia.

Newcastle (NSW) Convict Lumber Yard Archaeological Site of the 1814–1850 convict establishment. The site was excavated, and building outlines were marked with metal structures. The site is an additional tourism attraction in this regional town.

Source: Mike Pearson.

the growth of local heritage groups and the demand for protection of local heritage exemplified by the Save Our Suburbs movement in large cities indicates support for community involvement.

Trend: Community involvement

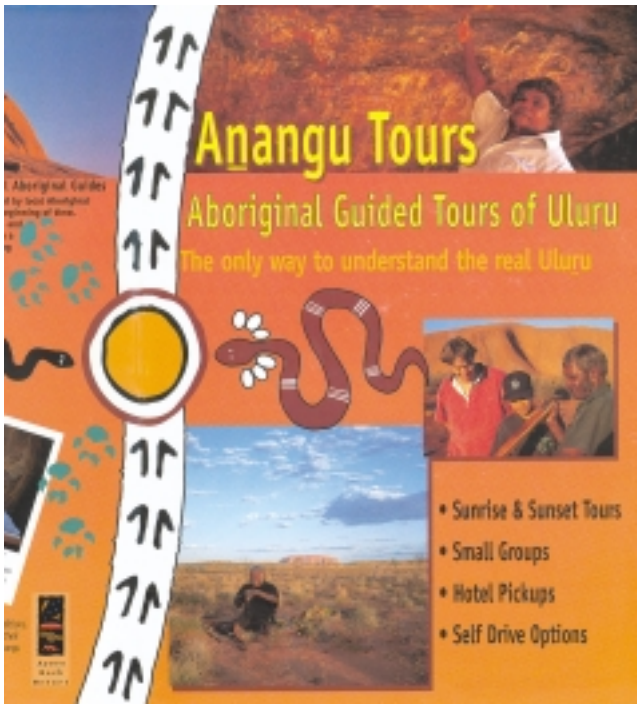
There is increasing involvement in natural heritage but less for Indigenous and historic heritage.

Effect of tourism on heritage

The effect of tourism reflects the positive–negative conundrum of heritage. Governments and tour operators encourage tourism for its revenue but there are insufficient controls in place to balance conservation with revenue. There is also concern that we present and interpret the heritage values of our special places appropriately. Development of management plans at sites of high tourist interest is being used increasingly to overcome these pressures.

Threats to the sustainability of cultural and natural heritage

Sustainable heritage means that the nation's heritage is respected and appreciated by Australians and international visitors and that use of, and visits to, heritage places and objects contribute to the social and economic well-being of the nation without detriment to the heritage resources and its values. Yet there exist some significant threats to the sustainability of Australia's heritage (Table 11).



Example of Indigenous tourism brochure.

Source: Anangu Tours.

Conclusion

Natural heritage has been the most important aspect of heritage over the last five years with many significant

Table 11: Natural and cultural heritage: key threats to sustainability in 2001

Issue	Detail	Comment
Knowledge about heritage places and objects	Surveys have been undertaken but the resulting data about heritage places has not been assessed for registration	Integrated assessments, identification and conservation of all heritage values on any particular piece of land is required
Physical condition of heritage places and objects	Little quantifiable data available and no national monitoring system is in place to assess the condition or health of heritage places	Demolition, clearing and incremental losses continue Heritage assistance programs at the local level are inadequate but could assist assessments
Cultural values of all types are being neglected in natural areas	Indigenous heritage places can only be conserved effectively *in situ* and as part of the natural environment of which they are an integral component Protocols not being always complied with, thus lack of sustainability of the heritage resource	Integrated conservation planning which provides for the protection for all values is essential Cultural landscape framework will assist in the integrated assessment of all values for a place
State of traditional Indigenous languages	The number of Indigenous languages and the percentage of speakers have continued to decline, although there is some language revival around one South Australian region	There are an estimated 55 000 Indigenous language speakers Only 17 Indigenous languages are regarded as 'strong' Lack of speakers in young age groups is a concern
Survival of heritage in areas of significant population change	Many places are under significant threat from urban expansion, redevelopment and rezoning on urban fringes and from neglect/abandonment in rural areas	Statistics reporting losses are poor especially for rural areas
Disposal of heritage properties	Government reorganisation in all jurisdictions has resulted in redundant heritage assets	Loss of function has resulted in changed and lost heritage values for many places
Community involvement	There has been a declining involvement of people in historic heritage and an increase in natural heritage issues Indigenous communities are participating more in heritage protection	As heritage becomes more professional in its methods and employment patterns change to shift and untenured work, there are fewer skilled volunteers available
Impact of tourism	Government policies encourage tourism for its revenue but there are negative effects from physical pressures on the heritage resource and from inadequate interpretation of the heritage values of places	Lack of monitoring of effects is a continuing concern Lack of evaluation of visitor understanding of heritage values of tourist places
Ignorance and lack of passion and vision for the future	Heritage, like beauty, has a subjective element to it; however, widespread ignorance of Australian settlement history, Indigenous history and basic ecology means that many citizens are unable to make contextual judgments	Heritage becomes a business and less able to inspire citizens about the privilege and responsibility of managing the only continent in the world occupied by one nation—Australia!
Changing legal and administrative arrangements for heritage conservation	Failure of national leadership to date to establish a set of minimum standards for the identification, listing and conservation of heritage places	Gaps in the identification and conservation of heritage places if implemented before state, territory and local systems are developed to fill the gaps left by the demise of the Register of the National Estate
No development or testing of models of sustainability applicable to heritage places	Places are only sustainable as heritage sites if adequately funded and protected so that their values are known and respected	Lack of monitoring of pressures affecting sustainability of historic heritage especially in urban areas

achievements. Australia's position has been enhanced with the inscription of three new World Heritage sites and the contribution of Australia's heritage expertise being recognised on a world scale.

Indigenous cultural heritage issues are becoming better known to Australians and the importance of heritage and culture recognised through the opening of the National Museum of Australia.

But for almost every advance in heritage, there has also been a retreat (e.g. a loss of heritage places and a loss of Indigenous languages). The uncertainty in the legislative framework for heritage raises questions about future heritage management.

Human settlements

Human settlements are where most Australians live and work. Their design, planning, construction and operation are fundamental to the productivity and competitiveness of the economy, the quality of life of all citizens and the ecological sustainability of the continent.

Human settlement in Australia dates back at least 60 000 years to an Indigenous population engaged in hunting and gathering. With the arrival of Europeans just over 200 years ago, the first of a series of major societal, economic, technological and settlement transitions occurred.

There have been several improvements in recent years. Examples include cleaner air in our cities, reduced use of water by households on a per household basis, increased recycling of some materials, improved efficiency in the use of energy by households and improved streetscapes in many parts of Australia. Nevertheless, many problems remain. Most problems occur as a result of the very high level of material and energy consumption, which shows no sign of abating and continues to increase at a high rate for many materials.

In considering the condition of human settlements in Australia, there are seven key issues, discussed below:

- the pattern of human settlements
- infrastructure, particularly for Indigenous communities
- material and energy consumption
- urban water use
- transport use
- indoor air quality
- management of waste.

A summary is presented in *Key findings* (page 9).

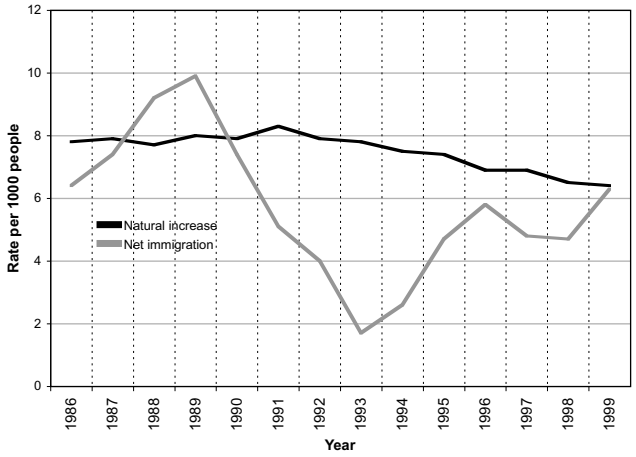


Figure 37: Components of population growth, Australia, 1986 to 1999.

Source: ABS (2000d).

Key issues

Environmental pressures are accentuated by the pattern of human settlements

Australia's population is estimated to be 19.3 million. The pattern of settlement is characterised by high rates of urbanisation but low density cities. Most Australians (about 60.7%) live in the five largest cities. Significant coastal non-metropolitan urban growth is also occurring, particularly in New South Wales, southern Queensland and south-west Western Australia.

Over the next 10 years, the population growth rate is expected to decline slightly from 1.1% to 0.9% per annum. The pattern of human settlement is not expected to change greatly although urbanisation is expected to increase. The five largest cities are expected to contain 61.6% of Australia's population in 10 years.

The main contributor to population growth continues to be natural increase (births minus deaths) but net immigration is also important. Its contribution is more variable (Figure 37).

The effect of this growth on human settlements is variable. Australia continues to experience very significant levels of population growth associated with the mega-metropolitan regions centred on the state capitals. The major component of this growth is continuing suburbanisation and the extension of urbanised area into the regions surrounding the officially designated metropolitan areas. These may develop further in prominence as high-speed ground transport (i.e. freeways, but more particularly high-speed rail) transforms provincial cities, such as Ballarat, Traralgon, Newcastle, the Gold Coast region and Toowoomba, into commuter areas of their respective state capitals because of reduced journey-to-work travel times.

The continued growth of these mega-metropolitan regions, particularly in the coastal margin, raises significant issues for policy and planning. For example the effect on often fragile coastal environments is substantial and in some jurisdictions, such as New South Wales, there are steps to regulate coastal development (see Premier's statement on Coastal–Package, 26 June 2001). The implications for the supply of water, provision of transportation infrastructure, management of waste outputs and loss of biodiversity at the urban fringe present major challenges.

Increased residential construction activity is one of the consequences of population growth. The decline in the average size of households (2.6 persons in 1996 compared with 3.3 persons in 1976) and the increase in average floor space (3% per annum over the last 7 years) add to the pressures.

Suburbanisation of both population and jobs post-World War II has been an important, indeed dominant, process shaping the development of big cities, with settlement pushing further out into the urban fringes and peri-urban regions. The general pattern of development had been of population growth in outer metropolitan areas and a decline in the population of

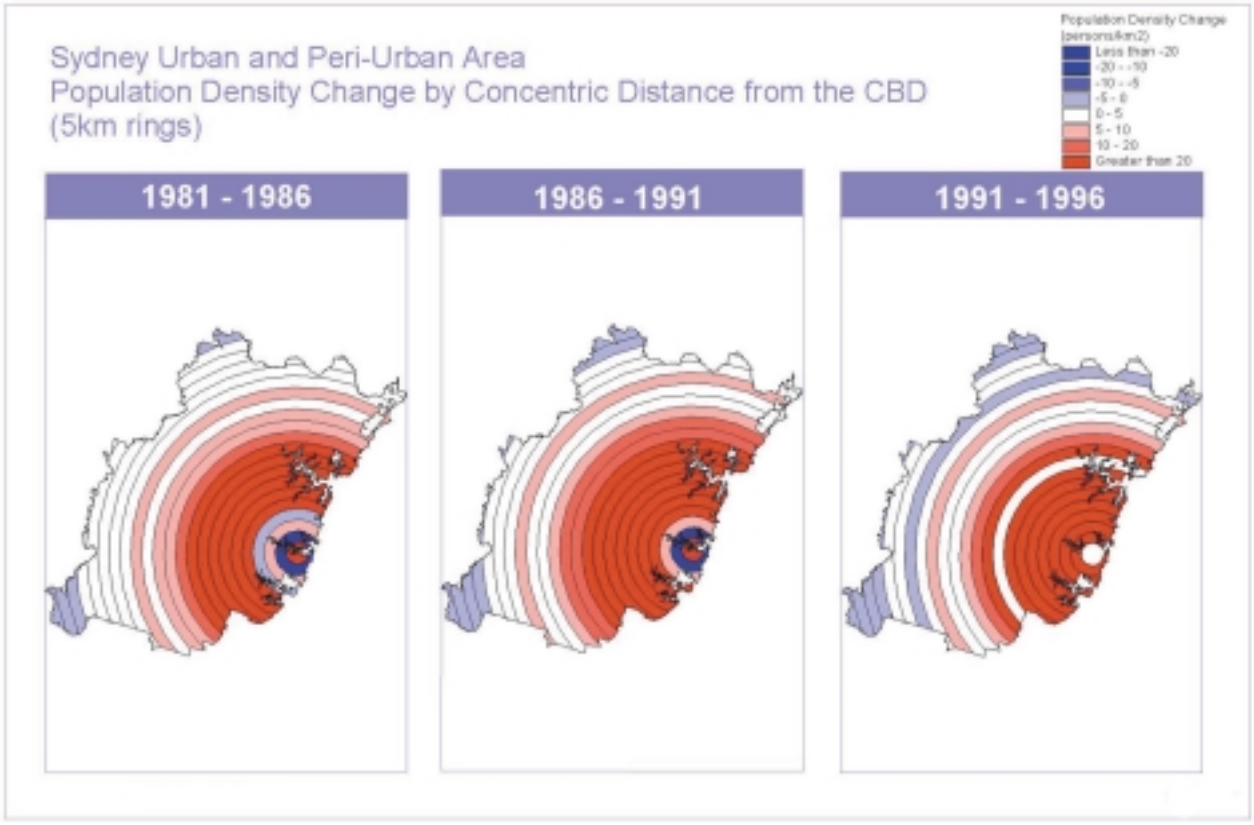


Figure 38: Change in population density, Sydney, 1981 to 1996.

Source: Baker et al. (2001).

the inner city suburbs. In the 1990s, a new trend is counteracting some of the push to further suburbanisation. Population numbers in inner-city suburbs have begun to increase in all five of the nation's big cities (Figure 38). After decades of decline, many of the older sections of the inner cities have taken on a new lease of life. The rates of population growth in the inner-city suburbs are, however, still well below those occurring in the outer suburbs and fringe areas. Thus, the relatively small aggregate effect of reurbanisation in redistributing population growth patterns in the big cities needs to be put in its proper perspective, as there is a tendency to exaggerate the overall impacts of the inner-city renaissance on growth patterns.

The previous Commonwealth government commissioned an Urban Design Task Force which published a report in 1994 on urban design in Australia. Subsequently, the current government decided to leave issues of urban design to the states and territories. There has been considerable research into good urban design but little in the way of programs apart from a few notable exceptions.

Outside the metropolitan areas there is significant growth along the coast, particularly in New South Wales and Queensland. The pattern of inland regional and rural settlement in Australia is characterised, however, by periods of growth and decline as the fortune of regions and their associated cities and towns rise and fall with demographic, social and economic change. There has been growth in several inland regions, mainly the larger provincial towns, but the population of smaller towns and rural areas has declined.

An important issue affecting the viability of many smaller towns is the impact that surrounding larger centres can have on economic and social activity. Over several decades many small inland towns have declined as a result of their rural hinterland populations bypassing them. A wider range of goods and services are available in the larger regional towns. This decline is expected to continue. This reduces the capacity of smaller settlements to deal with environmental and heritage issues from their own resources.

Another important influence on human settlements is the significant increase in short-term visitors. The lure of Australia as a tourist destination since the mid-1980s is reflected in the continuing increase in the numbers of short-term visitors; the annual growth rate has been nearly 10%. This increase affects Australia's cities and regions in a variety of ways and it is also spatially selective. Often it is responsible for significant growth in service-based industry and

The Green Games

The Sydney Olympic Games of 2000 (see http://www.sydneyolympicpark.nsw.gov.au) provided an opportunity to showcase sustainability of a human settlement. The main benefits of the Green Games were:

- hazardous waste site remediation into a world-class sporting, residential, business, recreational and conservation precinct
- water conservation through on site rainwater collection and irrigation, recycled water for toilet flushing, environmental flow enhancement for Boundary Creek
- energy conservation measures which include: passive cooling to reduce air-conditioning loads; one of the world's largest solar-powered suburb; and natural-gas-run buses. These measures considerably reduced greenhouse gas production
- waste management measures which included: 90% reuse and recycling of construction waste; recycled cardboard furniture and food and beverage packing; biodegradable cutlery and serviettes to maximise the utilisation of organic waste into saleable compost; excess seating provided with relocation and reuse prearranged.

employment and can provide an important economic stimulus, especially in regions that have declined as a result of the downturn in traditional industries. Overall, non-metropolitan locations attract fewer numbers of international tourists, the exceptions being the Whitsunday (Great Barrier Reef) coast in Queensland and the Uluru–Alice Springs area in the Northern Territory.

In summary, the particular pattern of human settlement in Australia accentuates pressures on the environment. The population in most of Australia's major cities will continue to increase. We need to plan for this increase. Good urban design is one way of reducing the environmental impact. But little is being done in the way of real change in urban design. There has been considerable research on the topic but there is no agreement on preferred urban form, taking account of environmental considerations; although there is growing evidence that developments with a more concentrated form of settlement deliver environmental benefits of lower VKT, energy consumption, carbon dioxide emissions and urban water use. Other factors such as improved streetscapes, noise, access and security are also important.

Trend: Form of human settlement

Pressures on the form of human settlements have remained constant since 1996 while responses have been inadequate in most respects.

Inadequate infrastructure, particularly for Indigenous communities

Indigenous demography and settlement patterns differ from the rest of Australia in several important respects (see *Growth in the number of Indigenous Australians* box on page 99). Proportionately, Indigenous peoples are more likely to live in rural and remote areas and are less likely to live in major urban centres than other Australians. Problems of isolation and access compound problems of these types of settlements. There are several Commonwealth and state programs aimed at improving the living conditions of Indigenous communities. Although some progress may have been made, a lot more needs to be done as many communities still have inadequate housing, power and water supply, sewerage and road access. Such developments may contribute to improved health outcomes and other benefits.

Australia has experienced considerable reductions in mortality in the 20th century, largely as a result of improvements in many social and environmental amenities and conditions (e.g. hospitals, sanitation, health education, quality of food and water supply). However, these improvements are not uniform. Indigenous peoples, and those living in rural and remote areas have higher death rates than the general population.

Although environmental hazards are increasingly seen as important factors influencing health, there is no strong evidence that morbidity rates due to these factors are increasing. The quality of drinking water is good as outbreaks of waterborne diseases are few. Although there

Growth in the number of Indigenous Australians

The official estimate of the number of Indigenous peoples has been increasing rapidly. Between 1991 and 1996, the population grew by around one-third to almost 353 000. This increase in numbers is influenced strongly by the change in the propensity for individuals to identify as Indigenous.

About half of the net increase can be explained by births, deaths or migration. Factors which may help to explain the remaining increase include changes in the rate at which children with only one Indigenous parent are identified as Indigenous; changes in the propensity of Indigenous peoples to record themselves as such on the census form; and improvements to census counting procedures.

The age distribution for Indigenous Australians differs markedly from that of the rest of the population. About 60% of Indigenous Australians are aged less than 20. The corresponding figure for all Australians is 35%. This is also reflected by the substantial differences in median ages—20 for Indigenous Australians compared with 33 for all Australians.

has been some increase in reported outbreaks of foodborne diseases, our food contains low levels of chemical residues and metals. There has been some increase in vectorborne diseases (e.g. encephalitis) in recent years, although they are still at low levels. Some believe global warming is a factor but there is no hard evidence.

However, the decline in spending on public sector infrastructure could have environmental consequences. For example, ageing sewer pipes are considered a major problem, with many between 50 and 100 years old. A report from the Institution of Engineers Australia (see http://www.infrastructurereportcard.org.au) on infrastructure rated the condition of the roads, bridges, railways and water and sewerage networks as relatively poor.

Trend: Urban infrastructure

The condition of some urban infrastructure is deteriorating, pressures on it are increasing and responses have not been fully adequate.

High material and energy consumption

Materials

Australia's level of per capita material flows is very high by world standards and continues to grow rapidly. Australia generates material flows of almost 180 t/person per year and there has been little progress on decoupling economic growth and material consumption. The current trend is not sustainable and the pressure to achieve dematerialised economies will require much more attention to, and analysis of, material flows in urban areas.

Studies of metabolic flows in European cities (e.g. the study of the urban metabolism of Vienna) show that it is not only important to measure flows of energy and materials into and out of urban areas, but also that it is important to look at accumulations of materials. Accumulations can be a significant potential source of both future pollution and stocks of materials for future recovery and use (Figure 39).

The use of most materials is largely set at the design stage of products and processes and therefore the focus for reduced material use should be at this stage. Ecodesign and cleaner production can reduce material consumption in production of products and services. However, gains from these type of initiatives have been more than offset by increases in per capita use of these products and additional features included with the products. Ecolabelling and product declarations have been used to try to drive consumer behaviour toward selecting products with recycled material, water and energy efficiency, or low toxicity in production or disposal, but have had limited success.

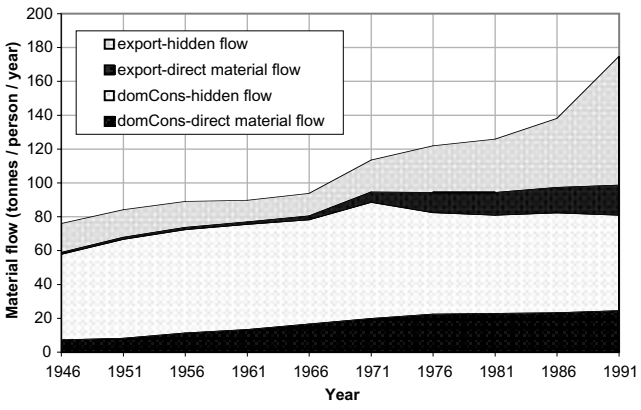


Figure 39: Components of total material flow per person, exports and domestic consumption each disaggregated into direct material input and hidden flow.

Source: Foran and Poldy (2000).

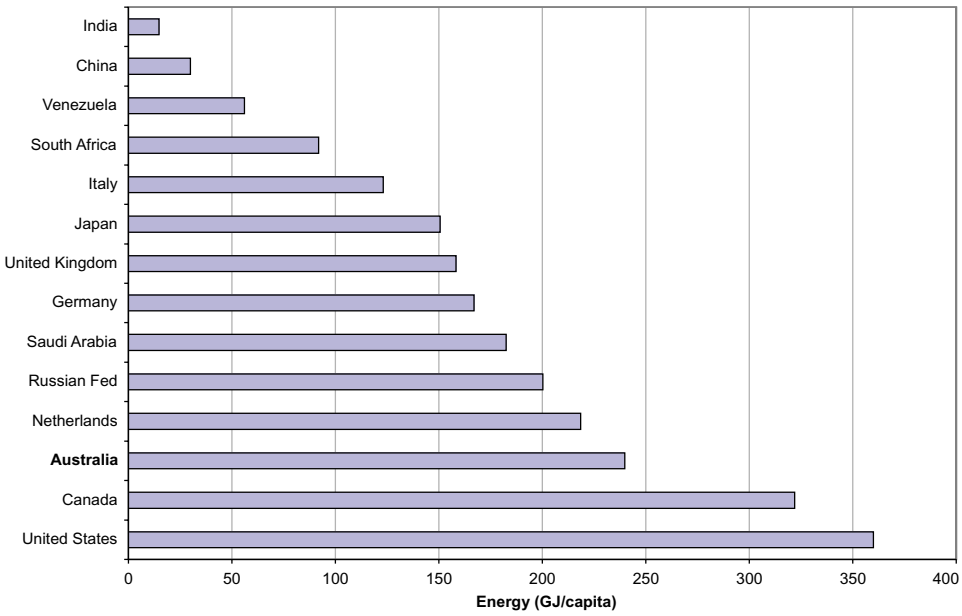


Figure 40: Comparison of Australian energy use per capita in 1995 with selected countries.

Source: WRI (http://www.wri.org).

A lack of regulatory and financial pressures (i.e. relative prices of ecoefficient energy and materials) limits the penetration of ecodesign and cleaner production technologies.

Trend: Material use

Material use per capita has continued to increase since 1996 while responses have been adequate to some extent.

Energy

Australia's per capita energy use is also very high by world standards (Figure 40) and continues to grow rapidly. Total energy use has doubled over the last 25 years and, unlike most other developed countries, at a faster rate than the GDP. With one of the highest rates of growth in energy use in the world, and the associated increasing emissions of greenhouse gases, energy usage is increasing at an unsustainable level. The main contributor to the growth in energy use is the generation of electricity to support the needs of a range of end users.

One of Australia's responses to global warming has involved increased emphasis on development of renewable energy and stronger policies on energy efficiency. The AGO was formed to stimulate and encourage these types of initiatives. Programs aimed at increasing energy efficiency (particularly in the household sector), and the use of sustainable energy sources are having an effect but are not enough to offset the impact of increasing demand. More efficient electricity generation would significantly improve the situation.

Schemes such as Green Power tariffs, where consumers voluntarily pay extra for energy derived from renewable sources, have only met with moderate success. We are still well short of the Commonwealth government's 2% renewable target, a mandatory requirement that electricity suppliers buy extra renewable energy.

Programs run by agencies such as the New South Wales Sustainable Energy Development Authority, the Sustainable Energy Authority of Victoria, agencies in other states, and the Commonwealth government's AGO and Department of Industry Science and Resources are all contributing to the development of sustainable energy products and services, as well as the growth of the industry itself. There has been higher take up in New South Wales than other parts of Australia. There is also an increasing interest at the local government level. Over 85 councils now participate in the Cities for Climate Protection program, which involves them in preparation of greenhouse inventories, action plans and targets, as well as implementation of measures to reduce emissions.

Despite these initiatives, energy from 'cleaner' renewable sources (Figure 41) is growing at a much slower rate than energy derived from other (non-renewable) sources (e.g. coal).

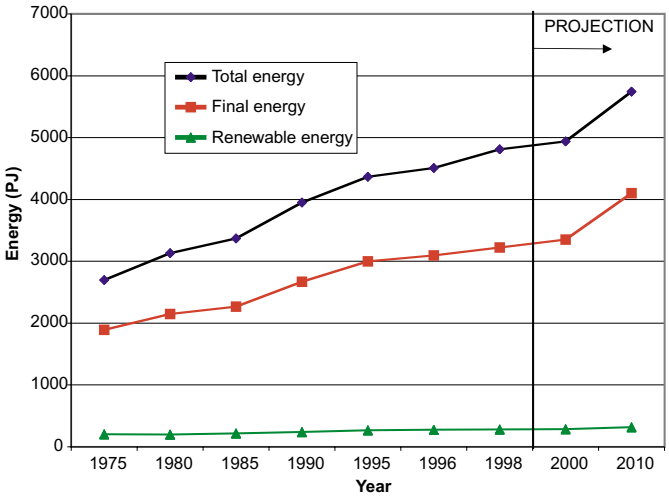


Figure 41: **Trends in total energy, final energy and renewable energy consumption in Australia 1975–2010.**

Source: Newton et al. (2001).

Reform of the energy market was originally seen as a greenhouse gas strategy, but the lowering of energy prices is encouraging higher use. The reforms have been specifically targeted at lowering energy prices, without internalising the full costs of energy production and use (i.e. the cost of their environmental effects). In contrast, the higher cost of renewable energy sources is discouraging their use and may explain their relatively low growth. Figure 42 compares electricity prices in Australia with other countries, confirming our relatively low energy prices.

Community awareness of the implications of their high energy use appears to be low. Increased awareness may influence some behaviour. Furthermore, there is little movement towards designing goods and services so that they have reduced energy and material inputs (e.g. by using recycled materials) even though this is technically feasible. Some market intervention that affects relative prices may be necessary to provide the incentives to move towards lower use of the energy sources with greatest environmental impacts.

Trend: Energy use

Energy use continues to grow while responses have been inadequate.

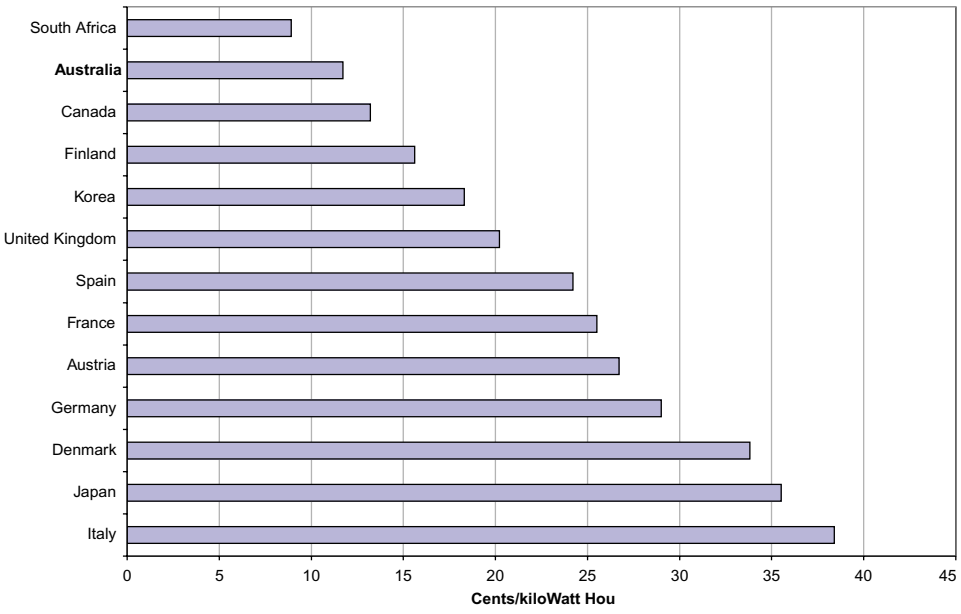


Figure 42: **Residential electricity price comparison, January 1999.**

Source: ESAA (1999).

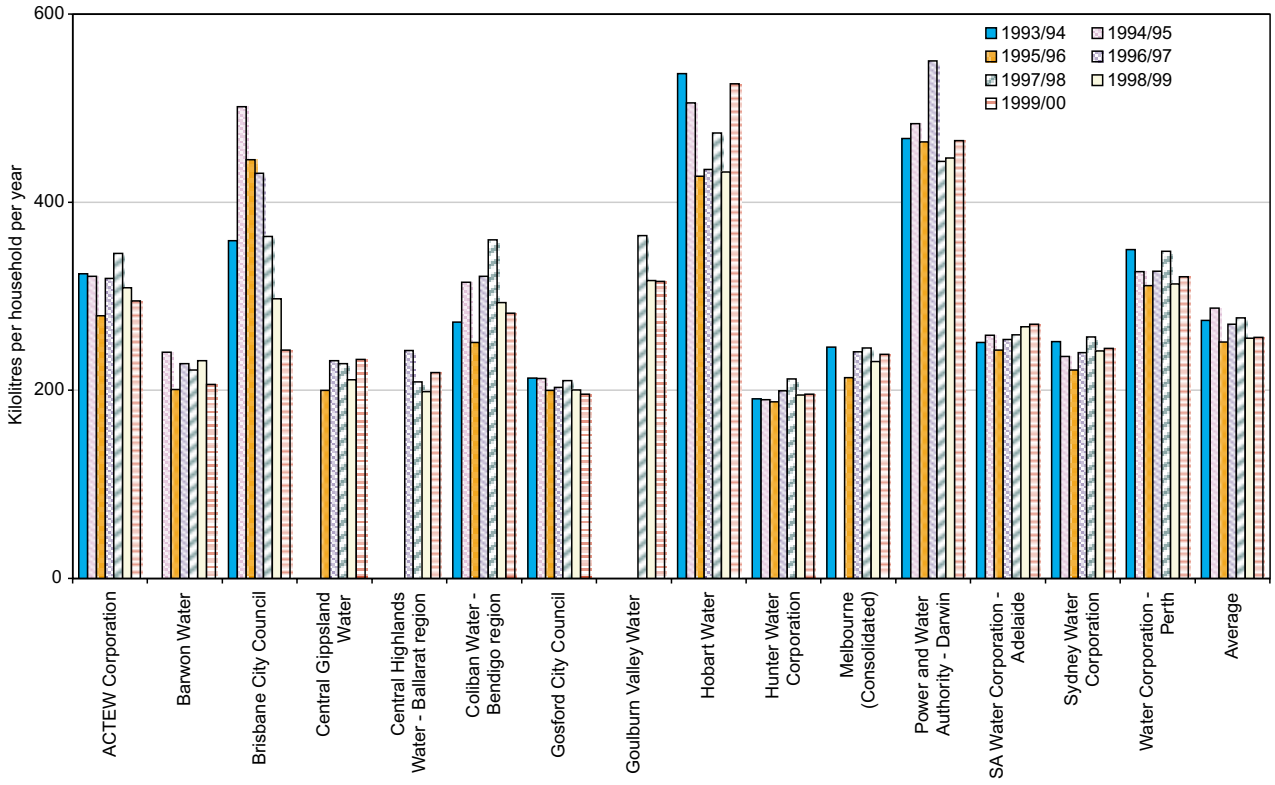


Figure 43: **Average per capita household water use for major urban areas.**

Source: Water Services Association of Australia (1999).

Urban water use

Residential use of water per household has decreased in most major urban areas in recent years. The urban water industry has changed considerably, largely in response to the COAG Water Reform Framework. There has been an emergence of a more mature water industry with a shift in emphasis from development to management. Pay-for-use price systems have been introduced as well as further organisational restructuring and reform.

Policy, regulatory, and commercial (operator) functions of organisations have been separated through restructuring and reform in order to clarify accountabilities. For example, urban water businesses are now provided with clear commercial goals of customer service, environmental compliance and sound business operation, free of other conflicting objectives. Regulatory roles have been transferred to regulatory authorities. Overall, these programs are viewed as successful. For example, true cost pricing of water supplies, in line with COAG requirements, has reduced urban water demand in most major areas (Figure 43).

Potential utilisation of alternate sources of water, such as stormwater and wastewater, is now being considered. Under the Commonwealth's 'Living Cities' Program, three programs, the Urban Stormwater Initiative, the Industry Partnership Program and Water Watch Australia, together aim to monitor and improve the health of urban waterways. Several state and territory-based programs have been introduced, together with community programs such as Streamwatch and Waterwatch. In addition, stormwater management plans for urban catchments are being developed by local authorities with financial support from state and territory agencies. Stormwater is increasingly seen as a resource to be collected and utilised rather than a waste to be disposed of. Programs to encourage greater reuse of stormwater and wastewater should be encouraged.

Trend: Urban water use

Residential water use per capita is decreasing while pressures are increasing and the response is adequate in most respects.

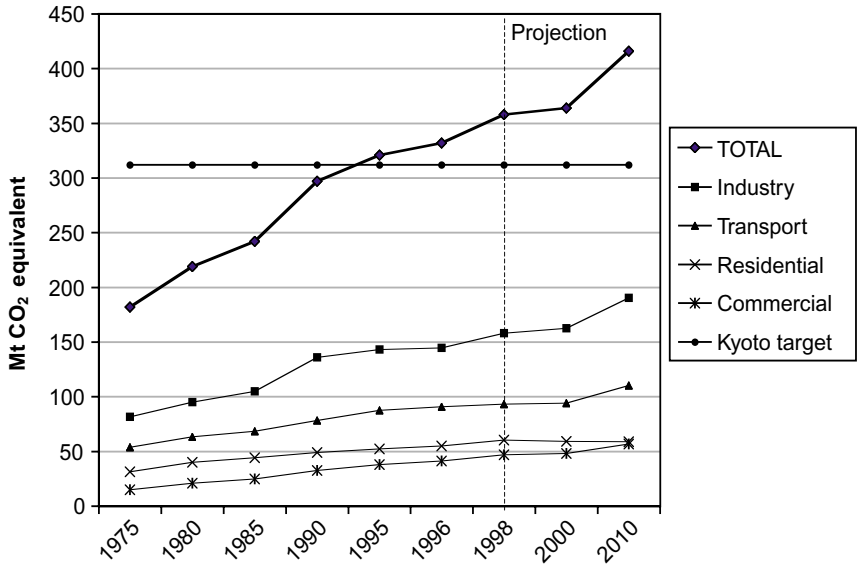


Figure 44: **Energy-related greenhouse gas emissions, Australia.**

Emissions from energy conversion and fugitive emissions have been allocated to end-use sectors.

Source: ABARE energy data; ABS data; Wilkenfeld and Associates (1998); Bush et al. (1999).

Increased transport use

Australia has a very high level of vehicle ownership by international standards. Increased out-of-home activities and road freight have also led to a significant increase in kilometres travelled (63% increase between 1981 and 2000).

These increases, particularly the high use of private transport, constitute a factor leading to Australia's high levels of per capita greenhouse gas emissions. The transport sector accounted for 16.1% of Australia's greenhouse gas emissions in 1999 (AGO 2001) and is one of the fastest growing sources of these emissions. Our per capita transport emissions are one of the highest in the world. Figure 44 shows past and projected greenhouse gas emissions from various sectors.

Increased transport use is also contributing to increased traffic congestion and environmental noise, accentuated by trends such as increased residential density and more evening activities. One in 10 dwellings in Australia's cities experience levels of road traffic noise over an 18-hour period, which exceeds recommended levels. This is occurring when workplace noise is decreasing because of the changing structure of Australian industry and improved occupational health and safety practices.

The extent of public transport use remains stagnant. Improved public transport could help to reduce private transport use. The level of public transport use depends on effective urban form and design as well as factors such as relative cost and convenience.

Vehicle fuel efficiency is improving, as is the level of emissions as a result of new government standards. New public infrastructure, such as motorways and highways, may have helped to reduce emissions. Improved motorways and highways are likely to increase usage, but whether these improvements will outweigh the increase in fuel efficiency is debatable. Positive developments have been more than offset by increased use, particularly of larger four-wheel drive vehicles, the ageing motor vehicle fleet and freight transport. Although the transport contribution to greenhouse gas emissions has increased, lead and carbon monoxide emissions are declining as a result of phasing out of leaded fuel and the introduction of higher emission standards for motor vehicles (see the *Atmosphere* theme report).

Trend: Transport use

Transport use is continuing to grow at a faster rate than population growth (i.e. more cars, more often and further). The condition of transport is deteriorating (i.e. increasing congestion, ageing vehicle fleet and infrastructure). However, there has been an adequate response in some respects (i.e. efficiency and emissions initiatives).

Table 12: **Indoor and outdoor air pollutant levels for some Australian buildings**

Pollutant	Health goal ($\mu g/m^3$, 0°C/ 101 kPa)	Typical indoor air concentrations ($\mu g/m^3$)			Typical outdoor air concentration ($\mu g/m^3$)
		New house/office	Established house	Established office	
Formaldehyde	130 (NHMRC)	100–800	20–120	40–120	10–20
Total VOCs	500 (NHMRC)	5 000–20 000	200–300	100–300	20–100
Nitrogen dioxide No unflued gas heater Unflued gas heater	225 (NEPM)	 — —	 10–35 60–1 500	 — —	 10–50 (300 peak)
Fine particles (PM10) Smoking Non-smoking	50 (NEPM)	 — 40–60	 >90 5–40	 100–300 10–40	 5–30
Dust mite allergens (per gram of house dust)	2–10 µg/g (WHO)	<0.1	10–60 coastal <1 inland	<2 (data limited)	<0.1

Source: Brown (1996, 1997, 1998a,b, 2000) and Manins et al. (2001).

Indoor air quality

Urban air quality is good, compared with cities of a similar size, with a range of Commonwealth and state programs having assisted. However, over 90% of our time is spent in enclosed environments (including vehicles), resulting in increasing concern about indoor air quality. Although there is a paucity of data on indoor air quality, the main issues include the initial periods of occupation for new or renovated houses and offices, urban transport and environments where smoking is allowed (Table 12). Insufficient information is available to determine changes in indoor air quality. Although the increasing prohibition of smoking in enclosed environments is positive, 39% of all children live with at least one adult who smokes. More information needs to be obtained on indoor air quality and its effects on human health and productivity. However, there are encouraging reports on prohibition of smoking in public places.

Trend: Indoor air quality

There are insufficient data to determine trends, and responses are inadequate in most respects.

Management of waste

Settlements depend upon energy, food, water and materials coming from a great diversity of places. Water, in particular, could become a limiting resource on the growth of some human settlements (e.g. in Adelaide). The level of reuse (Table 13) is starting to increase and this also provides a promising opportunity to increase available water supply to human settlements. Despite its potential, however, reuse of wastewater and stormwater is low in comparison with many other countries, particularly when Australia is regarded as one of the driest continents on earth.

Settlements also export wastes and emissions which can affect neighbouring areas, sometimes at considerable distances from them. Waste generation is at a high level with the per capita disposal rate for domestic waste at 620 kg/year, placing us second only to the USA among the OECD countries (Figure 45). Over 95% of solid waste is disposed to landfill, of

Table 13: **National wastewater reuse volumes and percentage by water sector**

Year	Volume reuse (ML)	Water sector			
		Domestic	Industrial	Commercial	Rural
1993–94	93 902	0	36	30	34
1994–95	101 292	0	35	26	39
1995–96	109 238	0	37	25	38
1996–97	134 427	0	43	26	31

Source: ABS (2000e).

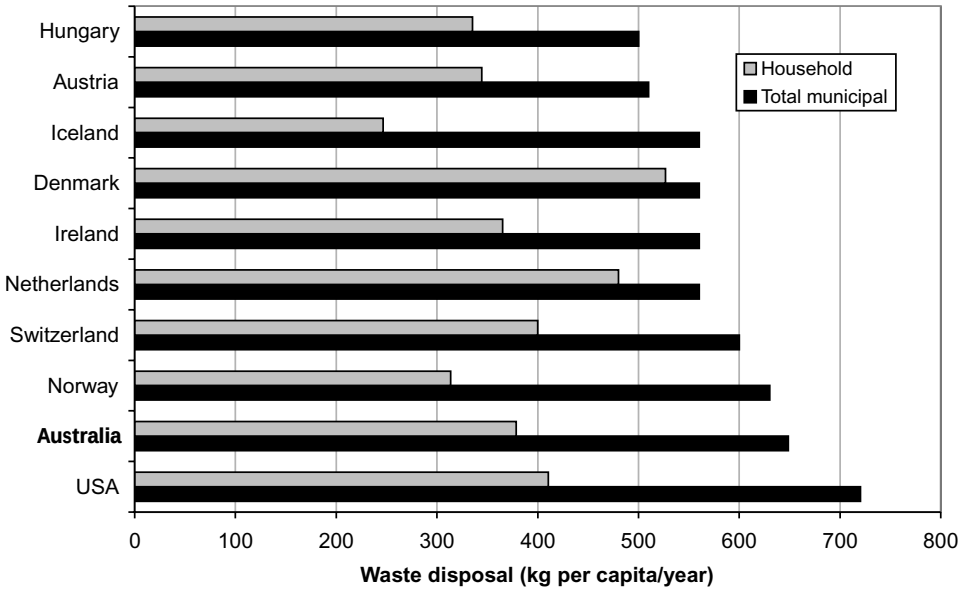


Figure 45: **Top 10 municipal waste disposers in the OECD.**

Source: OECD (1999).

which construction and demolition of buildings contributes between 40 and 50%. The level of household waste is not vastly different to other countries (Figure 45).

Trend: Waste management

As a result of increasing pressures and adequate responses in most respects, the condition is static.

The *National Waste Minimisation Act* was adopted in 1992, after which states and territories set waste reduction targets. Several important initiatives have followed. Although the waste reduction targets have not been met, the program has had a positive effect in several jurisdictions (Figure 46).

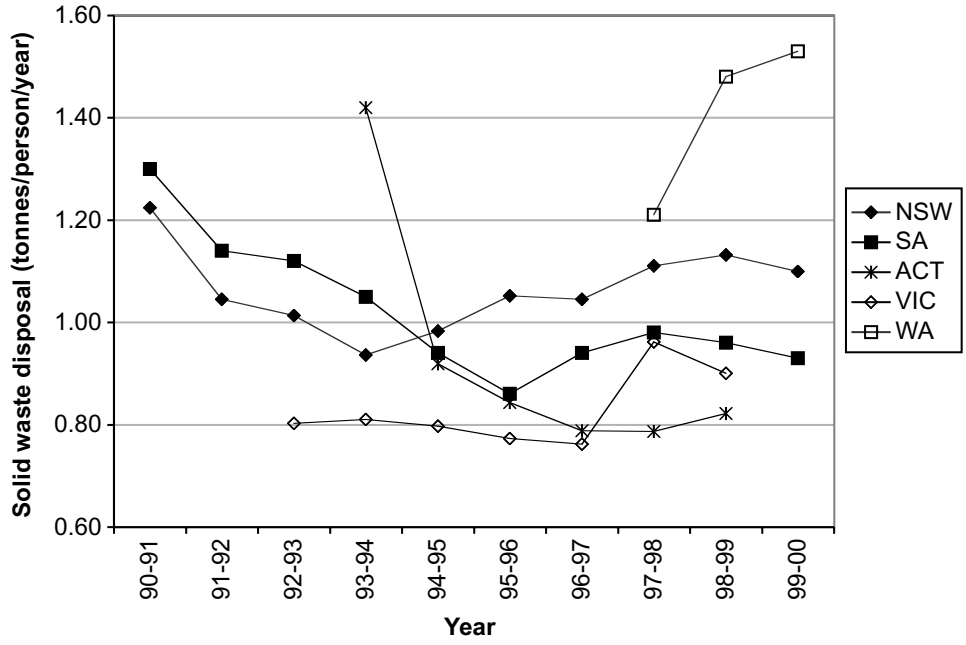


Figure 46: **Solid waste disposal rates (t/person per year).**

The definition of solid waste disposal for Victoria changed between 1996–97 and 1997–98 and this accounts for the apparent increase.

Source: EcoRecycle Victoria, EPA NSW, EPA SA, ACT Government, DEPWA.

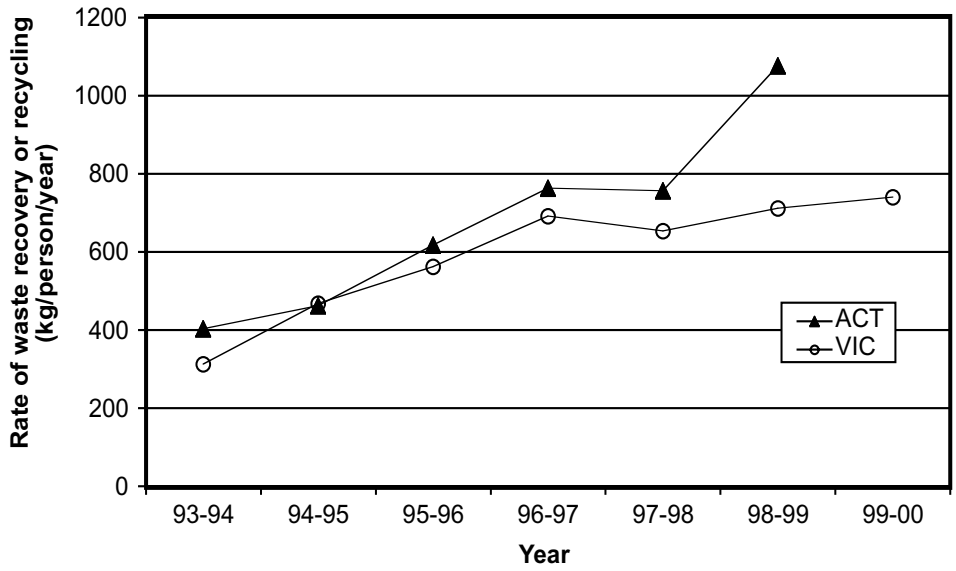


Figure 47: **Per capita waste recovery and recycling rates in the Australian Capital Territory and Victoria.**

Source: ACT Government (2000) and EcoRecycle Victoria (1998, 2000).

Programs to increase recycling have had some success, particularly with kerbside recycling and the reuse of materials from demolished buildings. In the five years between 1993–1994 and 1998–1999, quantities of waste disposed at landfills in the Australian Capital Territory were reduced by 40%, while the amount of wastes that were recycled more than doubled from 118 000 to 331 000 tonnes (ACT Government 2000). In Victoria, the quantities of wastes that were recovered and recycled have also steadily increased from 1.4 million tonnes in 1993 to 3.2 million tonnes in 1998–1999 (EcoRecycle Victoria 2000) (Figure 47).

Although waste recovery and recycling rates have improved in all jurisdictions, these fell well short of the national target of 50% reduction by 2000 (set in 1992). In Sydney, the level of waste reduction achieved by 2000 against the 1990 baseline was close to 18%. Further reductions are necessary and the targets set in 1992 should be revisited. Strengthening existing waste management programs is likely to be the best option.

The volume of wastewater and stormwater to be disposed has risen, but has been offset to some extent by the level of treatment, reuse and land-based disposal. Yet despite considerable investment in infrastructure and an improvement in coastal water quality, Sydney Harbour water quality is still affected by sewer overflows.

The quantity of hazardous waste generated has also been increasing rapidly. For example, in Sydney between 1992 and 1996, the amount of hazardous waste increased from 170 000 to 422 000 tonnes.

Conclusion

If existing trends continue, pressures from human settlements are not consistent with a sustainable environment. This is accentuated by:

- the form of settlement, particularly the high growth in coastal areas and urban fringes and the dispersed low-density form of settlement
- the very high per capita material usage which is still growing
- the very high per capita energy usage which is also still growing and leading to increases in greenhouse gas emissions, particularly through electricity generation and transport usage
- a high level of per capita waste by world standards although it appears to have stabilised in recent years
- the uneven distribution of wealth means that some settlements (e.g. many Indigenous settlements and small rural towns) do not always have the capacity to look after their environment and heritage.

Several responses by governments of all jurisdictions have been successful or partly successful. However, more needs to be done, to focus on more efficient resource use, i.e. doing more with less for longer. Creating sustainable settlements will require significant institutional and individual changes.

Future directions

The ASEC identified six key issues fundamental to the sustainability of Australia's environment. These are closely linked to the long-term sustainability of the nation's economic and social interests. These issues are:

- the protection of natural and cultural heritage
- barriers to implementing environmental sustainability
- adaptive management
- research and monitoring
- data and information management
- widespread adoption of sustainability in Australian society.

This Report points firmly to the need to integrate environmental, economic and social policy in the future. The current debate over the Kyoto Protocol, for example, highlights how policy makers are considering appropriate limits on greenhouse emissions together with resultant effects on economic and social systems.

Protecting our heritage

Heritage—our sense of place and our links to the past—helps define our identity and our values as a society. Sites with heritage values often attract tourism to both remote and highly settled parts of the continent. Crucial to their sustainability are the interpretation and presentation of their heritage values while regulating their use to avoid damage to their heritage values and effects on surrounding communities.

The increasing pace of urbanisation and development, along with the economic decline of some areas in rural and regional Australia, has often damaged our cultural heritage even before it is recognised or documented. However, the pace of change in itself is making people more aware of the potential for loss, and of the need to guard against it. It is vital that there be an increased emphasis at all levels on undertaking comprehensive heritage surveys. Regulation is important to ensure that heritage considerations are integrated into decision-making at an early stage, rather than as an afterthought. The state of heritage needs to be monitored regularly and reported on frequently and becomes a normal part of the business of Commonwealth, state, territory and local governments.

Of concern to the ASEC in preparing SoE (2001) was the relative imbalance in attention given to protecting natural over cultural heritage. This imbalance presents a barrier to our management and appreciation of heritage in an integrated way. It also diminishes the human contribution to our continent and ignores the layers of history and human use that create cultural landscapes. The balance needs to be restored otherwise maintenance of our cultural heritage will wane (relative to protection given to natural heritage) to the detriment of future generations.

The trend within the heritage profession in the 1990s of recognising cultural landscapes is not reflected in community understanding or government administration, which largely continues to separate Indigenous, historic and natural environments. The approach of listing individual places versus the recognition of those places in their broader landscape context, natural or cultural, rural or urban, is yet to be widely recognised as a preferable approach. More up-to-date ways to identify and protect the multiple heritage values in cultural landscapes need to be adopted by all jurisdictions in the future.

Understanding the connections between language, land, and the movement of Indigenous peoples remains a major challenge. This is especially required in remote areas as we strive to integrate the values of Indigenous peoples with their commercial land management responsibilities and the interests of non-Indigenous landholders with broader national goals. Such integration will be improved by ensuring more Indigenous heritage managers are trained for senior positions in state and Commonwealth agencies. To raise consciousness of Indigenous heritage—Australia's most extensive category of heritage—more opportunities to build protocols to protect Indigenous heritage and to exchange knowledge in an open and equal way between groups in society (*garma*) are needed.

Any move that might inhibit the process of identifying, documenting and managing Australia's distinctive natural and cultural heritage is of great concern. In particular, the proposed closure of the Register of the National Estate would be a retrograde move. At the

time of writing (mid-2001), there is uncertainty over future heritage management. The ASEC considers an overarching challenge is to agree upon a national strategy for the identification and management of Australia's heritage.

Barriers to implementing sustainability

Public good and private benefit

Landowners and land managers, together with those who influence their behaviour such as the financial institutions, will need to manage land for both the public benefit as well as the private good. There is by no means agreement within the Australian community that land management should take into account conservation and management actions on a landscape, or even on a catchment, scale. The New South Wales Farmers' Association, for example, has been voicing concern that 'steadily increasing Government expectations about the environmental outcomes required of owners of private land are eroding property rights and amount to theft by statute' (NSW Farmers' Association 2001).

The ASEC argues that equity considerations need to become part of any regional environmental management plan. This includes providing sufficient resources to balance the cost to individuals of including public good elements in any actions to improve the environment.

The Commonwealth *Native Title Act 1993* does enrich the opportunity for Indigenous peoples to protect their heritage while not impairing the rights of non-Indigenous parties with interests in land. The effect of native title on land and water management processes varies and continues to evolve through the development of Indigenous land use agreements and the impacts of judicial decisions.

The issue of land tenure and property rights will receive increasing attention by industry, individual landowners, land managers and possibly the judiciary in order to ensure that broadly agreed environmental results can be obtained from the expenditure of funds from private and public resources within the constraints of the legal system.

Financial tools for sustainability

The ASEC asserts that public action towards conservation and resource management will not, by itself, provide the necessary stimulus to achieve sustainability. Financial incentives, including the roles of taxation and rate relief need to be investigated. More extensive tax incentives such as those in the USA and UK may be required to encourage private conservation in Australia. Changes to capital gains tax and income tax law announced by the Prime Minister in August and October 2001 are aimed at benefiting landholders who set aside part or all of their land for conservation in perpetuity.

If private–public partnerships to foster sustainability are to occur on local, regional or national scales, then initiatives such as conservation trusts, compensation for restrictive covenants, promotion of land retirement with occupation rights to owners, or similar mechanisms (PriceWaterhouseCoopers 2001), will need to be considered carefully.

The importance of the role of the finance sector will increase as the environmental performance of companies becomes a factor in their ratings. Although there are signs this is happening, the extent to which shareholder sentiment, environmental law and disclosure requirements combine to produce improved environmental outcomes is still uncertain. In Europe and North America, the requirements of the finance sector in relation to environmental and social issues are more onerous than in Australia.

Many major companies see advantages for shareholders in taking positive steps towards environmental best practice and there are opportunities for investment in areas as diverse as solar energy, water management, heritage education, and use of genetic typing to protect and enhance biodiversity.

The links between environmental performance and credit, investment and reputation risks for companies are becoming more apparent. Assessing the environmental and financial performance of agricultural and pastoral properties in a similar manner will be difficult. Both financial and environmental risk should be considered where properties are undercapitalised or at risk, so that the full implications for the environment in which they are located are acknowledged in any financial or environmental management arrangements.

Regulatory tools

Land and water use is a pressing and critical problem for Australia. Regulation, supported by compliance mechanisms, will be needed to improve environmental quality in some areas for land and water use. As yet the commitments of the states and other authorities to regulating the water flows in the Murray–Darling river system, doing away with unsustainable irrigation practices, improving estuary water quality, and reducing land clearing, is far from satisfactory. A major coordinated effort between stakeholders will be necessary to solve these problems.

Regulatory tools have been effective in improving urban air quality over past years, as noted in the *Atmosphere* theme report. Commonwealth standards for emissions from motor vehicles, for example, have reduced the amount of sulfur dioxide and nitrous oxides able to be emitted into the atmosphere. Comparable regulation will almost certainly be required in water and land use management.

Adaptive management

Environmental management in Australia is fragmented vertically between levels of government and laterally at each level of government. It suffers further from an inability to integrate across a range of scales (i.e. from species or paddock to landscape or catchment systems; or from building to suburb to city to region). A problem is that institutions of government have failed to keep up with this need to integrate management systems, and regional problems confronting Australia reflect these institutional impediments.

Australia's inability to manage adaptively has affected long-term viability of economic, social and environmental systems. Many factors influence the pattern and intensity of these problems. Where problems are significant they may lead to enraged communities who, without obvious institutional solutions, will adopt simple solutions to situations that involve complex interconnected natural and human processes.

The tools for improving management systems need refining over the next few years if Australians are to learn to live sustainably. The Commonwealth has acquired some tools needed to change the institutional frameworks within which environmental management is conducted. At the Commonwealth level, the focus for national integrated policy and planning should be based on natural systems as well as offering incentives (e.g. tax) for modifying private sector behaviour. The state bureaucracies should be delivery and evaluation driven with much closer links to local government and communities for outcomes. Such a strategy is able to contribute to the rebuilding of economic activity in regional areas while recognising the need to protect and enhance environmental and heritage values at local, regional and national scales.

The drive towards sustainability from the perspective of a single nation responsible for the integrated, adaptive management of a megadiverse continent points to a clearer definition and acceptance of responsibilities and powers. The delivery of ecosystem services such as biodiversity, clean water, carbon sequestration, quality leisure, and the restoration of degraded landscapes and heritage places should come from a range of joint Commonwealth–State policies managed by a mix of state agencies with the assistance of local government, community groups and the private sector. Quality control should remain the preserve of the state agencies. In some specialised areas of production, industry regulatory organisations could be responsible for quality control.

The basis for such an approach is for management systems to be *adaptive*. A starting point is to recognise that environmental management is effectively an unreplicated experiment. Change is possible only if the system is understood. Such understanding provides a basis for monitoring the performance of the system and adjusting the system as management options are applied within the framework. In an adaptive system, scholarship has the dual role of discovering and defining desired reality, measuring actual reality, generating options and applying measurements that allow management to be adjusted. Management practices need to be adapted and developed progressively in accordance with the results of this 'experimental' evaluation, and this information made available to as wide an audience as possible.

Such an approach is likely to be of particular value where scientific understanding is limited (e.g. fire, tree planting, restoring hydrological balance, habitat management, and intensive visitor effects). State agencies assisted by Commonwealth incentives should facilitate adaptive management by local governments and the landholders and community groups on individual properties and reserves across regions in order to improve understanding of

effective conservation management at a landscape scale. This is also true for heritage properties where adaptive use aims to retain cultural heritage significance while allowing a new use for the resource.

In many ways adaptive management is common sense. However, the failure of Australians to understand the scale and complexity of the forces underlying environmental change that confronts them means that we need to learn again to live with the peculiarities of our continent, 'our country'. There have been numerous successful attempts to reach such a situation, the old Kidman Beef production model being one. But both SoE (1996) and SoE (2001) have documented those struggles which will persist unless a concerted effort is made to reorganise institutional arrangements for environmental management that emphasise integration, collective learning, incentives to change behaviour and adapt to long-term, not just short-term, pressures.

Research and monitoring

There is a pressing need to continue with research into the state of the environment, into methods of maintaining or improving the environment, and to evaluate the programs and policies designed to improve the condition of the environment. Organisations such as CSIRO, CRCs, state government agencies, universities and industry groups should all continue to make essential contributions. One example is the contribution made by the mining industry in the definition of background ecological and environmental conditions in the regions in which they operate. These efforts should be continued and be further encouraged. Studies commissioned by the states, the Commonwealth and private and public enterprises draw on the considerable expertise in environmental consulting available in Australia, and such activities should continue.

The knowledge contained in organisations and the skills of individuals will be of key importance to research and monitoring activities. Environmental professionals in industries such as the mining industry already exist. Agencies from state environmental agencies through to local councils employ environmental officers, and the research agencies of all kinds depend on new graduates with specialist knowledge of different aspects of the environment being available. Our education and employment systems need to ensure that the supply of such people continues.

Data and information management

Reliable data and information are key issues for SoE reporting in Australia. The theme reports provide extensive detail on problems with the availability of environmental data, its quality and the usefulness of the SoE indicators. Common problems across the themes include:

- important gaps in primary data
- lack of access to some data because of institutional barriers
- confusion about intellectual property and copyright
- lack of trend data for some variables
- some data cannot be aggregated and compared on a continental scale because of diversity of scales and geographical divisions that work against aggregation.

These limit Australia's capacity to measure environmental progress and by implication, they also limit its capacity to develop sound environmental policies, to make wise investments in environmental programs, to measure progress and to make wise statutory decisions.

The 1990s have seen a significant increase in the available data and information base on the environment. New information technology creates opportunities for drawing information together from a variety of systems and remote sensing, but can also result in a flood of data and information with little increased knowledge or understanding. It will be important to prioritise continuing investment in the collection of site data and the capacity to assess and integrate information.

The unique nature of the Australian environment presents particular challenges—a large terrestrial and marine environment, a highly endemic biota, and a small human population to draw expertise from. In the face of this challenge, Australian science has developed an advanced capacity to add value to data and information by using advanced modelling techniques. These approaches have been crucial to enabling the use of sparse data for decision-

making outcomes such as RFAs, national reserve planning and screening development proposals for potential effects on the environment.

Key challenges are the targeting of investment and the development of cooperative frameworks for information collection, access and use. Data are managed across a range of jurisdictions, and there are several institutional impediments which hamper access and use for integrated national views. An optimum approach is to seek agreed data standards and protocols from the data custodians, and to apply technology which allows for easy access to distributed databases. The fundamental principles are to maximise the return for decision makers, ensuring access, fitness for use, and integrity of the original data.

Areas requiring urgent further action include the development of:

- investment models for national data/information infrastructure
- definition of data that should remain in the public domain as opposed to data that should be commercialised
- common frameworks for the collection and sharing of data.

In response to changing budget priorities, some public agencies have been expected to generate revenues from data sales or from selling value-added products. By restricting the free flow of data in this way, use and reuse of data by both public and private sectors is reduced. Privatisation of once-public data holdings is also a concern. Some of these impediments are being resolved through the Commonwealth's Spatial Information Industry Action Agenda, and through the establishment of new spatial data management initiatives including the merger of AGSO-Geoscience and AUSLIG, Australia's national mapping agency, and a new Commonwealth Spatial Data and Access Pricing policy. These initiatives should assist in ensuring spatial data is made publicly available.

Substantive progress has already been made on national standards for data collection, access and use. ANZLIC (Australia New Zealand Land Information Council) is developing a Australian Spatial Data Infrastructure (ASDI) to provide better access to essential spatial data. A key element of the ASDI is the Australian Spatial Data Directory (ASDD), an online directory which allows users to search for spatial data sets from across various government and private sector custodians. Based on a nationally agreed metadata standard, this directory now contains information about some 40 000 data sets from 19 contributing organisations, including the private sector.

Through the National Land and Water Resources Audit, the Commonwealth government will have invested about $44 million over five years to provide a comprehensive national appraisal of Australia's natural resource base. This is significant step towards addressing important gaps in land, water and vegetation data. Although not yet finalised, the Audit was useful in the preparation of SoE (2001). It has succeeded in generating national baseline information. Fundamental to its success has been an ability to foster trust and collaboration between institutions (within and between jurisdictions), encourage agreement to national data standards and generate priorities for collecting primary data. In doing so, it has generated practical solutions where data collectors and data custodians are scattered across numerous institutions in all jurisdictions. A very useful trend has been to make its data freely available over the Internet (see http://www.nlwra.gov.au/ANRA/atlas_home.cfm).

Significant advances have been made in a range of available data required for environmental decision making, particularly under the EPBC Act. These include the implementation of a Collaborative Database on Protected Areas, a Directory of Important Wetlands and a nationally significant threatened and migratory species database. The Australian Biological Resources Study has continued to document Australian flora and fauna, and the Australian Virtual Herbarium is a promising new distributed species database.

The National Pollutant Inventory, also used in the preparation of SoE (2001), is a specific example of an ongoing commitment across jurisdictions to provide accessible and standardised data on emissions across Australia and should, in the ASEC's opinion, be supported and continued with the broadest possible remit.

It is expected that significant new data on land and water will be compiled under natural resource management policies and programs, notably the Extension to the NHT and the new NAP for Salinity and Water Quality. Access to such data must be integrated and freely available.

For SoE reporting purposes, agreement has been reached across Commonwealth and state jurisdictions on a set of core indicators (ANZECC 2000). Refinement of SoE indicators in the light of SoE (2001) is a priority for the Commonwealth, states and territories. The

development of terrestrial and marine biogeographical regions has provided a useful reporting framework for both SoE and the NLWRA, and complementary work on data standards is also needed.

A particularly important lack are data for assessing trends. Effective environmental investment needs to be informed by a sound understanding of cause and effect. Often, this requires decades of trend data. Nor can the scientific skills to collect the data, and to develop methodologies and models to use the data effectively, be turned on and off. A significant difficulty is that the horizon for governments is often much shorter than the environmental processes they are managing. A useful strategy might be to develop bipartisan support for a long-term national approach to environmental data. This may be best achieved by working with the major programs addressing Australia's environmental issues, perhaps through the new NRM Ministerial Council.

Towards sustainability

Australia is far from achieving sustainability, and major problems and impediments remain.

In many situations, such as changing our land use practices or reversing the over-allocation of river waters to irrigation, the challenges are immense. The recent publicity surrounding the extent of damage caused by rising water tables and land clearing must signal a start to a process, not an end.

Public attitudes and awareness is vitally important in our system of government where public opinion can drive regulatory and community actions. Australians need to know much more about how our environment works, and how and why it is changing. We need to use information technology to provide information to as many people as possible.

Australia is not alone in confronting the problems of sustainability. As in other countries, solving these problems involves many components, including:

- research
- the application of appropriate skills and knowledge
- information access
- community participation
- capital works
- long-term commitment of resources
- integrated decision-making across jurisdictions
- incentives to change attitudes of landowners and managers
- the use of regulation and market forces where appropriate.

The NAP for Salinity and Water Quality is an example of integrated, long-term investment in the protection and sustainability of catchment resources affected by salinisation. The NAP seeks to empower regional communities to use targeted and coordinated action to overcome the causes of dryland salinity. It can be seen as a model for regional national resource management and environmental management in Australia that involves:

- a central role for regional communities in both planning and implementation of plans
- a national/state accreditation process for the plans
- a sharing of costs between states and Commonwealth governments with a commitment expected as well from adequately resourced local governments
- an acceptance of the need for continued research and monitoring of outcomes to provide accountability and support for the adaptive learning process
- a willingness by landholders (and their financiers), supported by incentives, to care for others as well their own interests
- a recognition that issues need to be given priorities at a local or regional level, and that technical and financial resources must be directed to these priorities as a matter of urgency
- an understanding that many problems will be with us for decades and only patient, sustained investment and commitment by governments, industry, communities and landholders (and their financiers) will yield satisfactory outcomes.

The Commonwealth government is clearly in a key position to provide the necessary leadership to guide the nation further along the arduous path towards sustainability, but the states and territories, supported by local communities, are equally important. Steps taken with the new EPBC Act, the NAP for Salinity and Water Quality, and funding for the Extension to

the NHT in the 2001–02 Budget are all positive. Agreements between the Commonwealth, states and territories through COAG on water reform, biodiversity, heritage place protection and air pollution are considerable achievements.

The key to Australia's sustainable future lies in ourselves: our attitudes towards the environment, our heritage and each other. Positive change can be achieved when people see options for improvement in their quality of life and opportunities for their children and grandchildren. This change is accelerated when public awareness is translated into political action that influences the activities of our society to care for our country.

Appendix 1—Australian State of the Environment Committee

Committee members

The members of the Committee are:

Professor Bruce Thom (Chair), Director, Thombolo Pty Ltd and Chair of the Coastal Council of NSW, Emeritus Professor University of Sydney, Visiting Professor University of NSW

Associate Professor Bob Beeton, Head, School of Natural and Rural Systems Management, University of Queensland

Professor Peter Cullen, Director, Co-operative Research Centre for Freshwater Ecology

Ms Wendy McCarthy AO, Executive Director, McCarthy Management Pty Ltd

Mr Bill McLennan CBE, AM, Australian Statistician, Australian Bureau of Statistics *(till June 2000)*

Dr Libby Mattiske, Director, Mattiske Consulting Pty Ltd and member of the WA Environment Protection Authority

Dr Russell Reichelt, Director, Co-operative Research Centre for the Great Barrier Reef World Heritage Area incorporated as CRC Reef Research Centre.

Dr Alan Reid AM, Former CSIRO Division Chief. As a Fellow of the Australian Academy of Technological Sciences and Engineering, he directed the Inquiry into Urban Air Pollution that reported to the Commonwealth Government in 1997.

Dr Gaye Sculthorpe, Head, Department of Indigenous Cultures, Museum Victoria; and Commissioner, Australian Heritage Commission.

Mr Dennis Trewin, Australian Statistician, Australian Bureau of Statistics *(from July 2000)*

Mr Con Boekel, Assistant Secretary, Environment Information and Technological Strategies Branch, Environment Australia *(ex officio member) (from June 2000)*

Mr Stewart Needham, Assistant Secretary, Science and the Environment Branch, Environment Australia *(ex officio member) (till May 2000)*

Mrs Jenny Boshier, Director, State of the Environment Reporting Section (Secretary to Committee) *(ex officio member) (from June 2000)*

Dr Alex Zapantis, Director, State of the Environment Reporting Section (Secretary to Committee) *(ex officio member) (till December 1999)*

Committee's terms of reference

The terms of reference given to the Committee by Senator the Hon. Robert Hill, Minister for the Environment and Heritage, in February 1999 were as follows.

1 Supervise the preparation of the 2001 State of the Environment Report to ensure its scientific credibility, balance, coverage, independence and quality of work. Determine that the detailed structure of the Report is within the established reporting framework and is consistent with the Minister's letter of appointment. Keep the Minister advised on progress and present the completed report to the Minister.

2 Prepare the synthesis chapter of the 2001 State of the Environment Report, and determine and communicate its main messages to decision makers and the public.

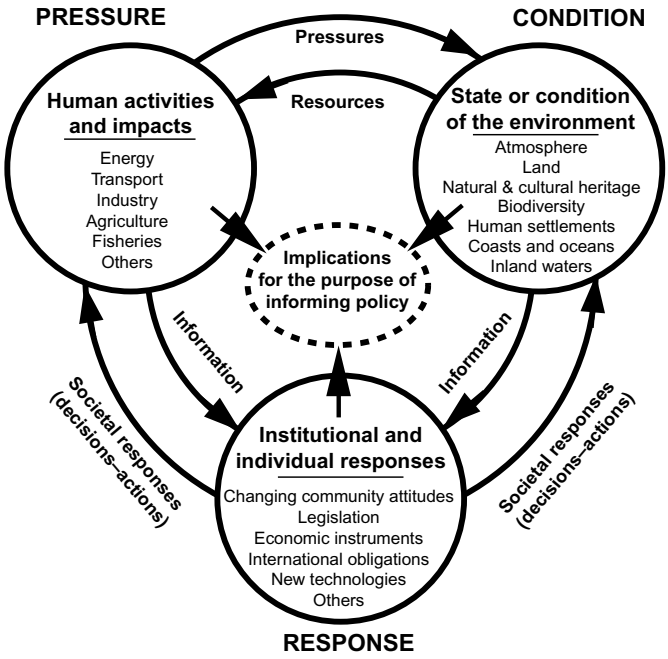
3 Assist in promoting awareness of the 2001 State of the Environment Report to environmental managers, decision makers and the public.

4 Evaluate the efficiency of the state of the environment reporting process and the effectiveness of the 2001 State of the Environment Report in communicating to environmental managers, decision makers and the public.

The Committee was asked to concentrate on changes since 1996, to pioneer the use of indicators on a continental scale, and to fill gaps in areas that were not fully covered last time. Also they were asked to build upon the 1996 State of the Environment Report to ensure continuity of the State of the Environment reporting system.

Secretariat

Current (and past) members of the State of the Environment Reporting Section:
John Armstead, Alex Davies, (Jim Derrick), (Geoff Dunn), Belinda Hack, (Gina Newton), Ian Robertson, (Allan Spessa), Gary Whatman and (Andrew Wynberg).



SoE reporting model.

Source: ASEC 1999.

Peer reviewers

The Committee gratefully thanks the following experts for valuable peer review comments upon this report:
Wendy Craik (Earth Sanctuaries Limited)
Julian Cribb (CSIRO National Awareness)
Ann Hamblin (Bureau of Rural Sciences)
Jane Lennon (Jane Lennon & Associates)
Ian Lowe (Griffith University)
Peter Manins (CSIRO Atmospheric Research)
Steven Münchenberg (Business Council of Australia)
Peter Newton (CSIRO Building, Construction and Engineering)
Rosemary Purdie (Murray–Darling Basin Commission)
Sharon Sullivan (Sullivan Blazejowski & Associates)
Jan Williams (RMIT University)
David Yencken (University of Melbourne).

Appendix 2—Environmental indicators for national state of the environment reporting

The scientific and technical basis for the indicators used in SoE (2001) is found largely in work commissioned by Environment Australia. This work is publicly available in the form of the following reports:

Fairweather P & Napier G 1998, *Environmental indicators for national state of the environment reporting— Inland waters*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Hamblin A 1998, *Environmental indicators for national state of the environment reporting—The Land*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Manton M & Jasper D 1998, *Environmental indicators for national state of the environment reporting—Atmosphere*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Newton P, Flood J, Berry M, Bhatia K, Brown S, Cabelli A, Gomboso J, Higgins J, Richardson A & Richie V 1998, *Environmental indicators for national state of the environment reporting—Human settlements*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Pearson M, Johnston D, Lennon J, McBryde I, Marshall D, Nash D & Wellington B 1998, *Environmental indicators for national state of the environment reporting—Natural and cultural heritage*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Saunders D, Margules C & Hill B 1998, *Environmental indicators for national state of the environment reporting—Biodiversity*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Ward T, Butler E & Hill B 1998, *Environmental indicators for national state of the environment reporting—Estuaries and the sea*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

The above reports can be found on the Internet at: http://www.ea.gov.au/soe/envindicators/index.html.

Appendix 3—People involved in SoE (2001) and the Theme Reports

The ASEC acknowledges the vital expert contribution made by the authors of the Reports. This provided a very significant foundation for SoE (2001). More than 106 experts (author teams and technical paper authors) contributed to preparing the Reports.

More than 70 specialists examined the Reports in draft form. In addition, many people provided information, usually at very short notice. These include individuals in state and territory government departments, private industry and voluntary organisations. Commonwealth government departments and members of the Commonwealth, state and territory ANZECC State of the Environment Reporting Task Force also helped identify errors of fact or omission. Their assistance is also gratefully acknowledged. The efforts of the data coordinators in State and Territory agencies were also appreciated.

Reports

The 2001 State of the Environment Report is based on seven Theme Reports that are listed below. The Reports are available on the enclosed CD-ROM.

The full list of theme authors are presented within the Reports available from CSIRO Publishing and on the web at: http://www.ea.gov.au/soe.

Australian State of the Environment Committee 2001, ***Coasts and oceans***, Australia State of the Environment Report 2001 (Theme Report), CSIRO Publishing on behalf of the Department of the Environment and Heritage, Canberra.

Ball J et al. 2001, ***Inland waters***, Australia State of the Environment Report 2001 (Theme Report), CSIRO Publishing on behalf of the Department of the Environment and Heritage, Canberra.

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Appendix 4—Resource management roles of major state/territory agencies[A]

Responsibility	Victoria	New South Wales	Queensland	Tasmania	South Australia	Western Australia	Northern Territory	Australian Capital Territory
Planning	Department of Infrastructure	Department of Urban Affairs and Planning	Department of Local Government and Planning	Department of Premier and Cabinet and Resource Planning and Development Commission	Department for Transport, Urban Planning and the Arts	Western Australian Planning Commission and the Ministry for Planning	Department of Lands, Planning and Environment	Department of Urban Services, Planning and Land Management
Public land management and Crown land	Department of Natural Resources and Environment	Department of Land and Water Conservation	Department of Natural Resources and Mines	Department of Primary Industries, Water and Environment	Department for Administrative and Information Services, Land Services Group	Department of Conservation and Land Management	Department of Lands, Planning and Environment	Department of Urban Services, Land and Property
Environment	Department of Natural Resources and Environment; Environment Protection Agency	Environment Protection Agency of NSW	Environmental Protection Agency	Department of Primary Industries, Water and Environment	Department for Environment and Heritage; (Environment Protection Agency)	Department of Environmental Protection	Department of Lands, Planning and Environment	Department of Urban Services, Environment ACT
National parks and reserves	Department of Natural Resources and Environment, Parks Victoria.	National Parks and Wildlife Service	Environmental Protection Agency	Department of Primary Industries, Water and Environment	Department for Environment and Heritage	Department of Conservation and Land Management	Parks and Wildlife Commission of the NT	Department of Urban Services
Water management	Department of Natural Resources and Environment, Regional Water Authorities, Regional Catchment Management Authorities	Department of Land and Water Conservation Sydney Catchment Authority, Sydney Water Corporation, Hunter Water Corporation, other Regional Water Authorities	Department of Natural Resources and Mines	Department of Primary Industries, Water and Environment	Department of Water Resources	Water & Rivers Commission & The Water Corporation	Department of Lands Planning and Environment	ACTEW Corporation Limited
Forestry	Department of Natural Resources and Environment	State Forests of NSW	Department of Natural Resources and Mines	Department of Infrastructure, Energy and Resources	Department for Administrative and Information Services, Forestry SA	Department of Conservation and Land Management & Forest Products Commission	Department of Primary Industry and Fisheries	Department of Urban Services
Natural, Indigenous and historic heritage	Aboriginal Affairs Victoria, Department of Infrastructure, Department of Natural Resources and Environment (inc. Parks Victoria)	NSW Heritage Office, Department of Aboriginal Affairs, Department of Urban Affairs and Planning, Department of Land and Water Conservation, National Parks and Wildlife Service	Department of Local Government and Planning (inc. QLD EPA and QLD Parks and Wildlife Service)	Tasmanian Heritage Council and Department of Primary Industries, Water and Environment	Division of State Aboriginal Affairs (part of Department for Transport, Urban Planning and the Arts), Department for Environment, and Heritage (inc. SA National Parks and Wildlife Service)	Heritage Council of Western Australia, Aboriginal Affairs Department, Department of Land Administration, Ministry for Planning, Department of Conservation and Land Management	Aboriginal Areas Protection Authority, Department of Lands, Planning and Environment, Parks and Wildlife Commission of the NT	Department of Urban Services

Responsibility	Victoria	New South Wales	Queensland	Tasmania	South Australia	Western Australia	Northern Territory	Australian Capital Territory
Source:[B]	http://www.vic.gov.au/[C]	http://www.nsw.gov.au/[C]	http://www.qld.gov.au/[C]	http://www.tas.gov.au/[C]	http://www.sa.gov.au/[D]	http://www.wa.gov.au/[D]	http://www.nt.gov.au/[D]	http://www.act.gov.au/[D]

[A] Although single agencies have been identified as a lead agency for the categories indicated, other agencies also have significant roles in these categories. Also the simplicity of this table in no way ignores the substantial responsibilities of local government for many of the categories indicated.
[B] The complexity between and frequent changes to state/territory agencies is such that website addresses are provided so the latest administrative arrangements can be obtained.
[C] Accessed 14 June 2001.
[D] Accessed 18 June 2001.

Abbreviations

AAP	Australian Associated Press
AATSE	Australian Academy of Technological Sciences and Engineering
ACF	Australian Conservation Foundation
AGO	Australian Greenhouse Office
ANZECC	Australia and New Zealand Environment Conservation Council
AQIS	Australian Quarantine Inspection Service
ASEC	Australian State of the Environment Committee
AUSLIG	Australian Surveying and Land Information Group
BoM	Bureau of Meteorology
CAR	Comprehensive, Adequate and Representative
CCAMLR	Convention on Conservation of Antarctic Marine Living Resources
CFCs	chlorofluorocarbons
CITES	Convention on International trade in Endangered Species of Wildlife Flora and Fauna
CO_2-e	carbon dioxide equivalent
COAG	Council of Australian Governments
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EEZ	Exclusive Economic Zone
ENSO	El Niño–Southern Oscillation
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
ESD	ecologically sustainable development
GIS	geographical information system
GMU	groundwater management units
IBRA	Interim Biogeographic Regionalisation for Australia
IMCRA	Interim Marine and Coastal Regionalisation for Australia
IPCC	Intergovernmental Panel on Climate Change
MARPOL Convention	International Convention for the Prevention of Pollution from Ships
MPA	Marine protected area
NAP	National Action Plan for Salinity and Water Quality
NDVI	Normalised Vegetation Difference Index
NEPM	National Environmental Protection Measure
NFF	National Farmers Federation
NGGI	National Greenhouse Gas Inventory
NGO	non-government organisation
NHT	Natural Heritage Trust
NLWRA	National Land and Water Resources Audit
NPI	National Pollutant Inventory
ppb	parts per billion
RCD	rabbit calicivirus disease
RFA	Regional Forest Agreement
SoE	State of the Environment
SoE (1996)	The 1996 State of the Environment report
SoE (2001)	The 2001 State of the Environment report
UV	ultraviolet
VKT	Vehicle kilometres travelled

Glossary

accretion	any gradual increase in size through growth or external addition
aerosol	a suspension of particles, other than water or ice, in the atmosphere and ranging in size from about 5 nm to larger than 10 µm in radius; may be either natural or caused by human activity and most of the latter are usually considered to be pollutants
air toxics	gaseous, aerosol or particulate pollutants (other than the six criteria pollutants) present in the air in low concentrations with characteristics such as toxicity or persistence so as to be a hazard to human, plant or animal life
airshed	a body of air bounded by topography and meteorology in which a contaminant, once emitted, is contained for a period of time
algal blooms	a sudden proliferation of microscopic algae in water bodies, stimulated by the input of nutrients such as phosphates
anthropogenic	of human origin or human induced
aquaculture	commercial growing of marine (mariculture) or freshwater animals and plants in water
aquifer	an underground layer of soil, rock or gravel able to hold and transmit water. Bores and wells are used to obtain water from aquifers
arid zone	often arbitrarily defined in Australia as those areas receiving <250 mm of annual rainfall in the south and 350 mm (or sometimes higher) in the north
atmospheric inversion	a cool layer of air gets trapped below a layer of warm air and is unable to rise. This 'ceiling' leads to a build up of polluted air close to the ground and prevents vertical mixing and dispersion of smoke and other air pollutants
Australia's marine area	area of sea or sea bed for which Australia has jurisdiction under the Law of the Sea Convention. It includes the Australian Exclusive Economic Zone around the mainland, islands and the Australian Antarctic Territory (AAT) and the continental shelf off the mainland and the AAT.
ballast water	water carried in tanks to maintain stability when a ship is lightly loaded; normally discharged to the sea when the ship is loaded with cargo
benthos	plant and animal life associated with aquatic floor and the sea bed
biodiversity	variability among living organisms from all sources (including terrestrial, marine and other ecosystems and ecological complexes of which they are part) and includes: diversity within species and between species and diversity of ecosystems
biogeochemical cycles	the movement of chemical elements between organisms and non-living compartments of the atmosphere, aquatic systems and soils
biomass	the quantity of organic matter within an ecosystem (usually expressed as dry weight for unit area or volume)
bioregion	a territory defined by a combination of biological, social and geographical criteria rather than by geopolitical considerations; generally, a system of related, interconnected ecosystems
biota	all of the organisms at a particular locality
blue-green algae	an ancient order of algae (with characteristics of bacteria) that have become more common in water bodies due to disturbance and pollution. Some species produce toxins that can cause sickness and nerve and liver damage.
broad-scale clearing	removing vegetation, particularly trees and shrubs, from a landscape
Burra Charter	a document which sets out the principles, processes and standards for the conservation of the cultural environment. Also known as The Australia ICOMOS Charter for Places of Cultural Significance following the 1999 revision which was published by Australia ICOMOS Inc. in 2000.
bycatch	the catch of species other than those targeted by fishing activity
carbon sequestration	the uptake and storage of carbon
catchment	the area determined by topographic features within which rainfall will contribute to runoff at a particular point under consideration
cetaceans	whales, dolphins and porpoises
chlorofluorocarbons (CFCs)	synthetic products, which do not occur naturally and contain chlorine and fluorine; commonly used in various industrial processes and as refrigerants and, prior to 1990, as a propellant gas for sprays; deplete ozone in the stratosphere and are powerful greenhouse gases
conservation	In relation to biodiversity: the protection, maintenance, management, sustainable use, restoration and enhancement of the natural environment. In relation to natural and cultural heritage: conservation implies keeping in safety or preserving the existing state of a heritage resource from destruction or change
contaminated site	a site at which hazardous substances occur at concentrations above background levels and where assessment shows it poses, or is likely to pose, an immediate or long-term hazard to human health or the environment
dryland salinity	areas where soil salinity levels are high enough to affect plant growth

ecologically sustainable development (ESD)	using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be increased
ecosystem	a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit
ecosystem services	organisms and environmental processes interacting to create a healthy environment for human beings, from production of oxygen to soil formation and maintenance of water quality
El Niño	an extensive warming of the central and eastern Pacific Ocean that leads to a major shift in weather patterns across the Pacific. In Australia (particularly eastern Australia), El Niño events are associated with an increased probability of drier conditions
endangered species	a species in danger of extinction and whose survival is unlikely if the causal factors continue. Included are species whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that the species are deemed to be in danger of extinction
endemic	native to a particular area and found nowhere else
energy efficiency	the means of using less energy in doing the same amount of work
enhanced greenhouse effect	the addition to the natural greenhouse effect resulting from human activities such as the burning of fossil fuels and land clearing, which increase the atmospheric levels of greenhouse gases such as carbon dioxide, methane, nitrous oxide, ozone and CFCs (*see also* greenhouse effect)
environment	Includes: ecosystems and their constituent parts, including people and communities; natural and physical resources; the qualities and characteristics of locations, places and areas; the social, economic and cultural aspects of a thing mentioned in the previous three criteria
eutrophication	process by which waters become enriched with nutrients, primarily nitrogen and phosphorus which stimulate the growth of aquatic flora and/or fauna
exceedances	those times a measurement of a component goes beyond a specified limit
Exclusive Economic Zone (EEZ)	a concept recognised under the United Nations Law of the Sea, whereby coastal states assume jurisdiction over the exploration and exploitation of marine resources extending 200 nautical miles from the shore or baseline
extensive land use zone (ELZ)	those areas, where the most common land use is pastoralism and where grazing by domestic stock and, to a much lesser extent, repeated burning are the major pressures
fire regime	the pattern of fires at a location; includes the frequency, intensity and seasonality of the fires
fugitive emissions	greenhouse gases emitted in an uncontrolled manner, such as during fuel production, processing, transmission, storage and distribution, and include emissions from oil and natural gas exploration, venting, flaring, as well as the mining of black coal
garma	to the Indigenous people of north-east Arnhem Land, garma is an open forum where people can share ideas. In its application to the intercultural interface, garma means a set of opportunities to build protocols for culture and knowledge exchange in an open and equal way between groups in society
genetically modified organisms	organisms whose genetic make up has been altered by the insertion or deletion of small fragments of DNA in order to create or enhance desirable characteristics from the same or another species
global warming	*see* enhanced greenhouse effect
greenhouse effect	a term used to describe the role of atmospheric trace gases—water vapour, carbon dioxide, methane, nitrous oxide, ozone, in keeping the earth's surface warmer than it would be otherwise (*see* enhanced greenhouse effect)
greenhouse gas emissions	emission of those gases that, by affecting the radiation transfer through the atmosphere, contribute to the greenhouse effect (*see* enhanced greenhouse effect)
groundwater	the water beneath the surface that can be collected with wells, tunnels, or drainage galleries, or that flows naturally to the earth's surface via seeps or springs
halons	include bromofluorocarbons and bromochlorofluorocarbons, which are very stable chemicals that act similarly to CFCs in ozone depletion; previously used in fire extinguishers
heavy metal	metallic element with relatively high atomic mass (over 5.0 specific gravity) such as lead, cadmium, arsenic and mercury; generally toxic in relatively low concentrations to plant and animal life
heritage objects	may be *in situ* at significant sites or held in collecting institutions such as archives, libraries, museums, galleries, zoos, herbaria or botanic gardens or historic buildings
hydrocarbons	organic molecules containing hydrogen and carbon; the major components of petroleum
Indigenous peoples	Aboriginal and Torres Strait Islander peoples of Australia
intensive land use zone (ILZ)	the location of clearing where the greatest disturbance has been native vegetation clearance and replacement with exotic crops, pasture and forest vegetation
intertidal	between the levels of low and high tide
invasive species	a species occurring as a result of human activities beyond its accepted normal distribution and which threatens valued environmental, agricultural or personal resources by the damage it causes
invertebrate	an animal without a backbone composed of vertebrae (e.g. insects, worms, snails, mussels, prawns and cuttlefish)

La Niña	warming of the western equatorial Pacific warm pool, north of New Guinea, accompanied by cooling in the equatorial eastern Pacific Ocean. La Niña is often associated with above average rainfall in eastern Australia (*see* El Niño)
Landcare	a program to further sustainable land management
macro algae	large form of algae of simple organisms mostly aquatic containing chlorophyll and/or other photosynthetic pigments
mangrove	a plant (belonging to any of a wide range of species, mainly trees and shrubs) that grows in sediment regularly inundated by sea water
melanoma	a malignant tumour derived from pigment-containing cells especially in skin
methyl bromide	a highly effective fumigant used to control insects, nematodes, weeds and pathogens, listed as an ozone-depleting substance
molluscs	a phylum of invertebrates, including snails, clams, octopuses, squids, and others
Montreal Protocol	Montreal Protocol on Substances that Deplete the Ozone Layer, agreed in Montreal in 1987
mid-latitudes	extend from the Tropics (23° 30" N and S) to the Arctic Circle (66° 30" N) and the Antarctic Circle (66° 30" S)
National Environment Protection Measures (NEPMs)	NEPMs are broad framework-setting statutory instruments defined in the NEPC legislation (see http://www.nepc.gov.au/)
national estate	The National Estate, as defined in the *Australian Heritage Commission Act 1975*, 'consists of those places, being components of the natural environment of Australia or the cultural environment of Australia, that have aesthetic, historic, scientific or social significance or other special value for future generations as well as for the present community'
Natural Heritage Trust	a body established by the *Natural Heritage Trust of Australia Act 1997* to stimulate conservation, sustainable use and repair of Australia's natural environment
non-point source	a source not easily identified at a particular place, often referred as diffuse sources
nutrient cycling	is the repeated pathway of particular nutrients or elements from the environment through one or more organisms back to the environment: includes the carbon cycle, the nitrogen cycle, the phosphorus cycle
old-growth forests	forests dominated by mature trees and with little or no evidence of any disturbance such as logging, road building or clearing
ozone depletion	the natural equilibrium between chemical reactions forming and destroying stratospheric ozone is disturbed by the release of manufactured chemicals
ozone layer	a region in the stratosphere where there is a small, but significant, amount of ozone
particulates	very small pieces of solid or liquid matter, such as soot, dust, smoke or mist
pathogen	an agent (e.g. a virus, protozoa or bacteria) that causes disease
PCBs (polychlorinated biphenyls)	a group of chlorinated organic compounds that are non-corroding and resistant to heat and biological degradation; used as insulation in electrical equipment; can accumulate in some species and disrupt reproduction
photochemical smog	air pollution caused by chemical reactions among various substances and pollutants in the atmosphere in the presence of sunlight; ozone is a major constituent
photolysis	sunlight causing the chemical bonds in a molecule to break
PM10 and PM2.5	particles with aerodynamic diameters of up to 10 µm and 2.5 µm, respectively
point-source pollution	pollution from a easily discernable, single source such as a factory or sewage treatment plant
potable water	water pure enough to drink by humans
proponent	a person or organisation seeking approval to conduct a business or activity that impacts on the environment
Ramsar Convention	The Convention on Wetlands, signed in Ramsar, Iran, in 1971 providing the framework for the conservation and wise use of wetlands and their resources. There are presently 122 Contracting Parties to the Convention, with 1031 wetland sites, totalling 78.2 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance
rangelands	native grasslands, shrublands and woodlands that cover a large proportion of the arid and semi-arid regions, and also include tropical savanna woodlands; regular cropping is not practised and the predominant agricultural use, if any, is grazing of sheep and cattle on native vegetation
Register of the National Estate	the national inventory of places of natural, historic and Indigenous heritage significance, which have been assessed by the Australian Heritage Commission and deemed to be worth conserving for present and future generations
regulated rivers	rivers whose flows are controlled or regulated by releases made from dams to meet the needs of licensed uses
remote sensing	may be broadly defined as the collection of information about an object without being in physical contact with the object. Aircraft and satellites are the common platforms from which remote sensing observations are made
rill erosion	a form of erosion involving formation of shallow gutters which may be removed by cultivation
riparian vegetation	plants communities on the fringes and adjacent to water bodies
river salinity	increasing concentrations of salt in rivers and creeks caused by saline discharges from dryland, irrigation and urban salinity
runoff	portion of rainfall not immediately absorbed into the soil and which becomes surface flow

salinisation	the process by which land becomes salt-affected
salinity	the concentration of salts in water and/or soil
seagrass	intertidal and subtidal flowering plants found mainly in shallow waters of protected coastal waters
seamounts	remnants of extinct volcanoes found in Australia's deep marine environment. They are typically cone-shaped, 200 to 500 m high and several kilometres across and between 650 and 1000 m below the sea surface
semi-arid	lands where rainfall is so low and unreliable that crops cannot be grown with any reliability (*see* arid zone)
sinks	processes or places that remove or store gases, solutes or solids in accumulating parts of the environment
sodic soils	soils with a high proportion of sodium relative to calcium, potassium and magnesium in the composition of the exchangeable cations on the clay fraction
Southern Oscillation	a fluctuation in the atmospheric circulation, in particular over the tropical areas of the Pacific and Indian oceans; in general, when atmospheric pressures are high over the eastern Pacific Ocean they tend to be low in the eastern Indian Ocean and *vice versa*; the fluctuation between the two produces a marked variation in parameters such as the sea surface temperature and rainfall over a wide area of the Pacific and has a cycle of two to seven years; the phenomenon is strongly linked to the El Niño
State of the Environment reporting	a scientific assessment of environmental conditions, focusing on the impacts of human activities, their significance for the environment and societal responses to the identified trends
sustainable	an activity able to be carried out without damaging the long-term health and integrity of natural and cultural environments
sustainable extraction limits	the volume of water extracted over a specific time frame that should not be exceeded to protect the higher social, environmental and economic uses associated with the aquifer
symbiotic	a close association between the individuals of pairs of species often leading to mutual gains
tectonic	forces or conditions within the earth that cause movements of the crust such as earthquakes, folds and faults
threatened	a species or community that is vulnerable, endangered or presumed extinct (as defined in the *Environment Protection and Biodiversity Conservation Act 1999*)
threatening process	a process that threatens, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community
tillage systems	the sequence of all operations involved in producing the crop, including soil manipulation, harvesting, chopping or shredding of residue and application of pesticides and fertilisers
toxicant	a substance that could cause adverse effects in a living organism
turbidity	the extent to which the passage of light through water is reduced by suspended matter
volatile organic compound (VOC)	carbon containing compounds occurring in ambient air as gases or vapour with boiling points between 50°C and 260°C. The VOCs that participate in smog formation reactions are called reactive organic compounds (ROCs) (e.g. benzene, xylene and toluene)
wastewater	used water; in most cases is not suitable for drinking
World Heritage sites	sites of outstanding universal natural or cultural significance that are included on the World Heritage List

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