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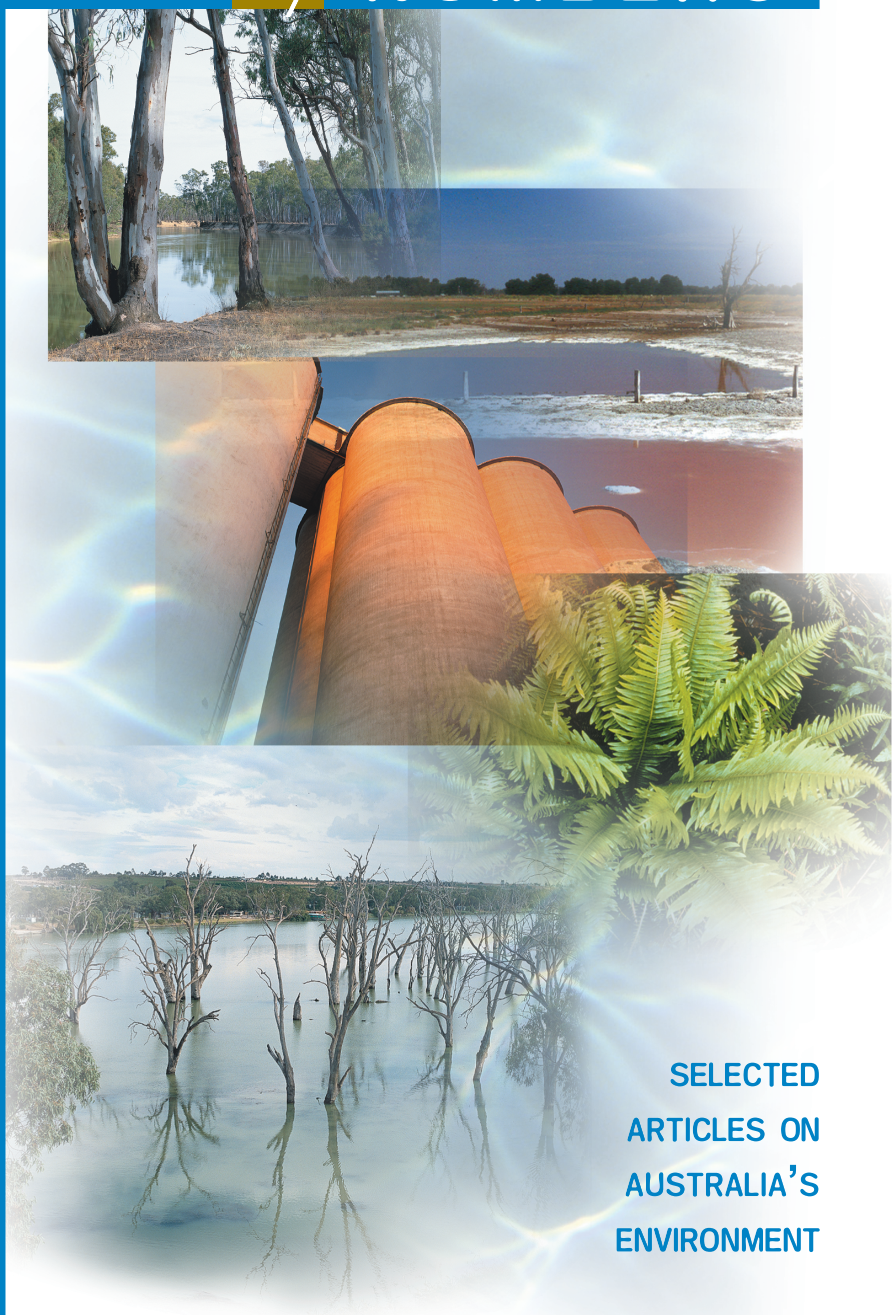
Australian Bureau of Statistics

Environment by NUMBERS



SELECTED ARTICLES ON AUSTRALIA'S ENVIRONMENT

New Issue

2003

ENVIRONMENT BY NUMBERS: SELECTED ARTICLES ON AUSTRALIA'S ENVIRONMENT

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AUSTRALIAN BUREAU OF STATISTICS
EMBARGO: 11:30AM (CANBERRA TIME) FRI 21 FEB 2003

ABS Catalogue no. 4617.0

ISBN 0642 47899 6

Cover photographs:

Murray at Gunbower Creek
Salinity near Barr Creek
Grain silos
Fern in the Snowy Mountains area
Drowned trees above Lock 1, Blanchetown

Photographs (from top to bottom) 1, 2 and 5 by John P. Baker
<www.johnbaker.apex.net.au>

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Preface

This publication brings together a series of articles on the environment published in the *Year Book Australia 2003*. Additional information on salinity is included in *Chapter 11, Environmental impacts of agriculture*. This is based on material contained in *Salinity on Australian Farms, 2002* (cat. no. 4615.0) which was released after the manuscript for the Year Book had been completed. We believe that, taken together, these articles provide a good numerical picture of issues associated with Australia's environment.

Many of the articles have been written by Australian Bureau of Statistics (ABS) staff. Others have been prepared by experts on the various topics. These are named at the start of the relevant articles. We are very grateful for their contributions and permission to reprint in this volume.

Australian Bureau of Statistics
Canberra
February 2003

Dennis Trewin
Australian Statistician

Symbols and abbreviations

The following symbols and abbreviations, are shown in tables and graphs:

'000	thousand
$'000	thousand dollars
$m	million dollars
$b	billion dollars
%	percentage
–	nill or rounded to zero (including null cells)
. .	Not applicable
*	subject to high standard errors and should be used with auction
<	less than
>	greater than
°C	degrees Celsius
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
Gg	gigagram
GJ	gigajoule
ha	hectare
kg	kilogram
km	kilometre
km^2	square kilometre
km^3	cubic kilometre
kt	kilotonne
kWh	killowatt hour
m^2	square metre
m^3	cubic metre
mill.	Million
ML	megalitre
mm	millimetre
Mt	megatonne
n.a.	not available
n.e.c.	not elsewhere classified
nd	no date
no.	number
n.p.	not for publication
PJ	petajoule

The following abbreviations are used for the titles of the Australian states and territories and Australia:

NSW	New South Wales
Vic.	Victoria
Qld	Queensland
WA	Western Australia
SA	South Australia
Tas.	Tasmania
NT	Northern Territory
ACT	Australian Capital Territory
Aust.	Australia

1 Environment by numbers — an overview

The Johannesburg World Summit on Sustainable Development in 2002 marked 10 years since the first summit in Rio de Janeiro in 1992. 2003 is also the International Year of Freshwater. Given these milestones, and the importance and topicality of sustainable development and environmental issues generally, the ABS decided to make environmental issues, and particularly sustainable development, a major theme of the 2003 edition of Year Book Australia. A number of articles throughout that edition address environmental issues, as do the Environment and Energy chapters of the Year Book.

The purpose of this introductory chapter is to draw together the threads in those articles, and of related parts of the Environment and Energy chapters, and thereby present a brief statistical overview of environmental issues in Australia.

Many environmental, social and sustainable economic development issues are interrelated. The chapter addresses them in the following order:

- rising per capita income and national wealth
- sustainable forestry
- sustainable fisheries and marine ecosystems
- sustainable mining
- sustainable land and water use (including salinity), and protecting Australia's biodiversity
- energy, greenhouse gases and climate change
- impacts of industrial activities, and of households
- accounting for the environment.

What do we mean by sustainable development?

The World Commission on Environment and Development (1987) defined Ecologically Sustainable Development as:

> development which meets the needs of the present without compromising the ability of future generations to meet their own needs.

The National Strategy for Ecologically Sustainable Development commits all Australian governments to the following three core objectives:

- to enhance individual and community wellbeing and welfare by following a path of economic development that safeguards the welfare of future generations
- to provide for equity within and between generations
- to protect biological diversity and maintain essential ecological processes and life support.

These objectives in turn suggest the following kinds of economic and environmental aims:

- rising national wealth per capita as well as income per capita — to achieve both implies replacing any natural resources used with alternative resources of an equal value
- using natural resources prudently and efficiently — this implies not using renewable resources (such as forests and wild fisheries) in excess of their natural regeneration. It also implies not consuming other resources (such as groundwater and surface water, fossil fuels and other mineral resources) beyond a critical level
- maintaining biodiversity, and not using sink functions beyond their assimilative capabilities
- minimising human contributions to global warming.

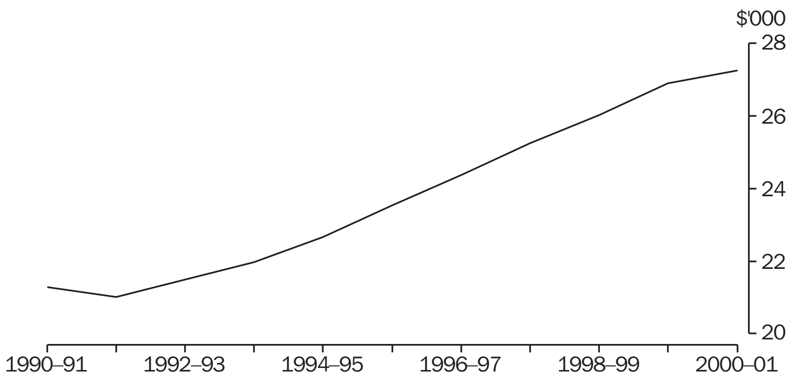
These aims provide the sustainability backdrop to the chapters which follow, drawn from *Year Book Australia 2003*.

Rising per capita income and national wealth

At the World Summit on Sustainable Development, many countries attached a high priority to improving the material wellbeing of their residents. For Australia, progress has been strong in this area. Two indicators compiled for *Measuring Australia's Progress, 2002* (1370.0) show this to be the case. Graph 1.1 shows a strong and continuous rise in real net national disposable income per head since 1992. Graph 1.2 shows, for real national net worth per head, that while there have been some fluctuations over this period, the trend has been strongly positive. The growth in both these indicators suggests that broadly the needs of the present generation are being met (through increasing levels of income) and that the needs of future generations are not being compromised (to the extent that national wealth, which underpins future national income, is increasing).

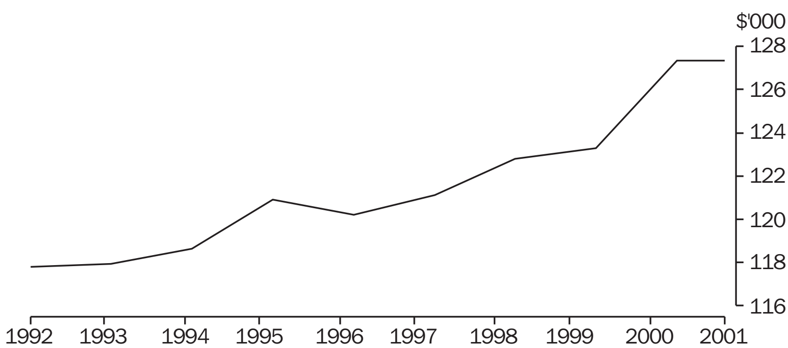
Frameworks for measuring progress and wellbeing are discussed in *Chapter 2*, *Beyond GDP: Towards wider measures of wellbeing*.

1.1 REAL NET NATIONAL DISPOSABLE INCOME PER CAPITA



Source: ABS 2002b.

1.2 REAL NATIONAL NET WORTH PER CAPITA(a) — At 30 June



(a) Reference year for chain volume estimates is 1999–2000. Data are not available prior to 1992.

Source: ABS 2002b.

Sustainable forestry

Chapter 3, Sustainable forest management and *Chapter 4, Forest conservation* describe the framework and processes used in Australia to manage Australia's forest resources in a way that strikes a reasonable balance between the economic, ecological, social and cultural values of forests for current and future generations.

The Montreal Process, established in 1994, is being used as a tool to assist in monitoring and reporting on Australia's progress toward sustainable forest management.

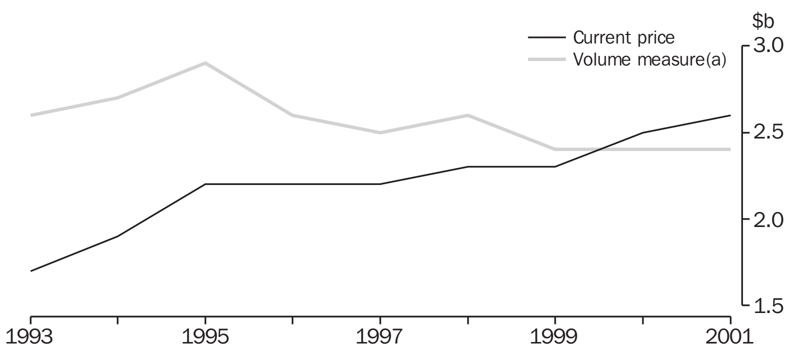
A number of threatening processes directly or indirectly jeopardise the health and vitality of forest ecosystems. These include clearing and fragmentation of habitats, mining, timber harvesting, the impact of invasive species, altered fire regimes, and climate change.

In recognition of the potentially adverse impacts of these threatening processes on Australia's forests, the Commonwealth Government and the state and territory governments have moved to protect Australia's forest ecosystems through forest conservation. About 26.8 million hectares (ha) of native forest are protected and conserved in reserves, representing 16% of Australia's remaining native forest estate.

Establishing a conservation reserve system is one of the key objectives of the Regional Forest Agreement (RFA) process implemented through the 1990s. The RFA process added 2.9 million ha to the existing estate of forest reserves, giving RFA regions a total of 10.4 million ha of forest in conservation reserves. This increased the reserved forest area in RFA regions by about 39%. More than 8.5 million ha are within formal dedicated conservation reserves. The RFAs increased old-growth forest protection across the 10 RFA regions by about 42%, from 2.4 million ha to 3.4 million ha. As a consequence, about 68% of existing old-growth forests in RFA regions have been reserved.

Unfortunately neither the Montreal indicators nor the information publicly available from the RFAs indicate the degree to which native forest timber resources are being depleted. The best available information is in an article in the June quarter 2002 edition of *Australian National Accounts: National Income, Expenditure and Product* (cat. no. 5206.0). This shows that the real or volume estimates of native standing timber available for production fell by 8% between 1993 and 2001 (graph 1.3), but appear to have stabilised in recent years.

1.3 NATIVE FOREST ASSETS — As at 30 June



(a) Reference year for volume measure is 1999–2000.

Source: ABS 2002a.

Sustainable fisheries and marine ecosystems

Chapter 5, *Fishing and the environment,* discusses the extent to which Australian fisheries stocks are being managed in a sustainable manner and the effects of fishing on habitat and non-target species.

It shows that fisheries production of a number of species has been declining since the late 1980s. Reasons for declines in some fisheries include overfishing, use of non-selective fishing gear, loss of habitat, pollution, natural disasters, and the complexity of Australia's marine jurisdiction, which hinders management of fish stocks.

Chapter 6, *Aquaculture and the environment* discusses Australia's rapidly expanding aquaculture industry (production rose by 146% in the decade to 2000–01, compared to a rise of 46% in the total gross value of fisheries production) and its environmental impacts. Aquaculture takes some pressure off wild fisheries, but it has the potential to alter coastal foreshores, estuaries, mangroves, salt marshes, and marine and other aquatic environments. The main environmental impacts of aquaculture are water pollution, pest species, the strain placed on wild fish populations for brood and feed purposes, and the culling of natural predators. The potential also exists to introduce diseases and for farmed exotic fish to escape into the wild.

Chapter 7, *Coastal and marine environment* discusses population and human settlement pressures on Australia's marine and coastal area (one of the largest in the world, extending over some 16 million square kilometres), which hosts a wide variety of habitats including estuaries and mangroves, dunes and beaches, rocky and coral reefs, seagrasses, gulfs and bays, seamounts, and a huge area of continental shelf. At 30 June 1996, 83% of Australia's population lived within 50 kilometres of the coast. All states except the Northern Territory and South Australia are experiencing higher rates of population growth and urban development within 3 kilometres of the coast than elsewhere within the state (Newton et al. 2001). The coastal strip is an ecologically sensitive zone, and urban sprawl, and pollution of rivers, lakes and seas, were described by the Resource Assessment Commission as the two most important problems faced by the coastal zone (RAC 1993).

Australia's estuaries in particular face a number of pressures from urban and industrial development in coastal areas, and from disturbance through land use and vegetation clearance in catchments. For example, estuaries are often used for dumping, sand or water extraction, and construction of marinas, ports and canal estates, and are susceptible to changes in natural flows caused by the construction of dams and weirs. Such pressures threaten the condition of estuaries by causing excess nutrient concentrations, sedimentation, loss of habitat, weed and pest infestation, and the accumulation of pollutants.

Another focus of the chapter is coral reefs, which are among the most productive and complex ecosystems in the world. The Great Barrier Reef is the largest coral reef in the world, consisting of about 3,000 individual reefs covering an area of 345,950 square kilometres.

Australian coral reefs face a variety of pressures. These include: run-off of sediment and nutrients at a number of coastal locations, which is steadily increasing through human activities (primarily from the effects of agriculture and land use practices, as well as increasing industrial and urban development); increased recreational and commercial fishing; increasing pressure from tourism developments; threats from invasive and pest species such as the crown of thorns starfish; and coral bleaching, possibly due to global warming (SoE 2001). *Chapter 8*, *Sustainable tourism in the Great Barrier Reef Marine Park* addresses management of the impacts of tourism on the Park.

Sustainable mining

Chapter 9, *Mining and the environment* briefly discusses the main environmental impacts of mineral mining, such as wastes, and the rate of resource use (where the supply of minerals depends on the rate of resource use, which is affected by the economic life of mineral deposits and the rate at which new reserves are discovered). The chapter also summarises environmental management initiatives, such as the use of legislation, environmental impact assessments, environmental protection expenditure, rehabilitation and industry self-regulation.

Data from the national balance sheet of the Australian national accounts, show that the quantity of economically viable mineral reserves is increasing (as new discoveries are made and new technologies and lower production costs make existing reserves more profitable).

Sustainable land and water use, and protecting Australia's biodiversity

Since European settlement of Australia, around 100 million ha of forest and woodland have been cleared, mostly for agricultural production (NFI 1998), and land continues to be cleared for agriculture. Today around 456 million ha, or 59% of land in Australia, are used for agriculture, making it the dominant form of land use. Agriculture is also the largest consumer of water in Australia; in 1996–97 it accounted for 15,500 gigalitres (GL) or 70% of total water use.

This publication contains a number of chapters on sustainable land and water use, and protecting Australia's biodiversity. *Chapter 10*, *Australia's rivers* is followed by *Chapter 11, Environmental impacts of agriculture,* which discusses land degradation and related issues, including results from the recently released *Salinity on Australian Farms, 2002* (ABS 2002c). *Chapter 12, Australia's biodiversity* discusses biodiversity, extent and clearing of native vegetation, and invasive species.

Some of the main findings from these chapters follow.

Australia's rivers

Water is essential for all living organisms. Australia is considered one of the driest inhabited continents. Compared to other continents, Australia is also characterised by variable climatic conditions and high levels of evapotranspiration. These factors result in a low proportion of rainfall converted to streamflow, making freshwater a valuable resource.

By world standards Australia is a dry continent with few freshwater resources. Australian rivers are characterised by relatively low and variable flows.

In much of the intensive land use zone of Australia, catchment land use has significantly modified the physical and chemical nature of the rivers. These now carry higher than natural levels of sediment and nutrient. In some regions, the biological condition of the rivers, wetlands and groundwater dependent ecosystems has been severely impacted by the extraction of large volumes of water for agricultural, urban and industrial use.

The consumption of Australia's freshwater resources from lakes, rivers and underground aquifers has increased strongly in the last two decades. Between 1983–84 and 1996–97 national water consumption increased from 14,600 GL to 23,300 GL annually (NLWRA 2001c).

Across Australia, catchment land use and diverting water are considered the most serious threats to the ecological condition of Australia's rivers, wetlands and groundwater dependent ecosystems.

Based on state assessments of sustainable yield, the 2001 National Land and Water Resources Audit determined that 34 (11%) of Australia's 325 surface water basins are overused, with a further 50 (15%) highly developed. On the other hand, 60% of Australia's river basins have less than 30% of the nominated sustainable flow regime diverted (NLWRA 2001c). Almost all of the basins with a high volume of unused sustainable yield are in the northern parts of Australia.

Land use in the catchment, combined with how well this use is managed, is a major driver of river condition. In the non-urban regions, most of the elevated nutrient and sediment loads to rivers are a consequence of using land for agricultural production. High fertiliser application rates, and other agricultural practices, have resulted in some landscapes leaking more nutrients into the waterways than they did before the adoption of European agricultural production systems (NLWRA 2001a).

Environmental impacts of agriculture

The chapter of this name looks at the impact of agricultural activities on the Australian environment. In particular it examines land and water use, salinity and the adoption of various land management practices.

The combined impacts of land and water use for agricultural production have been substantial. For example:

- The removal of native vegetation and the introduction of exotic species have contributed to the extinction and decline of many species of Australian wildlife (SoE 2001).

- The construction of dams and diversion of water from rivers have greatly altered water flows, reducing the amount of water flowing down rivers, and have changed the times of peak flows (ABS 2001a).
- There has been a deterioration of soil and water quality in many areas.

Salinity, sodicity and acidity are all naturally occurring conditions of Australian soils, but these have been exacerbated by agricultural activities.

In recent years salinity has gained prominence as a national environmental issue. Results from the 2002 Land Management and Salinity Survey show that around 20,000 farms and two million ha have land showing signs of salinity (ABS 2002c).

The impacts of salinity extend beyond the agriculture sector. Roads, houses and water supply infrastructure can all be degraded by it. Over four states (New South Wales, Victoria, South Australia and Western Australia) the roads, buildings and/or water supply infrastructure of 68 towns are at risk of damage from salinity. Biodiversity is also at risk through the loss and degradation of native vegetation. Across Australia around 630,000 ha of native vegetation and 80 wetlands, including wetlands of international importance, are at risk (NLWRA 2001b).

One factor contributing to salinity is the rise in water tables due to increased amounts of water entering underground water bodies from irrigated land. This ultimately results in increased salt loads entering river systems. Reduced river flows, brought about by the construction of dams, weirs and water diversions, compound the problem as the flow is insufficient to dilute saline groundwater inflows (ABS 1996).

Between 1990 and 2000 the area of irrigated land increased by more than half a million ha (30%). The growth in irrigated area was greatest in Queensland, where an additional 236,000 ha (or 76%) were irrigated in 2000, compared to the area irrigated in 1990. Irrigation can also cause a decline in soil structure and water quality, while the method of irrigation used influences the efficiency of water use and impacts on the environment (Smith 1998). Impacts on water quality result from the high levels of fertiliser use in conjunction with some irrigation methods. Continued awareness of the need for greater efficiency and technological advances can be expected to improve land management practices and reduce the decline in the health of land and water assets. For example, there has been a growth in the use of irrigation methods that are more efficient in terms of water delivery. In 2000 around 30% of irrigators reported using spray, micro spray or drip irrigation methods compared to 23% in 1990.

The increasing use of more efficient irrigation methods, the implementation of salinity management activities and adoption of other land use practices are an indication that farmers are more aware of the environmental impact of their activities than in the past. Much of the impact on the environment is the result of historical land management decisions, and has taken decades to manifest. The impact of agriculture on the environment can be reduced, and there are a number of community groups and government programs dedicated to achieving this. However, it is likely that the damage already done will take decades to abate and repair.

Australia's biodiversity

Australia is identified as one of 17 megadiverse countries. The loss of biodiversity is considered one of the most serious environmental problems in Australia.

Clearing of native vegetation is a significant threat to terrestrial biodiversity. Other threats include invasive species (i.e. pests and weeds), dryland salinity, pollution, nutrient loading and sedimentation of waterways and coastal areas, altered hydrological and fire regimes, and climate change. These processes constitute major threats to sustainable management of our ecosystems and the environment, as well as to the social and economic values of biodiversity.

Native vegetation is a key element contributing to Australia's biodiversity. In 2000, there were 5,251 protected areas in Australia, occupying 61.4 million ha and accounting for 8% of the total land area.

Energy, greenhouse gases and climate change

Using Australia's energy resources prudently and efficiently, and minimising energy-related contributions to greenhouse gas emissions and global warming are important environmental issues. The sorts of questions which are relevant include the extent to which Australia is energy sufficient, the extent of depletion of our reserves, and whether and how we are managing to reduce the links between economic growth on the one hand and energy use and greenhouse gas emissions on the other.

Australia has an abundance of fossil fuel and mineral energy resources which are not being depleted to any great extent by current patterns of use. The rate of energy use and the extent of greenhouse gas emissions appear no longer to be directly linked to gross domestic product (GDP). The factors underlying this favourable trend include: the continued growth in the dominance of service industries (relatively low users of energy and generators of greenhouse gases) in the economy, the increasing share of natural gas in overall energy use (natural gas produces less greenhouse gases per unit of energy), and continuing, albeit small, gains in how efficiently energy is used by industry and households.

The energy intensive export industries, such as heavy manufacturing and natural gas liquefaction, have a major impact on Australia's energy use and greenhouse gas emissions. In 1994–95, goods and services produced for export accounted for 29% of energy use, either directly or indirectly.

Energy

Chapter 13, Energy resources, production, trade and use shows that Australia has an abundance of energy resources, and our trends of energy production and use are a reflection of this abundance. Australia's per capita energy consumption is one of the highest in the world, with a heavy reliance on fossil fuels.

Between 1990–91 and 1998–99 Australia's total energy consumption increased by 23%. Over the same period, population increased by just under 10%, and real GDP by over 34%. The aggregate energy intensity (energy consumed per unit of output) of the economy declined by around 9% from 1990–91 to 1998–99, partly due to improved energy efficiency, but mainly due to a change in the structure of the economy towards less energy intensive service industries.

Australia is far more dependent on coal for the production of electricity than most Organisation for Economic Co-operation and Development (OECD) countries. *Chapter 14*, *Renewable energy in 2003*, shows that 94% of domestic energy use comes from fossil fuels. In 1999, of the 6% share of total primary energy coming from renewable energy, the major contributors were biomass in the form of bagasse (39%) which was used to generate electricity and steam, wood (39%) which was used primarily for home heating, hydro-electricity (21%) and solar (1%). Renewable energy contributed 11% to electricity generation; most electricity was generated from large-scale hydro-electric schemes (ABARE 1999).

Use of natural gas constituted the fastest growing primary energy use over the 20 years 1978–79 to 1998–99. The growth of coal (black and brown) use was also above the overall trend, due primarily to the strong growth in electricity generation over the period. The consumption of crude oil has also grown significantly, reflecting the heavy use of petroleum products in the transport sector. The annual growth in consumption of renewable energy sources has declined over the years (ANZMEC 2001).

Although depletion of fossil fuels is not an important issue for Australia for the foreseeable future, many environmental benefits are to be gained from renewable energy development. Renewable energy, energy efficiency and use of cleaner fossil fuel technologies are key tools in a strategy for sustainable energy use and reductions in greenhouse gas emissions. As well as being perpetually available, renewable energy sources are low pollutants and produce very little or no net greenhouse gas emissions when operating. In Australia, government, industry and community support are driving renewable energy growth, particularly for electricity generation and transport use.

Greenhouse gas emissions and climate change

Chapter 15, *Energy and the environment* discusses the production of energy-related greenhouse gases by industries, and energy-related emissions in the production and consumption of goods and services for the final use categories: consumption by households; comsumption by general government; exports; and gross fixed capital formation. *Chapter 16, Greenhouse gas emissions* describes the history behind and targets associated with the Kyoto Protocol (an international treaty under which developed countries have agreed to limit net greenhouse gas emissions).

Developed countries are committed to reducing their greenhouse gas emissions by at least 5% from 1990 levels by the period 2008–12. In recognition of the fact that developed countries have different economic circumstances and differing capacities to make emissions reductions, each developed country has a specific, differentiated target (AGO 2002). Australia has signed (but not ratified) the treaty, which has a target increase for Australia of 8% above 1990 levels by this time. This target includes a one-off benefit from land clearing, where reduced emissions compensate for large increases in transport and power generation.

The chapter shows that the stationary energy sector (emissions from fuel combustion in energy industries such as the electricity industry) is the biggest contributor of greenhouse gases (graph 1.4), accounting for 49% of net emissions in 2000, with electricity generation accounting for the majority of this sector's contributions (264 megatonnes of carbon dioxide equivalents (CO_2-e)). Large reductions in emissions have taken place in the forest and land use sector.

Chapter 17, *Climate change* discusses natural versus human induced climate change and whether, for example, the recent systematic drying of the south-west corner of Australia is due to some natural long-term fluctuation in (say) the southern ocean or whether it is a manifestation of large-scale geographically-anchored circulation changes forced by enhanced greenhouse warming. It makes the point that, with the current state of knowledge, it will be very difficult to provide temperature and climate projections which will be sufficiently reliable to support planning for adaptation over a lengthy timescale (a century).

Impacts of industrial activities and of households

Through their behaviour, industries and households have direct and indirect impacts on whether natural resources are used prudently and efficiently, and on the extent of waste and pollution. A number of chapters address environmental issues associated with the manufacturing, construction and transport industries and the behaviour of households.

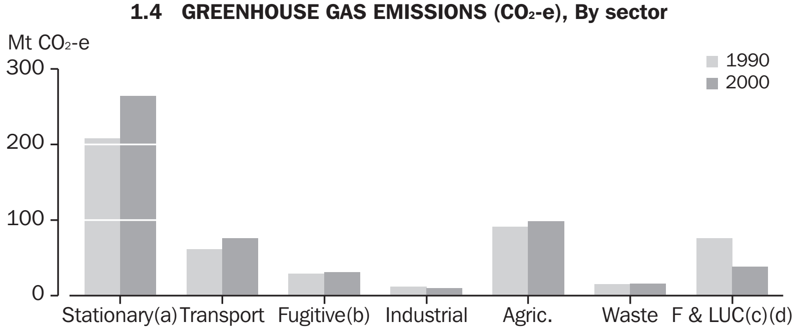
Chapter 18, Manufacturing and the environment observes that, after agriculture and mining, manufacturing has the next largest environmental impact. This industry:

- consumes considerable natural resources such as energy and water (19% of total primary energy use and 21% of total secondary energy use in 1997–98; 1% of water used in 1996–97, the sixth highest use)
- disposes of waste into the atmosphere, rivers and oceans, or as landfill (11% of the estimated total particulate emissions reported to the National Pollutant Inventory for 2000–01; 17% of total CO_2-e by Australian industries in 1997–98, the second highest source of greenhouse gas emissions after the electricity industry).

Chapter 19, *Construction and the environment* discusses the significant impact on the environment of the construction of residential buildings, commercial buildings and other infrastructure. Direct impacts include use of land, materials and energy, which in turn leads to greenhouse gas emissions and the production of other wastes. Indirect impacts include the energy consumed in providing building materials and in operating the completed buildings.

The chapter shows that Australians currently send approximately one tonne of construction and demolition waste per person per year to landfill. This can make up to 40% of landfill and represents a potentially valuable natural resource being wasted. Materials include metals, concrete and bricks, glass, fittings and fixtures from demolished or refurbished buildings, wood and wall panelling.

1.4 GREENHOUSE GAS EMISSIONS (CO_2-e), By sector



(a) Stationary energy. (b) Fugitive emissions from the production and distribution of coal and gas. (c) Estimated emissions from land clearing. These assessments should be treated as indicative only due to high uncertainties in emissions estimates. (d) Forestry and land use change.

Source: AGO 2002.

Chapter 20, *The WasteWise Construction Program* shows that, since its beginnings in 1995, the Program has, with the cooperation of five major Australian construction companies, pioneered best practice in waste reduction and recycling. The participating organisations have successfully decreased the amount of their waste going to landfill, in some cases by more than 90%.

Chapter 21, *The use of forest products* explores past and projected trends in the consumption of structural wood (mainly for building and construction), and its production, import and export. It observes that forest plantations have provided progressively more of Australia's structural wood resources in recent years. Some recent revisions to projected wood supplies from both forest plantations and native forest, however, suggest that this process is occurring more quickly than previously expected. It is now possible that forest plantations could be providing 75% of domestic industrial wood supplies by 2010, compared with expectations of only around 62% several years ago.

Chapter 22, *Attitudes of residential builders to energy issues and usage* shows that most builders are also sympathetic to the concept of the 'clean, green' home. In 2001–02 the majority of builders surveyed were installing dual flush toilets (99%), ceiling insulation (71%), wall insulation (63%), gas hot water systems (60%) and hot water temperature control (56%).

Chapter 23, Environmental impacts of Australia's transport system discusses the use of energy and greenhouse gases by the transport system, the increasing size of the transport task, increases in fuel efficiency, and the impact of transport on wildlife, biodiversity and aquatic environments. A number of indirect impacts of transport are also discussed, such as air pollution and related illnesses, the livability of urban environments and the environmental impacts of the materials used by the transport system.

Chapter 24, Environmental issues and behaviour has sections dealing with households' views and practices regarding water supply, quality and conservation, and household waste management.

The first of these shows that:

- In 2001, 73% of Australians were satisfied with the quality of tap-water for drinking.
- South Australians were the least satisfied (68%), to the extent that 10% of people indicated they did not drink any tap-water at all.
- Satisfaction with the quality of tap-water for drinking increased in most states and territories over the 1990s, the exceptions being South Australia and Tasmania.
- Australian households used 1.8 million megalitres of water in 1996–97, making households the second largest users of water after the agriculture sector.
- In 2001, 64% of households had a dual flush toilet (up from 55% in 1998), and 35% of households had a reduced flow shower head (up from 32% in 1998).
- Just over half (58%) of Australian households with a garden reported that they regularly conserve water in the garden, a further 3% reporting that they sometimes used water saving measures. The main method used by Australian home gardeners was to water either early in the morning or late in the evening when it was cooler. The next two most common practices were to water less frequently but for longer periods (20%), and to use recycled water (18%).

The section on household waste management found that:

- Australia is among the top 10 solid waste generators within the OECD.
- The main form of waste disposal in Australia is landfill, which accounts for over 95% of solid waste disposal in some states and territories.
- The impacts of landfill disposal include: use of land that could otherwise be used for another purpose; potential leachates from toxic wastes; release of methane from the decomposition of organic wastes; and greenhouse gas emissions through the transportation of wastes to landfills, which are mostly on the fringes of cities.
- Household recycling increased in Australia during the 1990s: in 1992 around 85% of people recycled at least one item of their household waste; by 2000 the vast majority of Australians (97%) practised at least some recycling, with 7% doing so for all recyclable items.

As shown in *Chapter 15, Energy and the environment,* a majority (about 56%) of Australia's energy-related greenhouse gases were emitted in the production and consumption of goods and services for the purpose of household final consumption. The consumption of electricity by households indirectly produced the greatest amount of energy-related greenhouse gas emissions (17%). This was followed by direct emissions by households (14%), most of which were due to the consumption of motor vehicle fuels.

This publication concludes with *Chapter 25, Accounting for the environment in the national accounts*, which returns to the theme of measurement taken up in Chapter 2, and on this the work being done by the ABS to extend the core national accounts into what could be called a satellite account for the environment.

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2 Beyond GDP: Towards wider measures of wellbeing[1]

Introduction

For many years growth in the volume estimates of real gross domestic product (GDP) and real GDP per capita have been used as benchmarks in the determination of changes in individuals' and countries' standards of living and wellbeing. Changes in real GDP are generally accompanied by broadly similar rates of change in consumption and income, and therefore making the link between changes in GDP and changes in the standard of living is appropriate. However, national accountants who compile GDP have long recognised that GDP is an imperfect measure of changes in economic wellbeing due, in part, to particular decisions that have been taken to define its scope, the fact that it is a gross measure and not a net measure (i.e. depreciation is not deducted), but mostly because it is simply a measure of production. For example, for reasons of practicality, the scope of GDP excludes the production of services produced and consumed within the household, and by definition GDP does not reflect the income flows between a country and the rest of the world. For these reasons, real net national disposable income (RNNDI) and RNNDI per capita are considered better measures of economic welfare. RNNDI goes part of the way to addressing some of the shortcomings of real GDP as a measure of economic welfare by deducting depreciation of produced assets and taking account of flows of income and current transfers between a country and the rest of the world.

At the same time, it is also being recognised that the measurement of welfare must encompass more than only economic concerns. This broadening of the measurement agenda has moved in concert with the increasing focus in public and corporate policy on the need to consider the environmental, social and economic aspects of life together. Responding to the measurement issues posed by the integration of economic, social and environmental aspects represents a significant challenge. This chapter provides a guide to the relevant issues and an introduction to work being undertaken both within Australia and overseas.

Measurement frameworks

The integration of three diverse areas of statistics requires a statistical framework of some kind. Frameworks are required:

- to place indicators in context and to organise available information
- to assess trade-offs and reinforcements between different dimensions of sustainable development
- to help set priorities across different policy areas
- to develop summary or aggregated indicators.

The development of appropriate frameworks is difficult, but much work has been done and is continuing:

- the statistical framework for economic statistics is well developed and it is this framework that is used to derive GDP (*System of National Accounts 1993* (SNA93))
- the statistical links between the economy and the environment are being increasingly well defined (*System of Integrated Environmental and Economic Accounting (SEEA)* (United Nations 2002))
- frameworks on the social side are less well established particularly with regard to linkages between society and the environment; recent contributions include the development of social accounting matrices and the measurement of human and social capital (SNA93)
- the genuine savings framework extends the traditional economic statistics boundaries to allow for environmental factors and human capital (see <http://www.worldbank.org>)
- the wealth accounting focus developed by the World Bank looks specifically at the composition and changes in countries' wealth as the determinant of sustainability (see <http://www.worldbank.org>)

1 From *Chapter 29, National accounts* in *Year Book Australia 2003.*

- some frameworks focus purely on physical relationships between resources, one example being the total material flows framework developed by the World Resources Institute (see <http://www.wri.org>).

Further development and discussion of measurement frameworks is essential to progress in this area.

Aggregate indicators

In the same way that GDP is a single measure of economic growth, many people have desired and developed single measures of sustainable development and welfare. These single indicators require the aggregation of a variety of economic, social and environmental variables in much the same way that GDP requires the aggregation of specific economic variables.

A number of aggregate indicators have been developed that focus on environmental variables. For example:

- Ecological Footprints developed by the World Wildlife Fund, the United Nations Environmental Program and others (see <http://www.unep.org>)
- the Environmental Sustainability Index developed by the World Economic Forum (see <http://www.weforum.org>)
- the Total Material Requirement developed by the World Resources Institute (see <http://www.wri.org>).

An aggregate indicator with a more social focus is the Human Development Index developed by the United Nations Development Program (see <http://www.undp.org>). This measure combines indicators of health, education and income.

Finally, there are some aggregate indicators that combine information on a much broader range of variables which are either aggregated in monetary terms or weighted together to form a composite index. Important examples include:

- Genuine Progress Indicators (GPI) and Indicators of Sustainable Economic Welfare originally developed by Nordhaus and Tobin (1972) in the early 1970s (see the Australia Institute's web site <http://www.gpionline.net> which gives a GPI for Australia)
- the Index of Economic Wellbeing developed by Osberg and Sharpe (1998)
- Genuine Savings developed by Pearce and Atkinson (1993) (see <http://www.worldbank.org>).

Although aggregate indicators provide a simplicity of message, there remain concerns over their conceptual and statistical validity and they are seldom measured officially. The lack of widely accepted frameworks, the difficulties in valuing environmental and social factors and hence allowing direct aggregation, and the subjectivity of selecting and weighting variables to include in composite indices are real and significant concerns. Despite these limitations, so long as the underlying logic of the indicator's construction can be understood, there will be instances where aggregate indicators can assist in drawing attention to, summarising and understanding cross-cutting changes.

Indicator sets

In order to present an integrated message on developments in economic, social and environmental areas of life, many groups and agencies, including the ABS, have turned to the use of indicator sets to bring together relevant information. Commonly, a compact set of high level (headline) indicators is selected to reflect changes in relevant economic, social and environmental concerns. Although there are significant difficulties in limiting the range of available indicators to a manageable number, many initiatives also present a broader range of indicators that provide detail below the headline level. Importantly, there is usually less scope to question the statistical validity of each of the indicators, which in turn gives an important element of confidence in the indicator set as a whole. As well, often there is no specific interpretive framework underlying the indicators and explaining how they are linked, and so users must form their own opinion about relative significance of change in an area such as health, say, against change in GDP or biodiversity.

There are now many examples of indicator sets. The most topical in Australia is the indicator set presented in *Measuring Australia's Progress, 2002* (cat. no. 1370.0) released in April 2002. Table 2.1 lists the headline dimensions and associated headline indicators from this release.

Other examples of indicator sets that may be of interest include:

- the Commonwealth of Australia's headline indicators of sustainable development (see <http://www.ea.gov.au>)
- *Growing Victoria Together* (see <http://www.growingvictoria.vic.gov.au>)
- *Tasmania Together* (see <http://www.tasmaniatogether.tas.gov.au>)
- *Indicators of Sustainable Development* developed by the United Kingdom government (see <http://www.sustainable-development.gov.uk>)
- *International Benchmarking of Denmark* released by the Danish government (see <http://www.fm.dk/sideforloebbeholder.asp?artikeIID=4503>)
- the preliminary set of sustainable development indicators developed by the Organisation for Economic and Co-operation and Development (OECD) (see OECD 2001, *Sustainable Development: Critical Issues*, at (<http://www.oecd.org>)
- the OECD/United Nations/World Bank core set of development indicators (see <http://www.oecd.org/dac/indicators>)
- the *Human Development Report* published by the United Nations Development Programme (see <http://www.undp.org>)
- the *World Development Indicators* published by the World Bank (see <http://www.worldbank.org>).

Conclusion

As society seeks to answer the broad economic, social and environmental questions that confront it, the provision of information to help answer these questions is essential. Importantly, the information needs to be presented in a coordinated way that assists rather than hinders possible interpretation. This chapter has presented a number of ways in which measurement has moved beyond the use of GDP as the indicator for all occasions. Although much work remains to be done there is a range of promising measurement approaches that can be developed.

2.1 HEADLINE INDICATORS — 2002

Headline dimension	Headline indicator
Health	Life expectancy at birth
Education and training	People aged 25–64 years with a vocational or higher education qualification
Work	Unemployment rate
Biodiversity	Number of extinct, endangered and vulnerable birds and mammals
Land clearance	Annual area of land cleared
Land degradation	Assets at risk in areas affected by salinity or in areas with a high potential to develop salinity
Inland waters	Proportion of water management areas where use exceeds 70% of sustainable yield
Air quality	Days in which health standards for fine particle concentrations are exceeded in selected capital cities
Greenhouse gases	Net greenhouse gas emissions
National wealth	Real national net worth per capita
National income	Real net national disposable income per capita
Economic disadvantage and inequality	Real equivalised average weekly disposable income of households in the second and third deciles of the income distribution
Housing	No headline indicator (although two indicators consider housing affordability and overcrowding)
Crime	Unlawful entry with intent and assault (victimisation rates)
Social attachment	No headline indicator (various indicators cover aspects, including people living alone, marriage and divorce, attendance at cultural venues and suicide rates)

Source: ABS 2002.

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3 Sustainable forest management[1]

Sustainable forest management (SFM) is a primary objective for those agencies concerned with the management of Australia's forest resources. The Ecologically Sustainable Development Working Groups (ESDWG 1991) defined SFM as 'optimising the tangible and intangible social and economic benefits which forests can provide to the community, with the goals of maintaining the functional basis of forested land, biodiversity and the options available for future generations'. To achieve SFM, the challenge for forest managers is to strike a reasonable balance between the economic, ecological, social and cultural values of forests for current and future generations.

Australia is promoting its SFM interests in a number of international forums and mechanisms. They include the United Nations Forum on Forests, the International Tropical Timber Organisation and the Montreal Process. Australia's initiatives, including the publication of a summary of internationally agreed forest actions, are regarded as providing practical solutions for advancing SFM. Another key activity is the development of an Australian Forestry Standard as an objective benchmark for forest management. The standard will enable Australia to compete in the international marketplace.

The Montreal Process: monitoring sustainable forest management

The Montreal Process, established in 1994, is being used as a tool to assist in the monitoring and reporting of Australia's progress toward SFM. The Montreal Process was established with the specific purpose of developing and implementing internationally agreed criteria and indicators for sustainable management of the world's temperate and boreal forests. The Montreal Process includes 12 countries on five continents, including Australia, which account for 90% of the world's temperate and boreal forests, and 45% of the world trade in forest products. Participation in the Montreal Process is voluntary and not intended to be legally binding.

The group has developed a comprehensive set of seven criteria (categories of forest values that are desirable to maintain) and 67 indicators (measurable aspects of these criteria) to characterise the state of a nation's forests and assess progress towards the goals of SFM. The seven criteria include vital ecosystem functions and attributes, socioeconomic benefits, and the laws and regulations that constitute the forest policy framework (AFFA 2002). The criteria are as follows:

1. conservation of biological diversity
2. maintenance of productive capacity of forest ecosystems
3. maintenance of ecosystem health and vitality
4. conservation and maintenance of soil and water resources
5. maintenance of forest contribution to global carbon cycles
6. maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies
7. legal, institutional and economic framework for forest conservation and sustainable management.

The indicators have been modified to specifically address Australian conditions. They are divided into three broad groups for implementation at a regional level within Australia:

Category A — already implemented or to be implemented in the short term

Category B — require some development

Category C — require longer term research and development.

1 From *Chapter 17, Forestry and fishing* in *Year Book Australia 2003.*

Australia's Montreal Process Implementation Group began drafting a progress report on implementing criteria and indicators of SFM in 2000–01, using a framework based on Montreal Process criteria and indicators. Joint projects with the states and territories have also improved the Commonwealth's SFM reporting capacity. This work will lead to the preparation of Australia's country report to the Montreal Process, and Australia's second *State of the Forests Report*, both of which will be published in 2003.

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4 Forest conservation[1]

A number of threatening processes directly or indirectly jeopardise the health and vitality of forest ecosystems. These include: clearing for cropping and grazing; mining; timber harvesting; the impact of invasive species; altered fire regimes; and climate change. Impacts vary enormously in their spatial extent and the time taken for their consequences to become apparent. The processes presenting the greatest immediate threats are clearing and fragmentation of habitats, although the impacts of harvesting are particularly pertinent in forests from which timber is produced.

In recognition of the potentially adverse impacts of these threatening processes on Australia's forests, the Commonwealth Government and the state and territory governments have endeavoured to protect Australia's forest ecosystems through forest conservation. The general aim of forest conservation is to ensure that forest ecosystems and the natural processes that sustain them remain intact for their own sake and for the benefit and enjoyment of future generations (NFI 1998). This implies preservation of the suite of economic, ecological, social and cultural values of forest ecosystems. Forest conservation is an important component of ecologically sustainable forest management (see *Chapter 3*, *Sustainable forest management*).

Across Australia, approximately 26.8 million hectares (ha) of native forest are protected and conserved in reserves, representing 16% of our remaining native forest estate (table 4.1). This compares favourably with a global average of 8% reserved (AFFA 2001). Australia's protected forest estate is subject to a number of types of tenure and intentions regarding management. About 12% of the native forest estate is in Nature Conservation Reserves (20.5 million ha), formally gazetted under state or territory and/or Commonwealth legislation (i.e. National Parks and Flora Reserves). The remaining conserved area occurs under tenures which are not principally managed for conservation but may afford some protection to many conservation values.

Australia's National Forest Policy Statement advocated the development of a comprehensive, adequate and representative (CAR) system of reserves for Australia's forests. The national CAR reserve system aims to safeguard biodiversity, old-growth, wilderness and other natural and cultural values of the forests. The 'comprehensive' dimension of the system aims to secure diversity across forest communities; the 'adequate' requirement ensures that the reserved areas are of sufficient size to maintain the viability and integrity of native forest populations, species and communities; and the 'representative' principle seeks to ensure that the diversity within a native forest community is preserved across its range (AFFA 2001).

Establishing a CAR reserve system is one of the key objectives of the Regional Forest Agreement (RFA) process. The RFA process adopted the nationally agreed 'JANIS criteria' to identify the areas of the forest that needed protection under the CAR reserve system. These criteria specify: the reservation of a proportion of the past extent of forest ecosystems and current rare or depleted ecosystems; the protection of old-growth and forested wilderness; and the protection of adequate high-quality habitat for forest species, particularly those considered endangered. Development of these CAR reserves is confined largely to RFA regions with forests intensively managed for timber production. The CAR reserve system is not applicable to the entire forest estate.

The RFA process added 2.9 million ha to the existing forest reserves estate, giving RFA regions a total of 10.4 million ha of forest in conservation reserves (table 4.2). This increased the reserved forest area in RFA regions by about 39%. More than 8.5 million ha are within formal dedicated conservation reserves. The RFAs increased old-growth forest protection across the 10 RFA regions by approximately 42%, from 2.4 million ha to 3.4 million ha. As a consequence, about 68% of existing old-growth forests in RFA regions have been reserved.

1 From *Chapter 17, Forestry and fishing* in *Year Book Australia 2003.*

4.1 PROTECTED NATIVE FOREST(a) — 2001

	Area of protected forest	Proportion of total native forest
	'000 ha	%
NSW	5 720	21
Vic.	5 189	67
Qld	3 665	8
WA	4 364	13
SA	3 960	37
Tas.	1 261	40
NT	2 500	7
ACT	108	89
Aust.	**26 766**	**16**

(a) Includes areas under conservation management that have not been formally gazetted under state or territory and/or Commonwealth legislation. Private forests informally managed for conservation are not included in the protected forest areas.

Source: Bureau of Rural Sciences 2001.

4.2 TOTAL RFA(a) REGIONS IN RESERVES(b) — March 2001

RFA/state	Pre-RFA(a) area	Post-RFA(a) area	Increase in reserves
	'000 ha	'000 ha	%
South-west WA/WA	932.6	1 047.2	12.3
East Gippsland/Vic.	573.6	581.1	1.3
Central Highlands/Vic.	177.6	293.9	65.5
North East/Vic.	394.8	591.5	49.8
Gippsland/Vic.	501.8	780.5	55.5
West/Vic.	466.4	629.3	34.9
Eden/NSW	160.4	266.1	65.9
Upper North East/NSW	243.7	705.0	189.2
Lower North East/NSW	747.0	1 367.0	83.0
Southern/NSW	1 003.1	1 401.0	39.7
Tasmania/Tas.	2 304.6	2 746.7	19.2
Total	**7 505.7**	**10 409.4**	**38.7**

(a) Regional Forest Agreement. (b) These figures have been agreed between Commonwealth agencies only. Some figures have not been agreed to by states and territories.

Source: AFFA 2002.

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5 Fishing and the environment[1]

A significant issue for fisheries in Australia is to ensure the ecological sustainability of wild fish stocks in the long term so that ecosystems that are fished remain diverse and healthy. Fishing also has impacts on the marine environment beyond the species it targets. This chapter focuses on the environmental impacts of various fishing activities on the marine environment, particularly the impact of commercial fisheries. Recreational fishing, which accounts for 13% by weight of total fish caught, and Indigenous fishing, are beyond the scope of the chapter.

The Australian marine environment

Australia's marine area is one of the largest in the world, extending over about 16 million square kilometres. This is more than double the continent's land area. Australia's ocean domain includes all ocean temperature zones (based on sea surface temperature), from tropical to polar. Australia's marine environment is very diverse in terms of the different physical features, species and ecosystems, and fisheries management and conservation vary from region to region (SoE 2001b). Of the 33 major animal groups, 28 are found in the sea and 13 are exclusively marine (DEST 1993). Australia has 5,250 known species of fish of which 4,150 have been described and 90% are endemic (only found in Australian waters). There are 9,500 species of crustaceans of which 6,426 have been described. Molluscs account for 12,250 species of which 90% are endemic with 9,336 of the molluscs described (SoE 2001a). Most of Australia's endemic marine species are found in the waters south of the continent (Zann 1995a). *Chapter 7, Coastal and marine environment* contains more information on marine biodiversity.

Status of Australian fisheries

A complete summary of the condition of all of Australia's fish stocks is not yet possible due to the different reporting approaches in the various Commonwealth, state and territory fisheries. One of the problems in attempting to assess the overall status of fisheries is that there is no national fisheries statistics database from which to assess trends (SoE 2001b).

Australia's commercial fishing fleet consists of approximately 10,000 vessels spread across the Commonwealth, state and territory fisheries. In the mid 1990s, approximately 200 different species of fish, 60 species of crustaceans and 30 species of molluscs were fished commercially (McLoughlin et al. 1993). By 2001, nearly 600 marine species were commercially fished.

A key finding in the 1996 State of the Environment report (SoE 1996) found that most Australian fisheries stocks were fully fished with little room for further development; management regimes were partly effective and improving; and the effects of fishing on habitat and non-target species were largely unknown (SoE 2001b). Following are definitions of the classifications used.

Underfished — a fish stock that has the potential to sustain catches higher than those currently taken. The classification is not applied to stocks that are subject to limited catches while rebuilding from overfishing.

Fully fished — a fish stock from which current catches and fishing pressure are close to optimum. Categorising a species as 'fully fished' implies that increased fishing pressure or catches (allowing for annual variability) may lead to overfishing.

Overfished — a fish stock in which the amount of fishing is excessive or for which the catch depletes the biomass below a specified limit; or a stock that reflects the effects of previous excessive fishing. While both conditions are covered in Fishery Status Reports (BRS nd) by a classification of overfished, it is important to recognise the distinction between overfished stocks and overfishing. A management regime might curtail overfishing, but it can still be some time (perhaps many years for some species) before a stock recovers; so a classification of overfished persists.

1 From *Chapter 17, Forestry and fishing* in *Year Book Australia 2003.*

Uncertain — a fish stock that may be underfished, fully fished or overfished but for which, there is inadequate information to determine its status (ABARE 2002).

Depletion of marine resources

Although fish are a renewable resource, fisheries production of a number of species has been declining since the late 1980s (Kearney 1995). Reasons for declines in some fisheries include overfishing, use of non-selective fishing gear, loss of habitat, pollution, natural disaster, and Australia's marine jurisdictional complexity which hinders management of a fish stock or population. Management of fisheries ecosystems, as opposed to the management of single species, is an important step towards better management of marine resources. The loss of a few key species has the potential to destroy whole ecosystems. For example, krill, the world's most abundant crustacean, has a key role in southern waters. Krill is the staple diet of many seals, whales, fish, squid, penguins and other seabirds, making it significant in the conservation of many species. If krill were to disappear, most of the creatures that feed on them would disappear (AAD 2000). There are very few examples in which fisheries management can claim clear success in achieving regulatory goals. The Western Australian Western Rock Lobster Fishery and the Tasmanian Abalone Fishery have managed to rebuild stocks over several years.

Impacts on target species

Species that are particularly vulnerable to fishing activities are usually slow growing, low breeding (they produce a low number of eggs compared to other fish), long-lived marine species that aggregate for their spawning. For example, the 'overfished' Eastern gemfish, taken in the Commonwealth South East Trawl Fishery off southern New South Wales, was fished excessively in the 1970s and 1980s, and as a result it is still vulnerable. A zero catch limit was set from 1993 to 1996. The total allowable catch (TAC) for 1997 was set at 1,000 tonnes, but the catch was only 393 tonnes. Scientific advice was that the TAC for 1998 should be zero, but a total of 500 tonnes was allocated to cover bycatch (see *Impacts on non-target species* for definition) and reduce discarding. The catch, however, was only 214 tonnes. The 1999 allocated catch for bycatch was 250 tonnes (actual catch 158 tonnes), and in 2000 the allocated catch for bycatch was reduced to 200 tonnes. Eastern gemfish remain vulnerable to targeted fishing as they congregate for their spawning run (SoE 2001b).

Impacts on non-target species

In some fisheries, large numbers of other species (non-targeted species) are also taken. These are termed 'bycatch', which refers to the species that are taken incidentally in a fishery. Bycatch species are usually of lesser value and of greater quantity than the target species, and are sometimes discarded. Management of bycatch is of particular concern as little is known about the impacts of retained or discarded bycatch on marine ecosystems.

The components of fishing bycatch can be described as:

- the non-target species retained (byproduct)
- the non-target species discarded
- the other non-target species affected by fishing gear, but which do not reach the deck.

Attempts to reduce bycatch

As a response to the significant issues and impacts of bycatch on the marine environment, the Commonwealth developed a National Bycatch Policy in 1999 and a Commonwealth Bycatch Policy in 2000. By the end of 2001, Bycatch Action Plans were developed for 14 of the 21 Commonwealth fisheries. Turtle exclusion devices (TEDs) and bycatch reduction devices (BRDs) allow escape and have been trialled in the Northern Prawn Fishery since 1993. They became compulsory in this fishery in 2000. Seal excluder devices are currently being trialled in the South East Trawl Fishery. These projects show that the use of TEDs and BRDs has resulted in a substantial decline in the catches of large animals such as turtles, stingrays and sharks. However, the use of BRDs in this fishery seems to have had little impact on the catch of the smaller, more abundant bycatch. The Commonwealth Government has provided just over $1m from the Natural Heritage Trust to establish the SeaNet extension service. The project is focused on increasing the rate of adoption by the commercial fishing sector of new fishing gear and practices to aid bycatch reduction and to implement environmental best practice (SoE 2001b).

Trawling

Trawling is one of the most widely used commercial fishing methods in Australia. Demersal trawling makes contact with the sea floor and therefore it can have substantial impacts on seabed habitats and benthic (occurring at or near the bottom of a water body) ecosystems (Harris & Ward 1999). The extent of essentially indiscriminate impacts can be significant, including physical removal, disturbance of organisms and non-living components and increases in water turbidity. The nature of the catch in trawl fisheries other than the target species can include threatened species (e.g. turtles) and invertebrate (e.g. jellyfish) and large amounts of non-target species. Nearly 10,000 turtles are caught accidentally by trawl fishing each year in northern Australia, but an estimated 90% of these are released alive (SoE 2001b). Australia has about 30 of the world's 50 sea snakes, around half of which are endemic. They are quite fragile animals and it has been estimated that between 10% and 40% taken in trawls die once released (Zann 1995b).

Repeated trawling may prevent the recolonisation of benthic species, both sedentary and mobile. Seamounts (sites of highly valued marine biodiversity) have been trawled for orange roughy and some have been damaged by this activity. Trawl nets may dislodge attached species such as sponges and modify the habitat and food chains. Possible effects of trawling also include changes in food webs, such as increased populations of scavengers such as seabirds, fish and crabs. A 1996 study by the CSIRO (Commonwealth Scientific and Industrial Research Organisation) and the Queensland Department of Primary Industries showed that each pass of the trawl along the sea bed removes about 5% to 25% of the seabed life. However, there is a cumulative effect; seven trawls over the same area of seabed removed about half the seabed life, and 13 trawls removed 70% to 90%. In the far northern Great Barrier Reef Marine Park, for every tonne of prawns harvested, about six to ten tonnes of other species are discarded (SoE 2001b). A study on the environmental effects of prawn trawling (Poiner et al. 1998) found that about one-third of bycatch species were crustaceans and two-thirds fish. Zoning in the Great Barrier Reef Marine Park prohibits trawling on about 20% of the sea floor (Zann 1995a).

There are both Commonwealth and state fisheries laws under which fisheries are managed through general regulations or other statutory methods. There are various methods to manage each fishery such as size and catch limits and gear restrictions. The *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)(the EPBC Act) came into force in July 2000. It requires an assessment and approval process for activities that are likely to have a significant impact on the Commonwealth marine environment, on nationally threatened species and ecological communities, and on internationally protected migratory species. The Act also requires that all Commonwealth managed fisheries have their own environmental impact strategically assessed. One of the most significant legislative changes is the removal of the general exemption of most marine fish from export control regulation under the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (Cwlth). The removal of the exemption makes the taking of marine native species consistent with the taking of terrestrial native species. This change comes into effect in December 2003. Before a fishery can become exempt from the Act, it must show that the fishery is ecologically sustainable in terms of its impact on: target species, non-target species and bycatch, and the ecosystem generally (including habitat) (SoE 2001b).

Longline fishing

Longline fishing involves setting baited hooks along a line up to 100 kilometres in length behind a boat. The line is deployed at various depths and is a particular threat to several non-target species, especially seabirds (EA 2000). The death rate of albatross averages 0.4 birds per 1,000 hooks deployed. The number of hooks set annually is high, between 50 and 100 million in the world's southern oceans alone (Robertson 2001). The interaction of sea birds that feed in open waters with longline fishing vessels can be fatal, and considerable concern has been raised about the effect of longlining on populations of albatross and on some species of petrels. Species of albatross are particularly at risk, not only because of the number of birds caught, but also because of their breeding patterns. Albatross are now listed as vulnerable by the Commonwealth Government. The Government put in place a threat abatement plan in 1998 with the aim of reducing bycatch to one bird per 20,000 hooks set. This is a reduction of 90% over a five-year period through techniques such as setting baits at night when seabirds are less active (EA 2000).

Ghost fishing

Ghost fishing refers to the lost, damaged or abandoned fishing nets and traps out at sea that continue to catch fish and other marine creatures. Worldwide, many thousands of marine mammals, turtles and seabirds die each year from swallowing plastic bags and other objects, or get trapped in discarded fishing gear. Fishing litter such as net fragments, ropes and bait straps may entangle marine animals, strangling or drowning them. In southern Australia, seals often get their necks entangled in lost or discarded fishing gear. It is estimated that at any one time around 500 seals in Tasmanian waters and 45 seals at Victoria's Seal Rocks have 'collars' of plastic litter (Zann 1995b). A study by the Bureau of Rural Sciences in 1989–91 of the composition of neck collars on entangled seals shows that trawl nets constitute the highest proportion followed by packaging bands.

Illegal fishing

Illegal, unreported and unregulated fishing is a growing problem. Illegal fishers generally damage marine ecosystems in a number of ways. They typically remove unsustainable numbers of their target species from the marine environment and often capture large amounts of bycatch due to indiscriminate fishing methods. This contributes significantly to the decline in fish stocks and undermines their sustainable management within the Australian Fishing Zone and worldwide. Illegal fishers also often abandon fishing gear to avoid apprehension, endangering non-target species in the environment (SoE 2001b). Periodically, larger trawlers and longliners of various nationalities are apprehended fishing illegally in Australian waters.

For further information on protection of the marine environment see *Chapter 7, Coastal and marine environment.*

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6 Aquaculture and the environment[1]

Aquaculture, as defined by the Food and Agriculture Organisation (FAO 2001) is:

> the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, and so on. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resource, with or without appropriate licences, are the harvest of fisheries.

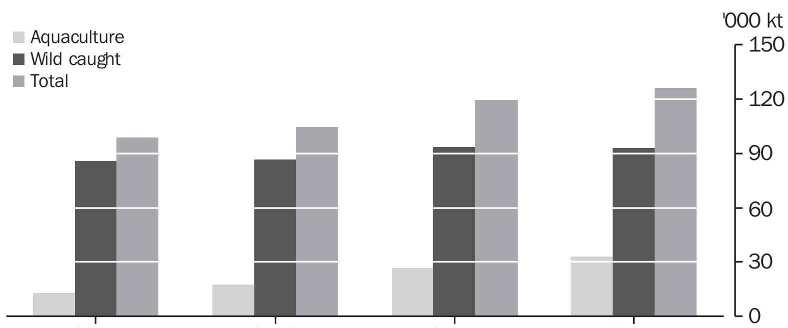
The two characteristics that therefore distinguish aquaculture from capture fisheries production are intervention in the rearing process and ownership of the stock being cultivated. This chapter addresses Australian aquaculture in a global and local context. It focuses on Australian systems of aquaculture production and associated environmental impacts. It also includes some positive outcomes and management practices.

Global aquaculture production

Fish supplies from traditional marine and inland capture fisheries are unlikely to increase substantially in the future and aquaculture production will need to rise to help satisfy growing world demand for fisheries products (FAO 1997).

The world's aquaculture industries are expanding rapidly, including the Australian aquaculture industry. Global aquaculture production has more than doubled in weight and value in the past 10 years (New 1999). During the period between 1990 and 1999, global production of wild caught fisheries rose by 7.3 million tonnes (9%), and global aquaculture production rose by 20.2 million tonnes (155%) (graph 6.1). In 1999, aquaculture accounted for 33.3 million tonnes (26.4%) of total world production of finfish, crustaceans and molluscs. Nearly all (98%) of world aquaculture production was produced in 30 countries, with China alone accounting for 22.8 million tonnes (69%) of world production in that year (ABARE 2002).

6.1 WORLD FISHERIES PRODUCTION(a)



(a) Finfish, crustaceans and molluscs for selected years.

Source: FAO 2001.

1 From *Chapter 17, Forestry and fishing* in *Year Book Australia 2003.*

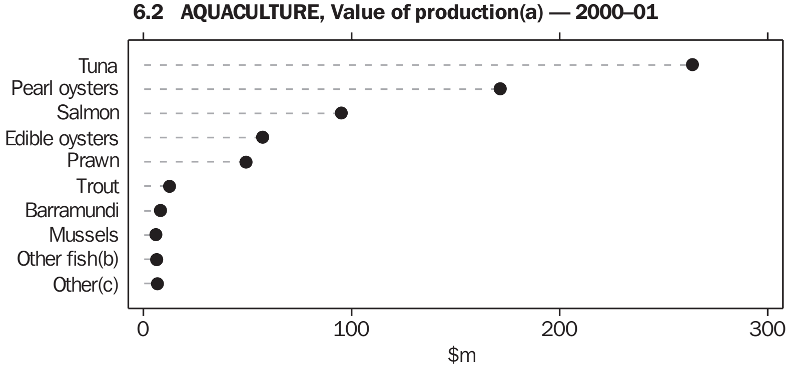
Australian aquaculture production

The Australian aquaculture industry occurs in diverse environmental areas including tropical, subtropical and temperate sectors. The production of juveniles of several species of finfish, molluscs and crustaceans has been undertaken for some years, initially for restocking wild populations and more recently as stock for grow-out operations providing mature fish to restaurants and export markets. The location of aquaculture is dependent on seasonal factors, the type of species being cultivated, the stage of aquatic organisms in their life-cycle and proximity to marine parks. Point-source pollution from aquaculture is increasingly subject to regulation. For example, in the Great Barrier Reef region new regulations were established in 1999 to control the quality of aquaculture discharges (SoE 2001). It is likely that aquaculture in regional areas will experience strong growth due to the lack of suitable sites and high competition for coastal zones near metropolitan cities.

Over the past 30 years there has been a significant increase and diversification of aquaculture species farmed in Australia. Of the approximately 60 different species farmed, the major contributors are tuna, pearl oysters, salmon, edible oysters and prawns (FRDC 2000) (graphs 6.2 and 6.3).

Australian aquaculture production rose by 146% in the decade to 2000–01, compared to a rise of 46% for the total gross value of fisheries production (graph 6.4). In 2000–01, aquaculture accounted for 30% of the total gross value of fisheries production, to the value of $746m, for 43,602 tonnes produced, compared with $237m in 1990–91 (ABARE 2002). Prawn farming production rose from 15 tonnes in 1984 to 2,800 tonnes in 2000–01. Australian aquaculture is expected to continue to show strong growth for the next 10 years and, on current estimates, the value of production will be in excess of $1b by the end of this period. The industry directly employs about 5,000 people (ABS 2002), provides regional development opportunities in rural Australia and contributes to export growth. Nevertheless, total production is low compared to that in other countries.

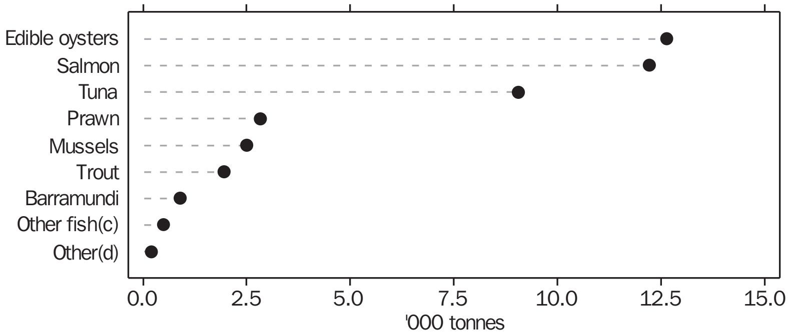
6.2 AQUACULTURE, Value of production(a) — 2000–01



(a) Excludes NT aquaculture, hatchery production, crocodiles, algae and aquarium worms. (b) Includes silver perch, eels, other native fish and aquarium fish. (c) Includes yabbies, marron, redclaw, scallops, giant clam and abalone.

Source: ABARE 2002.

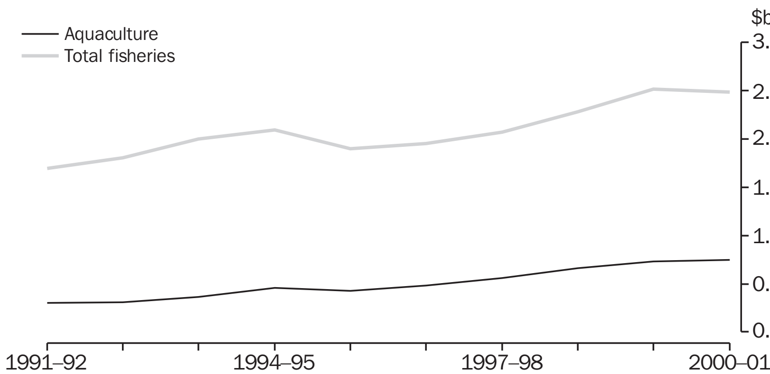
6.3 AQUACULTURE, Volume of production(a)(b) — 2000–01



(a) Excludes NT aquaculture, hatchery production, crocodiles, microalgae and aquarium worms. (b) Quantity of pearl oysters is not available. (c) Includes silver perch, eels, other native fish and aquarium fish. (d) Includes yabbies, marron, redclaw, scallops, giant clam and abalone.

Source: ABARE 2002.

6.4 AQUACULTURE AND FISHERIES, Value of production



Source: ABARE 2002.

Aquaculture systems

There are many types of aquaculture systems using a variety of management techniques. The main emphasis of the industry is on producing high value species in near-shore or land-based sites within the coastal zone; only about 10% of total production value is from freshwater species (Preston et al. 1997). Systems can be open or closed depending on the water flow. Open systems allow water to move through the cages such as in open seas or flowing rivers. In closed systems, the water flow is contained as in a lake or an aquarium. In some cases, more than one aquaculture system is used for the farming of a single species; for example, in the south-east of Tasmania, in the Huon Estuary, juvenile Atlantic salmon are hatched in freshwater facilities and, after several months of growth, they are transferred to acclimatisation ponds where the salinity of the water is gradually increased. After about eight months the salmon are transferred to open sea cages, where they are grown to a marketable size (Brown, Van Landeghem & Schuele 1997). Trout are usually farmed in conjunction with Atlantic salmon, in ocean water cages and marketed as ocean trout. Freshwater trout are also produced on small farms, often for the tourist trade through the provision of ‘catch your own trout’ ponds and dams.

Fish farming is one type of aquaculture that involves intensive cage culture of fish in multiple use water bodies. This method represents a more demanding challenge to achieving environmentally sustainable production than any other form of aquaculture. This is a result of the high level of input of nutrients to the water body in the form of fish faecal waste and uneaten food (Gowan & Bradbury 1987). Tuna and salmon are the two main species farmed in open sea cages in Australia. For example, wild juvenile Southern bluefin tuna are caught, then towed in special purpose-built towing cages to offshore farms where they are placed in floating sea pontoons in the coastal waters off Port Lincoln, South Australia. Tuna are fed on wild pilchards, jack mackerel and squid (Holland & Brown 1999). Initial tuna aquaculture production in 1991 of 26 tonnes increased to 2,089 tonnes in 1997 (Allan 1999). By July 2001, 9,051 tonnes of tuna were produced by aquaculture in South Australia, to the value of $263.8m (ABARE 2002).

Land-based aquaculture production systems in Australia include shallow ponds, freshwater dams and controlled environment indoor tanks in inland or coastal regions (Allan 1999); such systems tend to have lower operational costs than off-shore sites. For example, prawns are farmed in ponded areas along coastal waters and account for the highest proportion of pond aquaculture production in Australia. The majority of aquaculture prawn production in Australia is of black tiger prawns and kuruma prawns. Crustaceans such as yabby, redclaw and marron are farmed in dams and natural water bodies. Abalone are farmed in high technology on-shore tank facilities in which they spend their entire lives in a fully controlled environment (Brown, Van Landeghem & Schuele 1997).

Environmental impacts

The environmental impacts of aquaculture vary according to the species cultivated, the management practices used and location of the production system (Preston et al. 1997). Aquaculture has the potential to modify and alter coastal foreshores, estuaries, mangroves, salt marshes, and marine and other aquatic environments. The main environmental impacts of aquaculture are water pollution, pest species, the strain placed on wild fish populations for brood and feed purposes, and the culling of natural predators.

Water pollution from aquaculture is usually caused by faecal and urinary products, uneaten fish food, chemicals and antibiotics or vaccines used to control diseases. These may result in the significant organic pollution and increased turbidity of the water and the sea floor sediments in the vicinity of the cages, resulting in the temporary disappearance of animals and plants that live on or in the seabed. The contribution of effluent into waters already experiencing impacts can be significant (SoE 2001). Less than 30% of the protein in aquaculture feed is retained by the species farmed; the rest is either excreted or not eaten (CSIRO 1998). As an example of water pollution from aquaculture, the 110 hectares of prawn farms situated in the Logan River catchment in southern Queensland produce around 45 tonnes of nitrogen effluent. As a response, the Australian Prawn Farmers Association decided to implement national environmental practices which will ensure that prawn farming has no detrimental effect on water quality (SoE 2001). The regions of greatest concern are those adjacent to unique and environmentally sensitive areas such as the Great Barrier Reef Marine Park (see *Chapter 8, Sustainable tourism in the Great Barrier Reef Marine Park),* and other marine parks (Preston et al. 1997). Tuna farming in feedlots can generate a significant amount of pollution (Parliament of South Australia 2000) and recent research suggests that pollution is causing the sudden appearance of strange micro-organisms capable of poisoning fish (SoE 2001).

Aquatic pest species (native or exotic) have the potential to adversely affect wild fish stocks and their environment when they escape from aquaculture production systems. Escaped fish can, for instance, cross breed with wild fish, and this may have effects on the genetic integrity and survival of fish stocks (Holland & Brown 1999). Escaped fish may also contribute to the transfer of disease or may be in direct competition for habitat with wild stocks. Farm fish escape into the wild because of human error, storm and predator damage to net cages and inadvertent release during transport. While much is still unknown about diseases and their impacts, they have the potential to cause significant damage to wild fish and other aquatic plants and animals. For example, the marine protozoan pathogen *Neoparamoeba pemaquidensis,* that occurs seasonally in Atlantic salmon in Tasmania, is now regarded as a major disease which costs the industry $10m to $15m annually (SoE 2001).

Where aquaculture operations depend on wild-caught juvenile fish for brood stocks, there can be an effect on the wild populations (SoE 2001). Threats to wild fish stocks may also arise due to a high demand for wild captured fisheries (e.g. pilchards and anchovies) for the sourcing of feedstock and fishmeal. Aquaculture often uses fishmeal to feed farmed species; an estimated 2 kilograms of fishmeal are required to produce 1 kilogram of farmed fish or prawns, which places pressure on the fish species used for fishmeal (WRI et al. 2000). The harvesting of larger fish, to meet the need for cost-effective food regimes, may also add further pressure to wild fish stocks due to the lack of alternative fish food (Preston et al. 1997).

Natural predators such as sea birds and sea mammals in the vicinity of aquaculture farms are susceptible to unnatural dangers like entanglement and illegal killing of protected species. For example, dolphins, whales and seals can become entangled in the predator exclusion nets, such as those that surround the main nets of many tuna farm cages (SoE 2001). The South Australian Museum has been collecting records of dead and stranded dolphins around the South Australian coast for many years. In an initial study of the problem (Kemper & Gibbs 1997), at least 13% of all dolphin carcasses studied were believed to have died as a result of entanglement, including many in the tuna feedlots near Port Lincoln.

Positive environmental outcomes

Aquaculture provides the basis for improved biological understanding of Australia's native marine and freshwater species and can be used to re-establish populations of endangered and threatened aquatic species (ABS 1997). Aquaculture restocking programs are used to improve the catch in both commercial and recreational fisheries. Some species have intensive research and development programs in place, such as abalone, prawns, oysters and lobster. For example, some abalone that are produced in hatcheries are placed in specific coastal areas where depleted reefs are reseeded for future harvesting (Brown, Van Landeghem & Schuele 1997). The detailed research gathered on some marine species will help maintain healthy stocks in the wild and help preserve their genetic integrity. Scientific investigation and monitoring have an essential role in understanding and evaluating the boundaries of risk to help minimise negative environmental impacts.

Management practices

In Australia, state and territory governments are responsible for the development of Australian aquaculture. A number of states have aquaculture and local development plans in place. In 1994, a National Strategy for Aquaculture was established and in 1997 a review of this was completed. It highlighted the need for improved management of natural resources such as land and water (Holland & Brown 1999). By May 2000, an Aquaculture Action Agenda program was designed to assist government and industry to develop strategies. The program aimed to maximise industry growth opportunities; increase export opportunities; improve innovation, research and development; and expand the skills base of people working in the area as many skills in aquaculture are still a limited expertise.

Regulatory or prescriptive instruments used to manage resource use are approaches where controls are implemented, compliance is monitored and non-compliance is penalised (ABARE 1993). Some of the mechanisms used to help manage aquaculture whereby operators access stocks by trading with other operators for harvest rights include:

- environmental impact assessments
- siting guidelines
- standards
- pricing mechanisms
- deposit refund schemes
- emissions trading
- monitoring schemes
- zoning
- bans
- restrictions
- buffer zones
- individual transferable quota schemes.

Many industry associations have developed codes of practice for their particular aquaculture operations, for example the Australian Prawn Farmers Association and the Australian Tuna Boat Owners' Association (Caton & McLoughlin 2000).

Management of other land-based activities becomes crucial to the maintenance of coastal water quality for aquaculture as these are generally conducted on a much larger scale. Increasingly, there is a need for planning authorities to engage in integrated catchment management, considering all activities that may affect a waterway rather than attempting to regulate aquaculture in isolation (SoE 2001). The viability of all aquaculture operations is directly dependent on the maintenance of a healthy and productive aquatic environment. It is in the interest of aquaculture operators to ensure minimal pollution and to prevent negative environmental impacts (Holland & Brown 1999). In some countries, the uncontrolled expansion of aquaculture has resulted in environmental degradation and pollution, raising doubts about the long-term sustainability of some aquaculture systems. A conservative approach to aquaculture management has prevented uncontrolled development in Australia (Preston et al. 1997).

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7 Coastal and marine environment[1]

Australia's marine area is one of the largest in the world, extending over about 16 million square kilometres (including an Exclusive Economic Zone of some 11 square kilometres of ocean beyond the territorial sea), from Antarctica to near-equatorial latitudes — more than double Australia's land area. The length of the coastline of Australia's mainland and islands is about 61,700 km. Australia's marine and coastal regions host a broad variety of habitats ranging from estuaries and mangroves, dunes and beaches, rocky and coral reefs, seagrasses, gulfs and bays, seamounts, and a huge area of continental shelf.

Australian coastal and marine habitats are home to a wealth of fauna and flora species, most of which are only found in Australia. For example, Australia has:

- the world's highest levels of biodiversity for a number of types of marine invertebrates
- the highest mangrove species diversity
- the world's largest areas and highest species diversity of tropical and temperate seagrasses
- one of the largest areas of coral reefs (SoE 2001).

There are two distinct marine biogeographic regions in Australia: the temperate south, and the tropical north, which overlap on the western and eastern coastlines. In the south, which has been geographically and climatically isolated for around 40 million years, about 80–90% of species of most marine groups are endemic (found only in a particular area), or restricted to this area. In the north, which is connected by currents to the Indian and Pacific Ocean tropics, only around 10% of most groups are endemic (Zann 1995).

Land use and other human activities impact on the coastline and marine environment in a number of ways. Pressures can arise from local land-based pollution, poor drainage and effluent management, or can emanate from land disturbance in catchments many hundreds of kilometres away. Activities related to fisheries and aquaculture, the shipping and port industries, and marine tourism and recreation, are all potentially threatening to the health of Australia's coastal and marine environments.

A significant factor causing pressure on some parts of Australia's coastline is high population density in coastal regions, particularly along the east and south-east coasts and along the west coast south of Perth. As at 30 June 1996, 83% of the population lived within 50 km of the coast. All states except the Northern Territory and South Australia are experiencing higher rates of population growth and urban development within 3 km of the coast compared to the rest of Australia (Newton et al. 2001). The coastal strip is an ecologically sensitive zone, and urban sprawl, and pollution of rivers, lakes and seas, were described by the Resource Assessment Commission as the two most important problems faced by the coastal zone (RAC 1993).

This chapter focuses on two significant marine ecosystems — estuaries and coral reefs. It discusses the significance of these habitats and the processes which threaten them. This is followed by a discussion of marine protected areas in Australia. Further information on the Great Barrier Reef Marine Park can be found in *Chapter 8, Sustainable tourism in the Great Barrier Reef Marine Park.*

Estuaries

Estuaries are semi-enclosed coastal water bodies occurring where inland freshwaters meet inshore marine waters. These waterways are typically marine or brackish, but occasionally are dominated by freshwater. Estuaries are highly productive and diverse habitats that constitute an important part of Australia's coastal environment. They support fisheries, aquaculture and recreational activities, and are the preferred sites for many settlements, and for industry and ports. Australia has over 1,000 estuaries along its coastline. Of these, 783 are regarded as major estuaries: 415 in the tropics, 170 in the subtropics, and 198 in temperate areas (Zann 1995). The long arid coastlines in the south-west and west have few estuaries.

1 From *Chapter 14, Environment* in *Year Book Australia 2003.*

Australia's estuaries occur over a wide range of geological and climatic conditions and consequently display a great variety of forms. Different types of estuaries are defined by the relative influence of the natural processes that shape them. As part of the National Land and Water Resources Audit (NLWRA), Australia's estuaries were classified based on whether they are dominantly affected by river flows, tidal or wave action. According to the NLWRA, 17% of estuaries are wave-dominated estuaries; 11% are tide-dominated estuaries; 10% are wave-dominated deltas; 9% are tide-dominated deltas; 5% are strand plains, coastal lakes and lagoons; and 35% are tidal creeks and flats. Tide-dominated systems are mainly located in northern tropical Australia. Wave-dominated systems are mainly located in southern temperate regions. Their management needs and ecological processes vary (NLWRA 2002).

Australia's estuaries face a number of pressures from urban and industrial development in coastal areas, and from disturbance through land use and vegetation clearance in catchments. For example, estuaries are often used for dumping, sand or water extraction, construction of marinas, ports and canal estates, and are susceptible to changes in natural flows caused by the construction of dams and weirs. Such pressures threaten the condition of estuaries by causing excess nutrient concentrations, sedimentation, loss of habitat, weed and pest infestation, and the accumulation of pollutants.

Of the 972 estuaries assessed by NLWRA, 9% were in extensively modified condition, 19% were in modified condition, 22% were in largely unmodified condition and 50% were in near-pristine condition (table 7.1). Most of Australia's near-pristine estuaries are located away from population centres. The majority of estuaries in the Northern Territory are in near-pristine condition, primarily as a result of low population pressure and minimal catchment and estuarine shoreline development (graph 7.2). Conversely, most of the estuaries in New South Wales are under intense urban development pressure, with approximately 80% of the state's population living near an estuary (NLWRA 2002).

7.1 CONDITION OF ESTUARIES, By process type — 2002

Class	Near-pristine	Largely unmodified	Modified	Extensively modified	Total
Wave					
Wave-dominated estuary	28	41	62	25	156
Strandplain	36	13	10	1	60
Other	40	30	22	17	109
Tide					
Tide-dominated estuary	57	25	9	4	95
Tidal flat/creek	210	43	16	15	284
Other	40	17	23	9	89
River					
Wave-dominated delta	28	24	30	12	94
Tide-dominated delta	36	16	11	9	72
Other	9	1	3	—	13
Total	**484**	**210**	**186**	**92**	**972**

Source: NLWRA 2002.

7.2 NEAR-PRISTINE ESTUARIES — 2002

Source: NLWRA 2002.

Coral reefs

Coral reefs are accumulations of dead corals and other organisms with a limestone skeleton, cemented together by some algal species and by physical processes. The reef builds slowly towards the surface of the water, at the rate of a few millimetres per year. Once the reef reaches sea level, it grows horizontally. Reefs build as a result of the growth of corals and other living creatures. The accumulation of sand and rubble formed when organisms are broken down by waves and animals, such as worms and sponges that bore into the coral, also add to reef growth (CRC Reef 2002).

Coral reefs are exceptionally diverse marine systems that thrive in relatively low nutrient tropical waters and can only grow in waters where temperatures rarely fall below 18°C. They are among the most productive and complex ecosystems in the world. The Great Barrier Reef is the largest coral reef in the world, consisting of about 3,000 individual reefs covering an area of 345,950 square kilometres. Australia's coral reef systems include:

- Houtman–Abrolhos Islands reef system, offshore from Perth, which comprises the most southerly reefs in the Indian Ocean
- Ningaloo Reef off the Western Australian coast, stretching 230 km
- North West Shelf reefs, for example, Ashmore Reef off Western Australia, Scott (a pinnacle) and Seringapatam Reefs and Rowley Shoals (a marine park), Australia's only 'shelf-edge atolls'
- Cocos (Keeling) atoll, Australia's only true atoll
- Torres Strait reefs
- Great Barrier Reef system in Queensland, of some 2,300 km in length
- Coral Sea reefs, for example, the Coringa–Herald Reserve system, and the Lihou Reef which is the largest reef system in the Coral Sea
- high-latitude coral reefs, for example, Flinders Reef off Brisbane, the Solitary Islands off the New South Wales coast, and the Elizabeth and Middleton Reefs on the Lord Howe Rise (SoE 2001).

Australian coral reefs face a variety of pressures. These include: run-off of sediment and nutrients at a number of coastal locations, which is steadily increasing through human activities (primarily from the effects of agriculture and land use practices, as well as increasing industrial and urban development); increased recreational and commercial fishing; increasing pressure from tourism developments; threats from invasive and pest species such as the crown of thorns starfish; and coral bleaching possibly due to global warming (SoE 2001). *Chapter 8, Sustainable tourism in the Great Barrier Reef Marine Park* addresses management of the impacts on the Park from tourism.

A global assessment of reefs found that about 25% of the world's reefs have effectively been lost. The largest single cause has been a massive coral bleaching event in 1998, which destroyed about 16% of the world's coral reefs in nine months (Wilkinson 2000). It is likely that half of these reefs will never recover. The impacts of the bleaching event were equally as damaging on pristine, remote reefs as on reefs already stressed by human causes. Coral bleaching occurs when the sea surface temperature goes over a certain level, usually just over 30°C. The symbiotic algae (which provide coral polyps with nutrients) in the coral tissues are then expelled, allowing the white calcium carbonate skeleton to show through the clear animal tissue cover. If the temperature remains high for more than two weeks, the coral dies. In 1998, 3% of Australia's reefs were destroyed by coral bleaching. It is estimated that a further 1% of Australia's coral reefs have been destroyed by other causes, such as sediment and nutrient run-off from the land, increased recreational and commercial fishing, and the mining of sand and rocks (SoE 2001).

During March–April 2002, the Great Barrier Reef Marine Park Authority and the Cooperative Research Centre for the Great Barrier Reef World Heritage Area conducted aerial surveys to determine the area of bleaching on the Reef (GBRMPA 2002). The surveys studied 641 reefs, representing 22% of all reefs in the Marine Park. They found that bleaching was extremely widespread, extending over 1,450 km, including reefs from near the coast to the outer reefs. About 21% of these reefs showed a high level of bleaching (30% or greater of the reef affected), 36% were moderately bleached (1–30% of reef affected) and 43% had low to negligible levels of bleaching (less than 1% of the reef affected) (table 7.3).

In the Great Barrier Reef, during 2002 the worst affected reefs were those closest to the mainland. Nearly 50% of reefs near the coast (inshore reefs) were bleached to high or very high levels, with only 30% relatively unaffected (table 7.3). Many of the outer reefs (offshore reefs) were also affected, with over 50% of reefs bleached to some extent. Among the bleached reefs, however, the intensity of bleaching was highly variable (GRMPA 2002).

7.3 GREAT BARRIER REEF, Affected by coral bleaching

	1998	2002
	%	%
Inshore reefs		
Low level bleaching	13	30
Moderate level bleaching	33	23
High level bleaching	54	47
Offshore reefs		
Low level bleaching	72	49
Moderate level bleaching	23	43
High level bleaching	5	8
All reefs		
Low level bleaching	n.a.	43
Moderate level bleaching	n.a.	36
High level bleaching	n.a.	21

Source: GBRMPA 2002.

Marine protected areas

A key response to pressures on marine and coastal environments is the establishment of a National Representative System of Marine Protected Areas. This conservation reserve system formally addresses the management and protection of marine areas while allowing a range of sustainable uses. The preservation of the ecological viability of marine and estuarine systems and the protection of marine biodiversity are integral to the aims of Marine Protected Areas. These areas can be declared under Commonwealth, state or territory legislation in seas within each jurisdiction's waters. In November 2000, there were 190 marine protected areas covering about 60 million hectares (SoE 2001).

Marine protected areas range from nature reserves to marine parks, and can include reefs, seagrass beds, shipwrecks, archaeological sites, mangroves, underwater areas on the coast and seabeds in deep water. The Commonwealth Government has under its jurisdiction 13 marine protected areas, including the Great Barrier Reef Marine Park (table 7.4). With almost 34 million hectares protected, the Great Barrier Reef Marine Park is the world's largest marine protected area and, given its status as a World Heritage area, it is subject to a special management program administered by the Great Barrier Reef Marine Park Authority.

7.4 COMMONWEALTH MARINE PROTECTED AREAS — 2000

Name of Commonwealth reserve	Area protected ha	Date proclaimed
Marine national nature reserve		
Coringa-Herald	885 600	16 August 1982
Lihou Reef	844 000	16 August 1982
Ashmore Reef	58 300	16 August 1983
Elizabeth and Middleton Reef	188 000	23 December 1987
Mermaid Reef	53 984	10 April 1991
Marine reserve		
Tasmanian Seamounts	37 000	19 May 1999
Solitary Islands (Commonwealth waters)	12 962	3 March 1993
Cartier Island	16 700	21 June 2000
Marine park		
Great Australian Bight (Commonwealth waters)	1 976 900	22 April 1998
Ningaloo (Commonwealth waters)	232 600	20 May 1987
Macquarie Island (Commonwealth waters)	16 200 000	27 October 1999
Lord Howe Island (Commonwealth waters)	300 500	21 June 2000
Great Barrier Reef(a)	34 480 000	1 July 1975

(a) The Great Barrier Reef is managed by the Great Barrier Reef Marine Park Authority.

Source: EA 2000.

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8 Sustainable tourism in the Great Barrier Reef Marine Park[1]

This chapter was contributed by Hilary Skeat of the Tourism and Recreation Section in the Great Barrier Reef Marine Park Authority.

About the Great Barrier Reef

The Great Barrier Reef off Queensland's east coast is an international tourism icon. It is made up of about 2,900 unconnected coral reefs, stretching over 2,000 kilometres (km) from south of Papua New Guinea to Bundaberg. There are also about 900 islands within the Great Barrier Reef.

The Great Barrier Reef is a massive formation and is the only living structure that can be seen from the moon — astronauts describe it as 'a thin white line in the blue ocean'. The living reefs of today have grown since the last Ice Age 8,000 years ago. All the sandy islands within the Great Barrier Reef are less than about 6,000 years old.

The Great Barrier Reef is the largest, most complex and diverse coral reef system in the world. It is home to over 1,500 species of fish, 400 species of coral and many rare and endangered species. The area supports one of the largest dugong populations in the world and is an important breeding and feeding ground for whales and dolphins. Six of the world's seven species of marine turtles can also be found there.

Complementing the Reef's natural wonders is a rich cultural heritage. For thousands of years, this unique marine environment has been central to the social, economic and spiritual life of nearby coastal Aboriginal and Torres Strait Islander peoples.

The Great Barrier Reef was inscribed as a World Heritage area in 1981 in recognition of its natural significance. It is the largest World Heritage area ever established. Under the World Heritage Convention, Australia has an international obligation to protect, conserve, present and transmit this magnificent area for all future generations.

Map 8.1 shows the boundary of the Great Barrier Reef Marine Park, and the World Heritage area.

Great Barrier Reef Marine Park

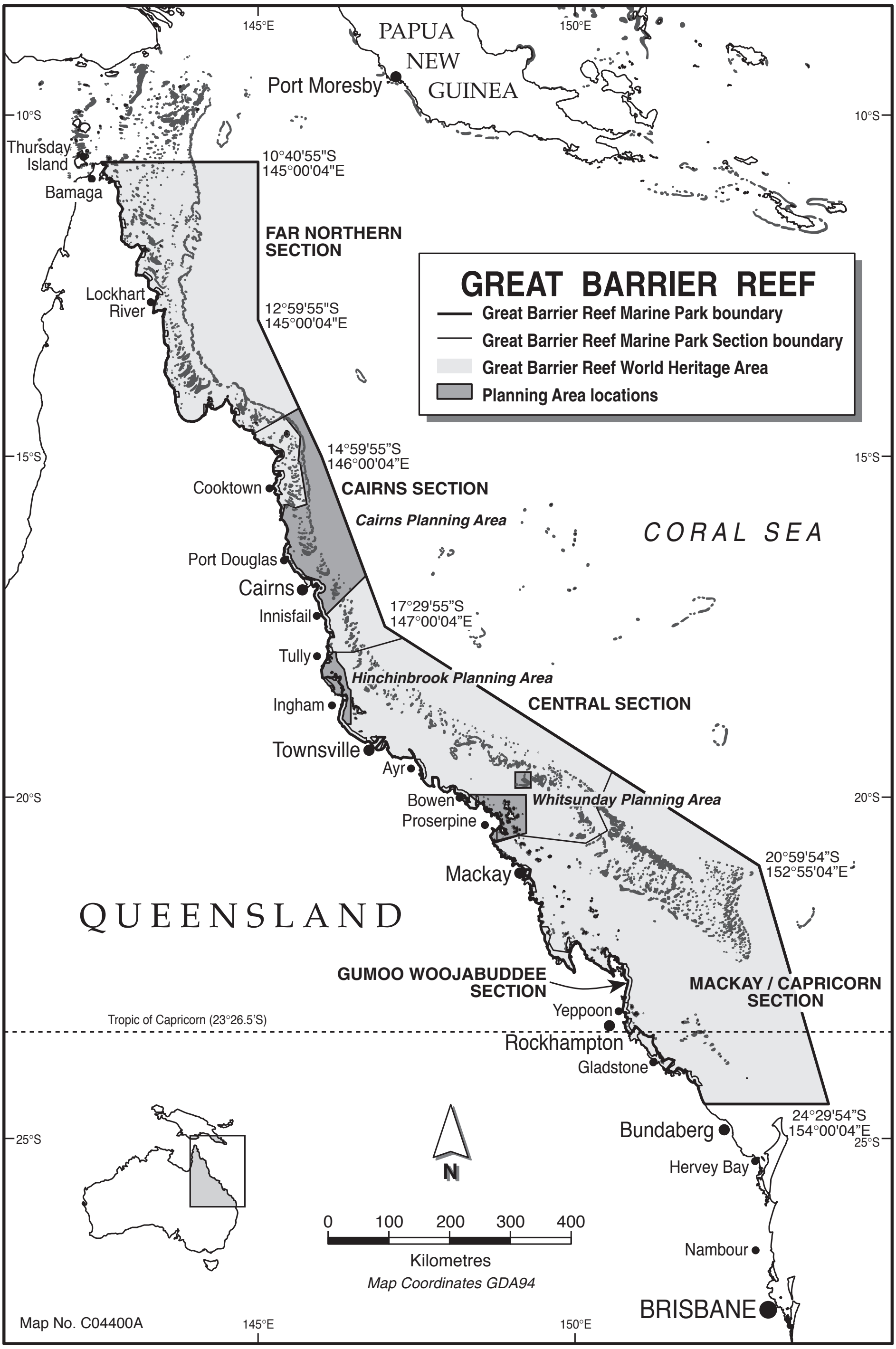
The Great Barrier Reef Marine Park is a marine protected area which includes almost all of the Great Barrier Reef. It encompasses an area of about 345,400 square kilometres, commencing at the tip of Cape York and extending along the Queensland coast to just north of Bundaberg. The Marine Park includes all of the marine environment below low water mark, except for a small number of exclusions around major shipping ports.

The Great Barrier Reef Marine Park is a protected area with a difference. While protection of the area and its values is the principal aim, a range of commercial and extractive activities is undertaken within the Marine Park. The major uses include tourism, commercial and recreational fishing, and shipping.

The Great Barrier Reef Marine Park Authority, a Commonwealth government agency, is responsible for ensuring that this multiple use Marine Park is used sustainably and is preserved for future generations. It is also the lead agency responsible for ensuring that Australia's obligations under the World Heritage Convention are met.

1 From *Chapter 22, Tourism* in *Year Book Australia 2003.*

8.1 GREAT BARRIER REEF



Source: Great Barrier Reef Marine Park Authority.

History of tourism use

The earliest instance of organised tourism on the Great Barrier Reef was in the 1890s when Green Island became a destination for pleasure cruises offshore of Cairns. By the 1930s tourism resorts had begun to develop at Green Island and at Heron Island further south. During the first half of the 20th century, most tourist activity was inshore and close to regional centres, being limited by vessel technology and poor transport links to southern capitals.

During the 1960s and 1970s there was steady growth in visitor numbers, particularly at Green Island and in the Whitsundays. By the end of the 1970s new, faster vessels extended the range of a day trip to the Reef to between 15 and 20 nautical miles.

Reef tourism grew rapidly in the 1980s and early 1990s, assisted by improved air access to a number of regional centres (including an international airport in Cairns) and improved road transport links. In the early 1980s visitor numbers to the Marine Park were increasing by about 30% per year. There was also a steady growth in the number of operations over this time, and the capacity, range and diversity of products offered expanded markedly. High-speed modern vessels extended the range of a day trip to the reef to over 50 nautical miles.

Tourism today

Tourism is now the largest commercial activity in the Great Barrier Reef Marine Park. Generating over $1b per annum, the marine tourism industry is a major contributor to the local and Australian economies.

About 1.6 million tourists now visit the Great Barrier Reef Marine Park each year. This number has remained relatively static since the mid 1990s. About 85% of tourists visit the Marine Park in the area offshore of Cairns and in the Whitsundays, a combined area of less than 10% of the Marine Park.

There are approximately 730 tourism operators and 1,500 vessels and aircraft permitted to operate in the Great Barrier Reef Marine Park. About 60% of these permitted operators are actively undertaking a tourism operation in the Marine Park.

There is a diverse range of tourism operations catering to the differing needs of visitors to the Great Barrier Reef. However the basis of any trip to the Reef is usually nature-based activities focused on the coral and other marine life. Activities typically include: snorkelling; scuba diving; fishing; excursions in glass-bottomed boats and semi-submersible vessels; and learning about the marine environment.

The marine tourism industry plays an important role in presenting the World Heritage area to a wide range of visitors. In fact, for many visitors to coastal Queensland, the tourism fleet is their primary means of experiencing the Great Barrier Reef and learning about its World Heritage values.

Managing tourism use of the Great Barrier Reef

Keeping the Barrier Reef ‘Great’ for future generations requires the cooperative effort of the Great Barrier Reef Marine Park Authority, the Queensland Parks and Wildlife Service, other government agencies, the marine tourism industry and other stakeholders. By working together, the diversity, integrity and productivity of the Great Barrier Reef can be maintained and the impacts of all activities in the Marine Park can be minimised. The goal is to provide for the protection, wise use, understanding and enjoyment of the Great Barrier Reef in perpetuity.

In managing tourism use of the Marine Park, particular attention is given to:

- protecting coral reefs and other habitats such as seagrass from anchor damage, poor diving practices, waste disposal, reef walking and collecting
- protecting turtles and seabirds from disturbance, especially during nesting seasons
- respecting the cultural importance of the Great Barrier Reef to Aboriginal and Torres Strait Islander peoples
- minimising conflicts in access within this multiple use Marine Park
- informing the community about the Great Barrier Reef and its World Heritage values
- encouraging the adoption of best practices within tourism operations
- assisting the marine tourism industry to contribute to management initiatives and monitoring programs.

Fundamental to management is the *Great Barrier Reef Marine Park Act 1975* (Cwlth). Its regulations provide the framework for the establishment, care and ongoing management of the Marine Park. There is also a reef-wide system of zoning which defines in broad terms a set of management objectives for each zone along with a description of what activities, especially extractive activities, may or may not take place, including those that require a permit. Permits are required for all tourism activities in the Marine Park. It is through these permits that the activities that may be undertaken by each operator are defined and any necessary conditions described.

Management issues relating to tourism use of a specific region can be further addressed through plans of management. Such plans have been developed for the Cairns Area and Whitsundays (the two major tourism nodes in the Marine Park). These plans are designed to manage:

- environmental protection of these high-use sites
- separation of different uses
- resolution of conflicting use
- limiting use where necessary.

Tourism use is also managed on a finer scale through specific management initiatives for popular reefs and bays. Here the focus is on localised issues, and any plans and management strategies are developed in close consultation with local users.

A set of best practices has been developed to guide the activities of tourism operators and visitors in the Marine Park. Many of the tourism associations have developed voluntary codes of conduct to ensure that their members' operations are sustainable. The Great Barrier Reef Marine Park Authority communicates information about management requirements and sustainable use through a range of quality information products and training opportunities.

Increasingly, the Great Barrier Reef Marine Park Authority is recognising the important role the marine tourism industry plays in presenting the area to the general public and its potential to work in partnership with managers to achieve best practice, sustainable use of the Marine Park. Through working cooperatively with the marine tourism industry, we aim to ensure a sustainable and vibrant future for tourism on the Great Barrier Reef.

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9 Mining and the environment[1]

Introduction

The impact of the mining industry on the environment has been a public concern, with growing appreciation of the natural environment and increasing awareness of the possible harmful effects that the industry's activities can cause. The industry and government have responded with a number of initiatives and regulations to protect and manage the environmental effects of mining activities.

The extractive nature of mining operations creates a variety of impacts on the environment before, during and after mining operations. The extent and nature of impacts can range from minimal to significant depending on a range of factors associated with each mine. These factors include: the characteristic of the ore body; the type of technology and extraction methods used in mining and the on-site processing of minerals; and the sensitivity of the local environment. The environmental impacts of mining, although significant, are generally confined to local areas. Apart from direct physical impacts of extractive activities, contamination of air, land and water may also result. However, mining in isolation may not be the main land use that upsets ecological systems, as environmental effects are cumulative in nature and other past activities or events may have contributed to these effects.

This chapter briefly discusses the main environmental impacts of mineral mining, such as wastes, and the rate of resource use (where the supply of minerals depends on the rate of resource use, which is affected by the economic life of mineral deposits and the rate at which new reserves are discovered). The chapter also summarises environmental management initiatives, such as the use of legislation, environmental impact assessments, environmental protection expenditure, rehabilitation and industry self-regulation.

Impact of the mining industry on the environment

Mineral exploration

Mineral exploration can impact on the environment. Its effect depends on the scale of exploration and what equipment is used in the exploration phase. Initial exploration may involve the use of satellites and aerial photography, with the latter impacting through noise and proximity to wildlife areas when conducted at a low altitude. Activities at ground level often require the use of bore holes, excavation pits and transect lines. The use of support equipment also leaves an impact on the environment; exploration vehicles require access tracks, and even helipads, if left unrehabilitated, can have medium- to long-term effects.

Mining operation

Environmental impacts may also occur through mine establishment, ore extraction, mineral concentration and associated transport, provision of infrastructure (which may include whole townships) and downstream processing.

Inherent to mining and mineral processing operations is the generation of wastes. These are mostly in the form of waste rocks, including surface waste rocks, rocks between ore bodies or layers and other unwanted material. This form of waste contains low or nil concentrations of the material desired and is often relatively toxic. Normally, waste rocks are stockpiled or dumped adjacent to or near the excavation area, to be used later as backfill during reclamation.

Mineral processing produces wastes in grain sizes of fine sand, silt and clay fractions. Referred to as mine tailings, this type of waste contains significant concentrations of minerals that are not amenable to recovery at the time of initial mining. Tailings are usually disposed of in specially lined tailings dams, which are normally capped and revegetated to prevent the release of environmentally harmful materials. Other wastes from mining may be in the form of water and air pollution. The majority of air emissions

1 From *Chapter 18, Mining* in *Year Book Australia 2003.*

associated with the mining industry include dust, oxides of nitrogen, sulphur dioxide and carbon monoxide. Some of these come from mining vehicles and on-site plant machinery. Water quality may be affected by:

- *acid mine drainage* — when large quantities of excavated rock containing sulphide minerals interact with water and oxygen to create sulphuric acid.
- *heavy metal contamination and leaching* — heavy metals occur naturally in many ores, and are often released in the mineral extraction process. Metals (i.e. arsenic, cobalt, copper, cadmium, lead, silver and zinc) contained in an excavated or exposed rock may be leached out and carried downstream by flowing water.
- *processing chemical pollution* — spilling, leaking or leaching of chemical agents (i.e. cyanide, sulphuric acid) from the minesite into nearby water bodies.
- *erosion and sedimentation* — erosion of cleared land surface and dumped waste material resulting in sediment loadings into the adjacent water bodies, particularly during rainfall.

Environmental impacts resulting from mining are not limited to current mining operations. Mining residues and scars at old mining sites may also impact on local environments. The legacy of abandoned, unrehabilitated minesites has required comprehensive remediation efforts paid for with taxpayers funds. One example is the Upper South Alligator River (north of Katherine) which forms part of Stage III of the Kakadu National Park World Heritage area. As the numbers of visitors increased to the area, a hazard reduction works program was conducted during the early 1990s (Mudd 2000).

Rate of mineral resource use

Minerals, oil and gas are finite and non-renewable resources; their consumption today poses a threat of scarcity to future generations. The mining industry has an obligation to operate within the concept of sustainable development. This is defined by the World Commission on Environment and Development report *Our Common Future* (The Bruntland Report) as 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). For the mining industry to be sustainable, it would need to maintain a rate of resource use which is reasonable, that is, its consumption of resources does not go beyond a level which can ensure the availability of resources for the future of the industry and the people. This rate of resource use depends on a variety of factors including the rate of use of existing known resources, the rate at which new resources are discovered, and the rate of recycling of existing materials. If discoveries or recycling do not keep pace with the rate of use, depletion will result.

Geoscience Australia has estimated that Australian stocks of crude oil will be exhausted in eight years if the current rate of production is maintained and there is no discovery of new reserves (GA 2001a). However, with continuing advances in technology for exploration and mining activities, the rate of discovery of new reserves has kept pace with the rate of production, allowing for changes in the actual and potential stocks of minerals, oil and gas. Modern technology has been a contributing factor to the efficient recovery of minerals, and the consequent fall in the cost of finding additional reserves of base metals in particular (ABS 2001a). For example, declining costs (and rising commodity prices) mean that processing of areas such as tailings and slag heaps becomes economically viable. Resource scarcity is also lessened by recycling and/or substitution.

In 2000 Australia's economic demonstrated resources (EDR) of bauxite, brown coal, copper, diamond, magnesite, mineral sands, nickel, phosphate, tantalum, uranium and vanadium increased, while those of black coal, gold, iron ore, manganese ore and lithium decreased (GA 2001b). EDR of zinc, lead and silver were maintained at levels similar to those reported in 1999.

9.1 ENERGY USE

	Mining		All users(a)	
	Primary energy(b)	Secondary energy(c)	Primary energy(b)	Secondary energy(c)
	PJ	PJ	PJ	PJ
1992–93	121	112	9 727	2 203
1993–94	125	116	9 865	2 253
1994–95	138	122	10 410	2 319
1995–96	151	134	11 787	2 387
1996–97	156	143	12 676	2 435
1997–98	164	150	13 250	2 489

(a) Industries, households and exports. (b) Primary energy sources include solar, wind, wood, bagasse, coal, oil and gas, and uranium concentrates. (c) Secondary energy sources are those mainly derived from a primary energy source such as thermal electricity, which is derived mainly from coal, and refined petroleum products (e.g. automotive petrol) derived from crude oil.

Source: ABS 2001b.

Use of energy and water by the mining industry

The mining industry is not a major user of energy as compared to other industries like manufacturing and electricity. It used about equal proportions of both primary and secondary energy sources in the period 1992–93 to 1997–98 (table 9.1).

The mining industry's use of total energy was 314 petajoules (PJ) in 1997–98, as compared to 121 PJ in 1992–93.

The mining industry is not a high user of water. Between 1993–94 and 1996–97, it accounted for 3% of total water consumed (table 9.2). Most of water consumed was sourced from the environment.

9.2 NET WATER CONSUMPTION

	Mining	All users(a)
	ML	ML
1993–94	591 194	18 575 443
1994–95	600 458	21 141 525
1995–96	590 527	19 875 227
1996–97	570 217	22 185 731

(a) Industries and households.

Source: ABS 2000.

Environmental management

In order to mitigate the adverse impacts from mining activities mentioned above, the mining industry and government undertake environmental management measures. These measures are aimed at the prevention, reduction or elimination of pollution or any degradation of the environment. They include waste management and protection of biodiversity, landscape, air and climate (MCA 2002). Protection mechanisms are backed by environmental legislation from the states and, increasingly, the Commonwealth, which has been assuming more responsibilities and imposing standards on the states.

In Australia, the state and territory governments own and administer mineral and petroleum rights over land, and seaward to three nautical miles from the sea baseline. In these areas, although the Commonwealth Government has some responsibilities regarding the environmental protection, the states and territories are the main authorities for environmental management of most mines within their respective jurisdictions.

Environmental management involves the use of mechanisms in the development, operation and subsequent rehabilitation of mine sites. These mechanisms are supported by legislation. The mining industry has also introduced its own code for self regulation.

Competing land use values

There is little choice in where mining occurs as it depends on the location of the minerals. As a result, there is often competition relating to land use between mining and for example, urbanisation, agriculture and conservation. Mining operations are therefore required to comply with comprehensive measures to control their environmental impacts. One measure is the use of buffer zones where land around a mine site is used for other purposes such as grazing (such as the Bengalla Mine near Muswellbrook, New South Wales). In cases where mines are located close to urban centres, a number of mechanisms, both formal and informal, must be in place to ensure that sustainable relationships are established by companies with various stakeholders, including local communities (as between Bendigo Mining NL and the City of Bendigo). Particularly stringent regulations apply where mining operations are located near or next to ecologically sensitive areas, requiring comprehensive environmental protection measures and agreements with governments and local communities (such as the Century Zinc mine lease in north-western Queensland and the 1997 Gulf Communities Agreement).

Legislation on environment

Under Australian constitutional and legal arrangements, the state and territory governments have key responsibility for the management of mineral resources on land. Offshore the Commonwealth has overall responsibility with administrative arrangements shared with state and territory governments (Mining Working Group 1991). The Commonwealth may also exercise its powers and responsibilities where developments may affect the national interest.

The key Commonwealth legislation dealing with environmental impacts, the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)(EPBC Act), came into effect on 16 July 2000. Under the Act, actions that are likely to have a significant impact on a matter of national environmental significance are subject to a comprehensive referral, assessment, and approval process. The Act has relevance to mining (particularly uranium mining as a nuclear related matter) and any impact it may have on a Commonwealth area (such as a national park).

States and territories administer mineral rights through the issue of permits for exploration and mining according to their own mineral end environmental legislative frameworks. Prescribed standards of environmental performance are set out in respective state and territory legislation establishing powers and regulations which control the collection of royalties, and inspection and control of exploration and mining (Hancock 1993). Regulatory authorities in the states and territories are usually departments of mines and/or environmental protection authorities.

The Commonwealth and each state and territory has legislation relating to Environmental Impact Assessment (EIA) (EA 2002). EIA is the process of assessing likely environmental impacts of a proposal and identifying options to minimise damage. It is only necessary for a project that has a potential significant environmental impact. The main purpose of EIA is to inform decision makers of the likely impacts of a proposal before a decision is made.

Rehabilitation

The amount of 'rehabilitation' to an area disturbed by mining can range from restoration, where an area is brought to as near as possible to pre-mining condition, to recontouring and revegetating to a state that is non-polluting and compatible with environmental regeneration and community expectations (Hancock 1993). Recontouring can involve construction of pit walls and waste dumps, covering of reactive materials, dismantling of buildings/plant, revegetation, and ongoing environmental quality monitoring. Under legislation, mining companies are required to pay performance guarantee bonds which act as an administrative and environmental management tool. Bonds are usually paid to a state mining authority (repaid after successful rehabilitation), creating a financial incentive to ensure that rehabilitation is carried out. Bonds also provide a source of funds for remediation efforts in the event of a corporate failure of a mining venture.

Minerals Industry Code

A key industry initiative is the Australian Minerals Industry Code for Environmental Management. The aim of the code was not to set standards or to instruct companies how they should run their operations, but to change values and behaviour towards improving environmental performance and public accountability. The minerals industry launched the Code (which is voluntary) in December 1996. As at 1 January 2002, 43 companies have committed themselves to the 2000 Code, representing over 300 operations and well over 85% of production in the Australian minerals industry (AMEEF 2002).

An essential feature of the Code is provision for greater public accountability and verification of the industry's impact on the environment measured against the implementation of the Code's principles. A company's performance is assessed on key areas covering energy use and efficiency, water consumption, land rehabilitation, air emissions, biodiversity, and incidence and severity of environmental issues.

At least 45 company environmental reports have now been released since the Code was initiated in 1996. An External Environmental Advisory Group was also established to serve as a forum for the industry to seek independent advice on assessing and improving environmental performance

(MCA 2001). More recently the mining industry has developed expertise in environmental management, to ensure that environmental protection is achieved in planning and operating resource developments. This expertise has been built up across a wide variety of climatic and geographic conditions in Australia and overseas.

Many environmental impacts associated with the mining industry are now reduced or removed, due to improved management by the industry and an increase in environmental responsibilities of the industry imposed by government. Part of the improvement lies in the requirement for companies to budget for expenditure on environmental protection measures, including rehabilitation of mined-out areas and waste control.

Environment protection expenditure by the mining industry

Total expenditure for environment protection by the mining industry increased by 6% from $368.9m in 1996–97 to $390.6m in 2000–01. Metal ore mining accounted for most of this expenditure (58%), followed by coal mining (24%), and oil and gas extraction (8%).

In 2000–01, current expenditure accounted for 73% of total expenditure (table 9.3), an increase from 62% in 1996–97. This was due to an increase in current expenditure of 24% and a decline in capital expenditure of 24% (table 9.4).

9.3 CURRENT ENVIRONMENT PROTECTION EXPENDITURE(a), Mining industry

	1996–97	2000–01						
	Total	Mine site rehabilitation	Solid waste	Liquid waste	Air emissions	Other	Administration	Total
Industry	$m	$m	$m	$m	$m	$m	$m	$m
Coal mining	58.5	35.8	21.2	6.3	4.0	5.8	9.4	82.4
Oil and gas extraction	21.9	1.8	3.3	6.3	0.9	3.5	7.8	23.5
Metal ore mining	103.9	50.2	24.6	11.4	34.1	7.7	26.4	154.4
Other mining	31.2	9.9	4.7	0.9	1.5	2.0	4.4	23.5
Total mining	**(b)228.1**	**97.7**	**53.8**	**24.8**	**40.5**	**19.0**	**48.0**	**283.8**

(a) Current expenditure generally relates to payments of a non-capital nature, for example, payments to government agencies or private businesses for waste removal services, environmental audits, site cleaning and environmental impact assessments.
(b) Includes current expenditure in Services to mining which accounts for $12.7m. This industry was not covered in the 2000–01 survey.

Source: ABS 1999; ABS 2002.

9.4 CAPITAL ENVIRONMENT PROTECTION EXPENDITURE(a), Mining industry

	1996–97	2000–01					
	Total	Mine site rehabilitation	Solid waste	Liquid waste	Air emissions	Other	Total
Industry	$m	$m	$m	$m	$m	$m	$m
Coal mining	44.4	n.p.	3.4	4.4	n.p.	n.p.	11.6
Oil and gas extraction	10.4	n.p.	0.4	0.8	n.p.	n.p.	14.5
Metal ore mining	69.2	4.4	47.7	11.6	4.7	3.0	71.5
Other mining	15.7	1.2	2.6	0.4	4.7	0.3	9.2
Total mining	**(b)140.8**	**7.4**	**54.2**	**17.3**	**23.1**	**4.9**	**106.8**

(a) Capital cost can be regarded as expenditure on the acquisition of assets designed specifically to assist with environmental protection measures. (b) Includes capital expenditure in Services to mining which accounts for $1.1m. This industry was not covered in the 2000–01 survey.

Source: ABS 1999; ABS 2002.

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10 Australia's rivers[1]

This chapter was contributed by John Whittington and Peter Liston of the Cooperative Research Centre for Freshwater Ecology.

By world standards Australia is a dry continent with few freshwater resources. Australian rivers are characterised by relatively low and variable flows.

In much of the intensive land use zone of Australia, catchment land use has significantly modified the physical and chemical nature of the rivers. These now carry higher than natural levels of sediment and nutrient. In some regions, the biological condition of the rivers, wetlands and groundwater dependent ecosystems has been severely impacted by the extraction of large volumes of water for agricultural, urban and industrial use.

It is widely recognised that the condition of many of Australia's rivers has declined below a level that the broader community considers satisfactory. The states, with Federal Government support, are acting to improve catchment management and reduce the ecological pressures associated with high levels of abstraction.

Variability — a characteristic of Australia's rivers

Rainfall is distributed unevenly, both geographically and seasonally, across Australia. In vast areas the average annual rainfall is less than 200 millimetres per year, while in parts of north eastern Queensland and western Tasmania rainfall exceeds 3,000 millimetres per year. Most of this rainfall, even in the wetter catchments, does not run off into the river systems. On average, only 12% (less than 3% in the drier areas and up to 24% in the wetter areas) of rainfall enters the rivers; the remaining rainfall is accounted for by evaporation, used by vegetation or stored in lakes, wetlands and groundwater aquifers. Almost 50% of Australia's average annual run-off enters the Gulf of Carpentaria, a region of relatively limited water resource development, and the Timor Sea (NLWRA 2001b).

Driven by a changeable climate, variable river flow is a characteristic of Australian rivers. Flow variability can be described by the coefficient of variation of annual flows (CVR), calculated as the standard deviation divided by the mean. Australia and South Africa have CVR well in excess of the world average (Finlayson & McMahon 1988). While this relationship is true for all catchment sizes, it is particularly so for Australia's large (greater than 100,000 square kilometres (km^2) inland catchments, which have a CVR of 1.12, nearly four times the world average of 0.33. As well as more variable flow, extreme floods occur more often in Australia and South Africa than in the rest of the world (Finlayson & McMahon 1988).

Highly variable flows have important implications for river management as the flora and fauna of Australia's rivers have evolved with this variability. River regulation by dams reduces the numbers and extent of floods and dry periods, and reduces water quality. These changes affect the way the river functions physically and chemically, in turn impacting on the plants and animals living there.

The high run-off variability and extreme flood pattern influence the size and type of Australia's major dams. The level of demand and reliability expected by Australian water users, combined with the high levels of evaporation in Australia, has led to Australia's relatively high storage volumes. Australia's large dam storage capacity of 79,000 gigalitres (GL) (in 447 large dams) is four times annual surface water diversions of 19,100 GL (NLWRA 2001b).

Pressures on the rivers

The consumption of Australia's freshwater resources from lakes, rivers and underground aquifers has increased dramatically in the last two decades. Between 1983–84 and 1996–97 national water consumption increased from 14,600 GL to 23,300 GL (NLWRA 2001b). Of the water diverted in 1996–97, approximately 75%

1 From *Chapter 14, Environment* in *Year Book Australia 2003.*

was used for irrigated agriculture (17,356 GL), 5% (1,238 GL) for other rural purposes such as stock and domestic uses, with the remaining 20% (4,673 GL) for urban and industrial purposes (NLWRA 2001b).

Irrigated agriculture is by far the biggest consumer of Australia's freshwater resources. In return, major economic and social benefits accrue to Australia from irrigated agriculture. Without irrigation, a significant proportion of Australia's agricultural industries would either not exist or would be greatly diminished. Towns and industries that rely on these enterprises would contract or disappear. Total annual profits from irrigated agriculture averaged over the five years to 1996–97 were $3.84b, accounting for over 50% of the total profits from Australian agriculture (NLWRA 2002b).

Across Australia, catchment land use and diverting water are considered the most serious threats to the ecological condition of Australia's rivers, wetlands and groundwater dependent ecosystems. Determining a sustainable level of diversions (sustainable yield) to support either rural, urban or industrial use is complex. It inevitably requires a trade-off between environmental, cultural, social and economic values. Each state and territory government has developed its own methods for estimating sustainable yield. The relative weighting given to various social, environmental and economic values reflects local knowledge and values. As would be expected, the weightings given to these values are often highly contentious.

Based on state assessments of sustainable yield the Audit (NLWRA 2001b) determined that 34 (10.5%) of Australia's 325 surface water basins are overused, with a further 50 (15.4%) highly developed. On the other hand, 60% of Australia's river basins have less than 30% of the nominated sustainable flow regime diverted (NLWRA 2001b). Almost all of the basins with a high volume of unused sustainable yield are in the northern parts of Australia. Undoubtedly, these regions will be heavily targeted for water resource development in the future, and long-term planning for this needs to be undertaken so as to avoid the mistakes made in many of the southern water basins.

Land use in the catchment, combined with how well this use is managed, is a major driver of river condition. Approximately 60% of the Australian continent is used for agriculture, predominantly cropping and grazing (NLWRA 2002b). In the non-urban regions, most of the elevated nutrient and sediment loads to rivers are a consequence of using land for agricultural production. High fertiliser application rates, and other agricultural practices, have resulted in some landscapes leaking more nutrients into the waterways than they did before the adoption of European agricultural production systems. Attention to management of on-farm nutrient balances should reduce the leakage of nutrients into Australian rivers (NLWRA 2001a).

Widespread clearing, particularly of the riparian vegetation and in areas vulnerable to soil erosion, results in higher than natural sediment loads to many rivers. Increased sediment loads smother important habitat for aquatic biota, for example, deep holes in rivers that provide important refuges for many native fish and other biota are frequently filled in. Increased sediment loads also increase turbidity, resulting in reduced aquatic plant growth and increased costs of water treatment. The Audit estimates that a 5% increase in turbidity of Australian streams will increase water treatment costs by $715m over the next 20 years (NLWRA 2002b).

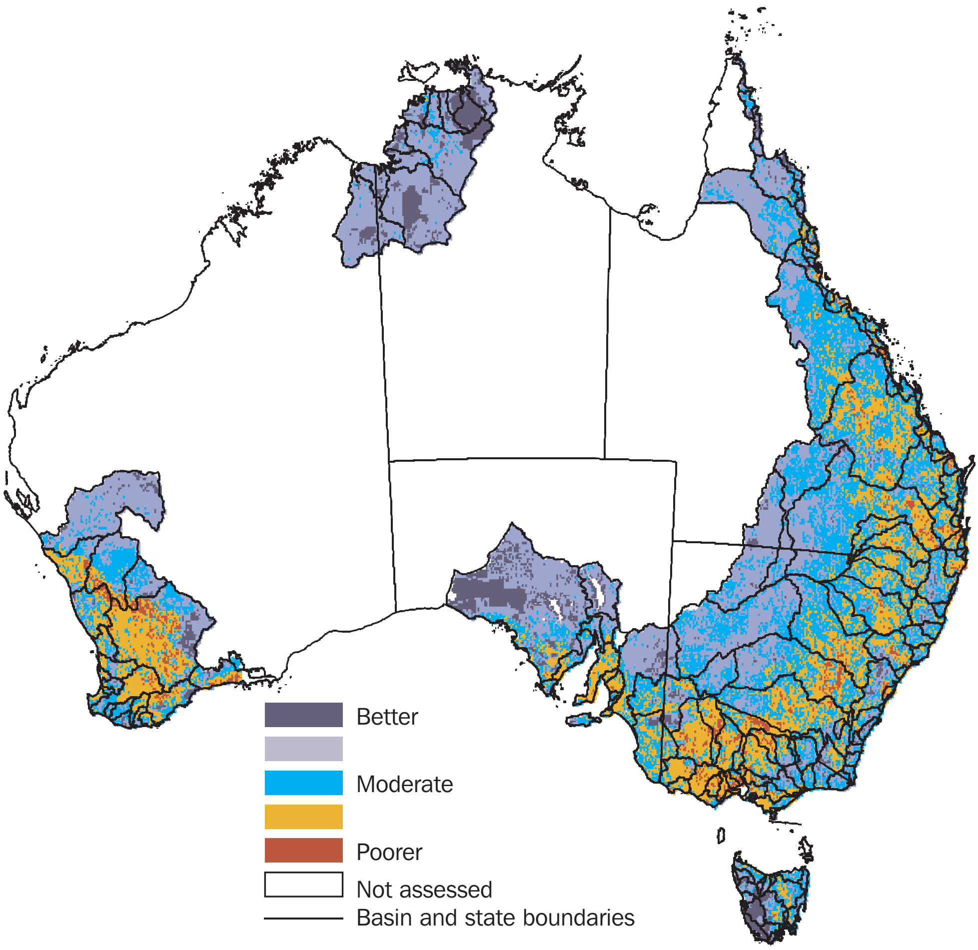
River condition depends on catchment condition

Use of Australia's land and water resources places pressures on the river systems. The Audit describes the impact of these pressures on the condition of Australia's rivers (NLWRA 2002a).

The Audit reports catchment condition across Australia using an index composed of 14 sub-indices that describe attributes of the catchments, land, water and biota. The differences in the condition between catchments were described by a few indicators: vegetation cover, native vegetation fragmentation, sediment and nutrient inputs to rivers, catchment hydrology (particularly the effects of dams), and land use intensity (NLWRA 2002a). The catchments in the poorest condition were in areas with intensive land use. These catchments are generally in cleared, agronomically marginal rainfall areas that have soils of relatively poor fertility and structure (map 10.1) (NLWRA 2002a). Until the condition of these catchments is significantly improved, we should expect that river condition in these catchments will continue to decline.

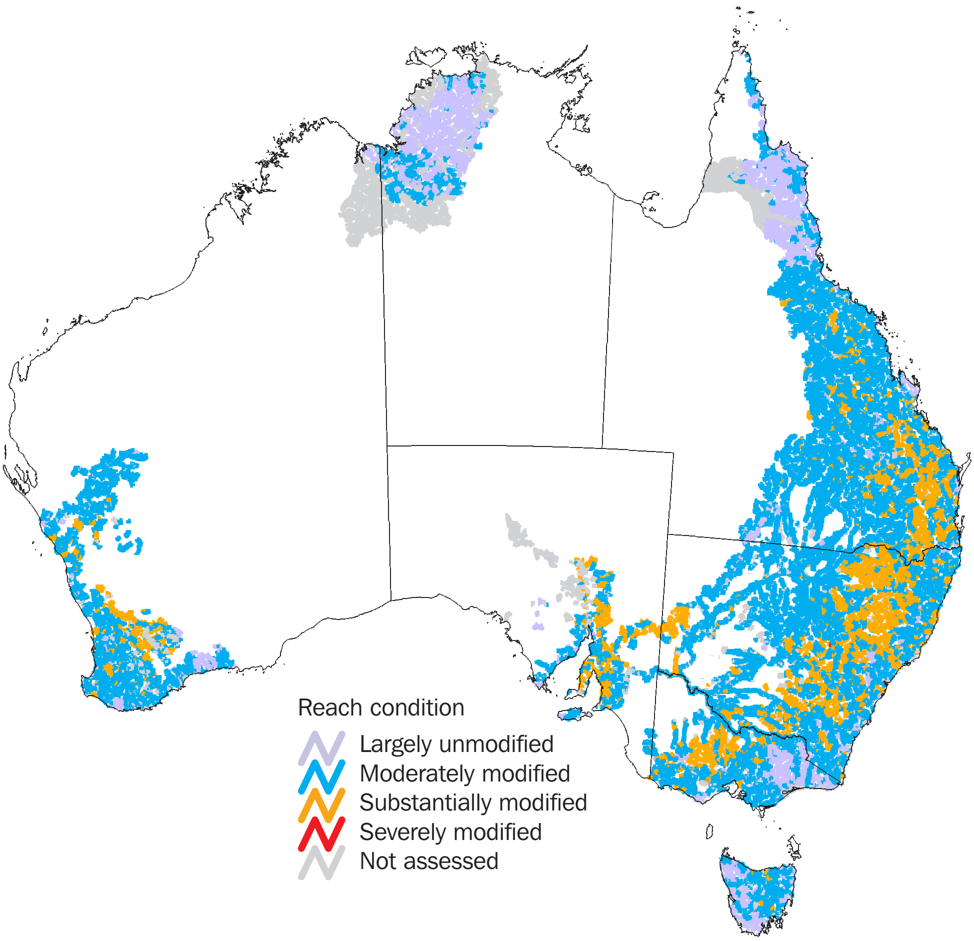
The Audit (NLWRA 2002a) describes river condition using an environmental index that combines the effects of catchment disturbance, habitat condition, hydrological disturbance, and nutrient and suspended sediment loads. The environmental index shows that within the intensive land use zone of Australia, which represents approximately 40% (3 million km^2) of the continent, over 85% of the rivers have been degraded to some extent by human activity (map 10.2). The percentage of river significantly modified, ranges from 97% of river length in New South Wales rivers to 34% in Northern Territory (NLWRA 2002a).

10.1 CATCHMENT CONDITION FOR 5 KM x 5 KM CELLS



Source: National Land and Water Resources Audit Assessment of Catchment Condition 2002 Database.

10.2 CONDITION OF RIVER REACHES BASED ON THE ENVIRONMENT INDEX



Source: National Land and Water Resources Audit Assessment of Catchment Condition 2002 Database.

The Audit reports a relatively high correlation between catchment condition and river condition as described by the Environment Index (NLWRA 2002a). While these indices are not entirely independent, the strong correlation underscores the need to consider broad catchment management as part of any river management program.

The rivers are carrying more nutrient and sediment

Australia's history of agricultural practices has resulted in an accelerated leakage of nutrient and sediment from Australian landscapes. The Audit (NLWRA 2002a) reports that nutrient and suspended sediment loads to be significantly higher than natural levels for 92% of river length (map 10.3). Total phosphorus (TP) loads in rivers averaged 2.8 times higher than estimates for pre-European settlement levels and total nitrogen (TN) loads are 2.1 times higher

(NLWRA 2001a). Exceeding national guidelines for nutrient concentrations is a major concern in 61% of river basins (NLWRA 2001b).

The dominant sources of TP and TN to the rivers vary depending on the local climate, geography, geology and land use. In Queensland and New South Wales, hill-slope erosion dominates, while in coastal Victoria, South Australia, Western Australia and Tasmania, river bank erosion and dissolved phosphorus run-off dominates. TN loads come predominantly from hill-slope erosion in Queensland and coastal New South Wales, and as dissolved run-off in coastal Victoria, South Australia, Tasmania and much of Western Australia (NLWRA 2001a). Most nutrient and sediment entering the waterways are deposited on floodplains. Of the TP entering the waterways, 60% is deposited on floodplains, 13% in reservoirs and 27% reaches the coast. Of the total TN entering the river systems, 41% is deposited on floodplains, 9% stored in reservoirs, and 39% reaches the coast. The remaining 11% is converted to nitrogen gas and lost to the atmosphere.

Accumulation of sand and gravels is a major stressor in many Australian streams. Extensive delivery of sediment to the rivers occurs downstream from areas of hill-slope erosion (50 million tonnes per year), gully erosion (44 million tonnes per year) and streambank erosion (33 million tonnes per year) (NLWRA 2001a). Most of the sediment supplied to rivers is deposited in channels, floodplains and reservoirs, with about 20% entering the ocean (NLWRA 2001a).

About 30,000 kilometres of river length have experienced sediment accumulation of greater than 0.3 metres since European settlement. The Murray–Darling Basin is one of the worst affected basins, with 20% of river length accumulating more than 0.3 metres of sediment. Land management that targets erosion control could provide a significant benefit to managing supply sediment loads and nutrient loads to many rivers.

The rivers have less water

Assessing the impact of human activities on the flow regime of Australia's rivers is complicated by the relative lack of suitable hydrological information. The Audit found adequate information on which to determine natural flows for only 30% of the total river length in Australia's intensive land use zone (NLWRA 2002a).

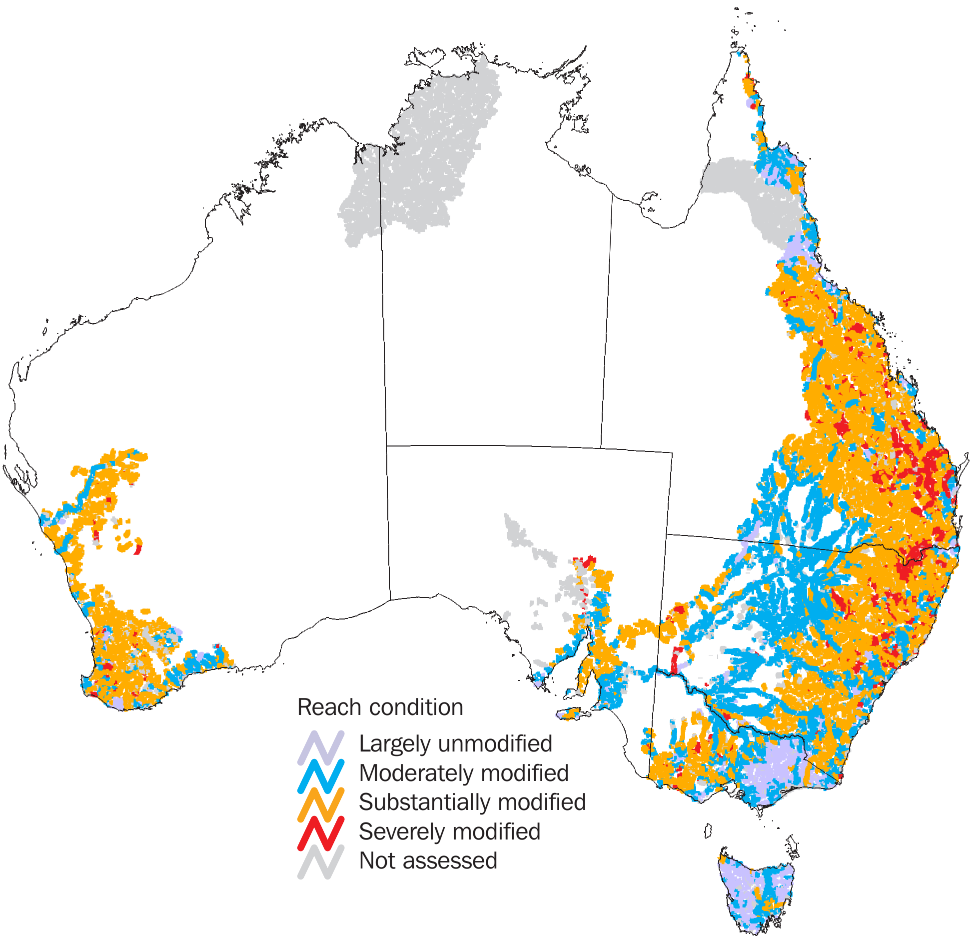
Rivers below major dams, termed regulated rivers, generally flow for longer periods than natural, and the seasonal variability in flows is reduced (NLWRA 2002a). There are fewer small floods and dry periods and there is frequently a reversal of seasonal flows, such that water is retained in the dams during the wetter periods and rivers run high during the dry periods to supply irrigation water.

Less is known about the level of hydrological disturbance in rivers which do not have major dams above them. Flow is frequently reduced by abstraction, particularly during the low flow periods, but estimates of this are generally crude and are usually made on an annual or seasonal basis (NLWRA 2002a). Large-scale harvesting of floodwaters occurs in some river systems, where private floodplain storages can capture a significant proportion of flow. For example, there is significant floodplain harvesting on the Balonne floodplain. Total water storage on the Balonne floodplain is estimated to be 1,160 GL, which is equivalent to the current mean annual flow in the Balonne River (Whittington et al. 2002).

Aquatic animals reflect river and catchment use

Across the world there has been a trend toward using assessments of the condition of biotic communities to assess river condition. It is argued that the plants and animals dependent on a river will integrate the effects of environmental degradation and of pollution and are therefore the fundamental indicators of river condition (Norris & Thoms 1999). While there are many biological indicators that could be used, there are very limited data for most of them. The most comprehensive data set for aquatic biota is the information from the National River Health Program (NRHP). This program assessed river health using aquatic macroinvertebrate communities at approximately 6,000 sites across Australia, and provides the most comprehensive assessment of biotic river health available across Australia.

10.3 CONDITION OF RIVER REACHES BASED ON THE NUTRIENT AND SUSPENDED SEDIMENT LOAD INDEX



Source: National Land and Water Resources Audit Assessment of Catchment Condition 2002 Database.

Based on data from the NRHP, the majority of rivers (69%) across Australia were found to be in good condition (NLWRA 2002a). The remaining 31% were suffering for some degree of impairment, ranging from mild impairment where some of the animals normally occurring in a river were missing, to major damage where most animals were missing. The rivers with biota in good condition tended to be in national parks, mountainous regions or remote regions. Rivers showing impact tended to be close to major cities or in highly developed agricultural areas. Also impacted were rivers in mountainous regions affected by river regulation.

The environmental factors most significantly impacting on river biological condition were poor water quality, damaged habitat, changed hydrological condition or a combination of these factors. Regions such as the Murray–Darling Basin, with considerable river regulation associated with intensive agricultural development, tended to have poor biological condition brought on by environmental degradation across multiple factors (NLWRA 2002a).

Biological data do not always give the same picture on river condition as do environmental data. In part this is attributable to the limits of one group of the biota to reflect the full range of environmental changes that can occur. Fish or algae may be better indicators for some environmental impacts. However, in many instances, a more important reason for the mismatch between biological and environmental assessments is the timelag between environmental damage occurring and its biological consequences. It may be months or years before the full impact of a change in river flows or in salinity is realised by the biota. In these circumstances the degraded environmental condition can act as an early warning of the biological damage that will occur unless restoration measures are undertaken.

Protection of freshwater ecosystems

Australia has a poor record of managing aquatic habitats. Responsibility for land and water management lies with the states and territories, though the Federal Government has been a substantial source of funding for water resource development and more recently, rehabilitation. Within most states there has been considerable activity to provide adequate flows for the environment. This has been largely driven by the Water Reform Agenda of the Council of Australian Governments, which states that the environment be recognised as a legitimate user of water, and that each jurisdiction formally determine allocations for the environment. However, despite considerable activity, progress has been slow. As at June 2000, only 43 (13%) of Australia's 325 river basins have formal allocations of flow to the environment (NLWRA 2001b).

Conservation of Australia's ecosystems has historically focused on protection of terrestrial ecosystems. Within the 7.8% of Australia's total land area that is within formally protected areas, some native terrestrial ecosystems are well protected and others are not (NLWRA 2001c). Recent efforts to increase the comprehensiveness of protected ecosystems have prioritised bioregions that have relatively low levels of protection using the Interim Biogeographic Regionalisation for Australia (IBRA) framework. While the IBRA bioregions are an accepted landscape framework for conserving terrestrial biodiversity (Cresswell & Thomas 1997), they are unlikely to be an appropriate framework for conserving aquatic biodiversity. If aquatic ecosystems fall within existing reserve systems, such as parts of the Australian Alps and south-west Tasmania, they can be adequately protected. However, this is not usually the case, and therefore frameworks that explicitly address the diversity of aquatic ecosystems need to be developed. Such a framework has been proposed by Davies (2001), which provides for the establishment of a freshwater and estuarine reserve system based on the principles of comprehensiveness, adequacy and representativeness, (CAR reserve system) in a similar way to that described for forest reserves (JANIS 1997). This is currently being implemented in Tasmania.

Like rivers, wetlands are not adequately protected. It is estimated that since European settlement approximately 50% of Australia's wetlands have been converted to other uses. In some regions the rate of loss has been even higher (Commonwealth of Australia 1997). Of those remaining, many are threatened by water abstraction, weeds and grazing. The Federal Government has published a Directory of Important Wetlands in Australia (Environment Australia 2001). The directory describes 851 wetlands (totalling 57,829,522 hectares) of national importance, but protection of these is highly variable. Of these wetlands, 57 wetlands, with a total surface area of 5,310,179 hectares, are designated to the List of Wetlands of International Importance of the Ramsar Convention, referred to as Ramsar wetlands. Once listed as a Ramsar wetland, the Federal Government must ensure that the wetland is managed such that its ecological character is maintained. However, the protected status of many of Australia's Ramsar wetlands is compromised because protection does not extend to the source of the wetland's water. For example, as a result of water abstraction upstream, median annual flows to the Ramsar listed Narran Lakes in northern New South Wales have been increased to approximately 24% of natural, and the interval between significant flooding events has been increased from 2 years to 6.5 years (Whittington et al. 2002). It is argued that without significant alterations to water management upstream of Narran Lakes, the current level of diversion will result in a significant reduction in the health of the Narran Lakes system (Whittington et al. 2002).

There is growing recognition of the value of the few relatively unimpacted rivers in Australia (Cullen 2002). However, efforts to protect these aquatic systems are limited (Cullen 2002). Morton et al. (2002) have called for the establishment of a system of heritage rivers to protect the remaining relatively undamaged rivers. Cullen (2002) argues that the extraction of water is the major threatening process in these rivers and must be controlled.

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11 Environmental impacts of agriculture[1]

This chapter looks at the impacts of agricultural activities on the Australian environment. In particular it examines land and water use, salinity and the adoption of various land management practices.

Land and water are essential for agricultural production. Since European settlement of Australia around 100 million hectares (ha) of forest and woodland have been cleared, mostly for agricultural production (NFI 1998), and land continues to be cleared for agriculture. Today around 456 million ha, or 59% of land in Australia, are used for agriculture, making it the dominant form of land use. Agriculture is also the largest consumer of water in Australia; in 1996–97 it accounted for 15,502 gigalitres or 70% of total water use (graph 11.1).

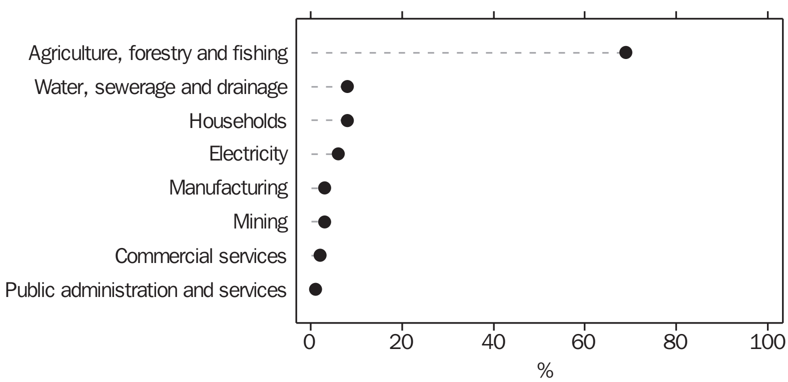
The combined impacts of land and water use for agricultural production have been substantial. For example:

- The removal of native vegetation and the introduction of exotic species have contributed to the extinction and decline of many species of Australian wildlife (Hamblin 2001).
- The construction of dams and diversion of water from rivers have greatly altered water flows, reducing the amount of water flowing down rivers, and have changed the times of peak flows (ABS 2001b).
- There has been a deterioration of soil and water quality in many areas.

Tables 11.2 and 11.3 show the area affected by three types of land degradation, as well as their estimated annual cost to agricultural production. Water quality is discussed in *Chapter 10, Australia's rivers*, and hence it will not be considered here.

Salinity, sodicity and acidity are all naturally occurring conditions of Australian soils, but these have been exacerbated by agricultural activities. Sodicity is a condition in which the sodium levels of the soil increase to the extent that they affect the physical properties of the soil. Sodic soils are prone to waterlogging. Acidity is a condition in which the concentration of hydrogen ions increases in the soil, which can cause the death of many plant species. Salinity is the build-up of salts in the soil, which also can kill plants.

11.1 WATER USE — 1996–97



Source: ABS 2000.

1 From *Chapter 16, Agriculture* in *Year Book Australia 2003* and *'Salinity on Australian Farms, 2002'*.

In recent years salinity has gained prominence as a national environmental issue (see for example, MDBC 1999; Commonwealth of Australia 2000; NLWRA 2001). Early results from the 2001 ABS Agricultural Census showed that around 26,000 farmers have salinity and/or are managing salinity on their properties. Table 11.4 shows that the proportion of farms reporting managing for salinity is greater than those reporting salinity, which is an indication that farmers are taking action to prevent or reduce the impact of salinity on agricultural land. Salinity information for 2002, which was released after the Year Book was compiled, is presented later in this chapter.

Various activities have been used by farmers to manage or prevent salinity. The type of management adopted depends on the nature of the farm: cattle farmers adopt practices different from those used by orchardists. Three commonly promoted salinity management actions are the planting of lucerne, salt-tolerant pastures and trees. Others include pumping groundwater (to lower water tables) and digging drains, especially where the salinity is severe or high value crops (e.g. grapes) are involved.

The impacts of salinity extend beyond the agriculture sector. Roads, houses and water supply infrastructure can all be degraded by it. Over four states (New South Wales, Victoria, South Australia and Western Australia) the road, buildings and/or water supply infrastructure of 68 towns are at risk of damage from salinity. Biodiversity is also at risk through the loss and degradation of native vegetation. Across Australia around 630,000 ha of native vegetation and 80 wetlands, including wetlands of international importance, are at risk (NLWRA 2001).

One factor contributing to salinity is the rise in water tables due to increased amounts of water entering underground water bodies from irrigated land. This ultimately results in increased salt loads entering river systems. Reduced river flows, brought about by the construction of dams, weirs and water diversions, compound the problem as the flow is insufficient to dilute saline groundwater inflows (ABS 1996).

11.2 EXTENT OF SALINITY, SODICITY AND ACIDITY — 2000

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	**Aust.**
	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	**'000 ha**
Saline soils	89	287	62	472	2 169	26	—	—	**3 206**
Sodic soils	24 713	8 008	42 191	7 635	14 615	504	11 533	1	**109 219**
Acidic soils	4 095	2 754	6 192	20	4 602	677	2 973	4	**21 317**

Source: NLWRA 2002.

11.3 ANNUAL COST(a) TO AGRICULTURE OF SALINITY, SODICITY AND ACIDITY — 2000

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Aust.
	$m	$m	$m	$m	$m	$m	$m	$m	$m
Saline soils	6.3	18.5	10.2	39.1	111.0	1.9	—	—	187.0
Sodic soils	280.3	342.5	180.3	126.4	89.7	12.3	3.0	—	1 034.6
Acidic soils	378.7	471.1	232.5	2.9	226.1	214.8	58.2	0.2	1 584.5
Combined cost(b)	**624.1**	**757.4**	**392.9**	**162.0**	**341.6**	**220.3**	**61.1**	**0.2**	**2 559.5**

(a) For a description of method used to derive see NLWRA 2002. (b) Salinity, sodicity and acidity constraints often coincide, so the aggregate affect is less than sum of each constraint.

Source: NLWRA 2002.

11.4 FARMERS REPORTING SALINITY OR SALINITY MANAGEMENT — 2000–01

	Salinity	Salinity management
	%	%
New South Wales	6	16
Victoria	11	20
Queensland	3	8
South Australia	13	21
Western Australia	37	37
Tasmania	5	8
Northern Territory	3	6
Australian Capital Territory	3	10
Australia	**10**	**17**

Source: ABS data available on request, preliminary data from the 2000–01 Agricultural Census.

In recent years the area irrigated has increased substantially. Between 1990 and 2000 the area of irrigated land increased by more than half a million ha or 30%. The growth in irrigated area was greatest in Queensland, where an additional 236,000 ha (or 76%) were irrigated in 2000, compared to the area irrigated in 1990 (table 11.5).

Irrigation can also cause a decline in soil structure and water quality, while the method of irrigation used influences the efficiency of water use and impact on the environment (Smith 1998). Impacts on water quality result from the high levels of fertiliser use in conjunction with some irrigation methods. Continued awareness of the need for greater efficiency and technological advance can be expected to improve land management practices and reduce the decline in the health of land and water assets. For example, there has been a growth in the use of irrigation methods that are more efficient in terms of water delivery. In 2000 around 30% of irrigators reported using spray, micro spray or drip irrigation methods compared to 23% in 1990 (table 11.6).

A number of factors affect the choice of irrigation methods used by farmers. These include cost, available technology, soil type, type of crop, climate and topography. In 1999–2000, furrow or flood irrigation methods were used for nearly 70% of all irrigated land. Flood irrigation, used on the majority of pastures and cereal crops, is popular probably because it is cheaper than the other methods available (Vic SoE 1991). If not managed correctly, furrow and flood irrigation can be highly inefficient and have detrimental effects on the water table and surrounding water bodies. However, for some crops, like rice, it is essential.

11.5 IRRIGATED AREA

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	**Aust.**
	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	**'000 ha**
1990	820	526	312	99	29	44	—	—	**1 832**
2000	944	626	548	159	39	62	6	—	**2 384**

Source: ABS 1991; ABS 2001a.

11.6 IRRIGATION METHODS

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Aust.
	%	%	%	%	%	%	%	%	%
1990									
Spray method (excluding micro spray)	13	8	43	51	26	77	(a)	(a)	20
Drip or micro spray	1	2	4	13	18	3	(a)	(a)	3
Furrow or flood	84	90	46	33	48	11	(a)	(a)	74
Other	2	—	7	3	8	8	(a)	(a)	3
Irrigation methods reported(b)	100	100	100	100	100	100	(a)	(a)	100
2000									
Spray method (excluding micro spray)	11	12	37	44	23	86	26	58	22
Drip or micro spray	3	5	8	33	38	6	68	42	8
Furrow or flood	85	82	54	21	35	8	—	—	70
Other	*1	*—	1	1	4	—	5	—	1
Irrigation methods reported(b)	100	100	100	100	100	100	100	100	100

(a) Not collected. (b) Percentages may not add to 100 due to rounding individual values.

Source: ABS 1991; ABS 2001a.

In 1999–2000, the spray method was used on approximately 22% of irrigated land. Spray irrigation has a higher installation cost and can be used for the application of slightly more saline water (generally from groundwater sources). The spray method produces less waterlogging than the flooding method, but is ineffective in high winds and can sometimes wash fertilisers from crops. Drip irrigation, also know as micro or trickle irrigation, is used on a smaller scale than other methods, and accounted for approximately 8% of irrigated land in 1999–2000. It is used on high value crops like grapes, citrus and tomatoes. Although the drip method is highly efficient, as evaporation losses are substantially reduced, it has higher installation and maintenance costs. Other technological innovations, such as laser levelling, have improved water efficiency (Smith 1998).

Many other land management practices can have environmental benefits. The planting of trees and fencing of native vegetation are two obvious examples (see ABS 2001a). These protect land and water quality as well as creating habitat for native animals and plants. Less obvious practices also help to make a difference. For example, stubble management methods can influence rates of soil erosion and the amount of organic matter retained in the soil (stubble is what remains of plants after crops have been harvested). In 2000–01 around 5 million ha of stubble were left intact (table 11.7). This stubble would have protected the soil from erosion by wind and rain.

The increasing use of more efficient irrigation methods, the implementation of salinity management activities and adoption of other land use practices are an indication that farmers are more aware of the environmental impact of their activities than in the past. Much of the impact on the environment is the result of historical land management decisions, and has taken decades to manifest. The impact of agriculture on the environment can be reduced and there are a number of community groups and government programs dedicated to achieving this. However, it is likely that the damage already done will take decades to abate and repair.

Salinity and land management

The following information did not appear in the Yearbook, but is based on *Salinity on Australian Farms, 2002* (cat. no. 4615.0) which was released in December 2002.

In May 2002, the ABS conducted the Land Management and Salinity Survey as a supplement to the 2001 Agricultural Census. The survey was mainly targeted at farm establishments which answered ‘yes’ to either or both questions in the 2001 Agricultural Census regarding the existence of land affected by salinity or the use of salinity management strategies.

The 2002 Land Management and Salinity Survey collected information from farmers on the extent of land showing signs of salinity (table 11.8), the strategies used by farmers to manage and prevent salinity (table 11.9) and some of the reasons and barriers to land management change (table 11.10 and table 11.11).

The results of the survey are available at various geographical and statistical levels including: national, by state, by industry category, by area of holding, by estimated value of agricultural operations, by irrigated/non-irrigated farms and by National Action Plan for Salinity and Water Quality (NAP) regions. The survey is the largest of its type ever conducted in Australia and has the advantage of enabling comparisons of farm management activities to economic and other information collected by the ABS and other agencies.

11.7 USE OF STUBBLE MANAGEMENT PRACTICES — 2000–01

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT
	’000 ha	’000 ha	’000 ha	’000 ha	’000 ha	’000 ha	’000 ha	’000 ha
Most stubble removed by baling or heavy grazing	315	168	167	337	804	7	1	—
Stubble left intact (no cultivation)	862	257	592	545	2 756	3	—	—
Stubble ploughed into soil	1 600	487	740	511	357	13	—	—
Stubble removed by cool burn	745	248	60	263	393	4	—	—
Stubble removed by hot burn	841	466	23	389	469	3	—	—
Stubble mulched	378	290	279	467	105	2	—	—
All other methods	152	70	85	147	216	1	—	—
Total area treated	**4 893**	**1 987**	**1 948**	**2 659**	**5 099**	**33**	**—**	**—**

Source: Agricultural Commodities, Australia, 2000–01 (7121.0); ABS data available on request, preliminary data from the 2000–01 Agricultural Census.

Main findings

A little under 20,000 farmers and 2 million ha of agricultural land were reported by farmers as showing signs of salinity, with approximately 820,000 ha of land unable to be used for production (table 11.8). Western Australia had the highest number of farms (6,900 farms) and the greatest area of land (1.2 million ha) showing signs of salinity.

Farms primarily involved with the production of beef cattle, sheep and grains accounted for 16,000 or 82% of the farms showing signs of salinity, and 1.9 million ha or 97% of the agricultural land showing signs of salinity. Non-irrigated farms accounted for 1.8 million ha or 93% of the agricultural land showing signs of salinity.

Nearly 30,000 farms have implemented salinity management practices, including just over 7,000 irrigated farms which made changes to irrigation practices for salinity management purposes. The main salinity management strategies used by farmers to manage or prevent salinity were: using crops, pastures and fodder plants, for example, deep rooted perennials and saltbush, fencing off saline areas, and building earthworks such as drains (table 11.9).

11.8 LAND SHOWING SIGNS OF SALINITY — Summary, by state

State	Farms with land showing signs of salinity	Proportion of total farms in state(a)	Land showing signs of salinity	Proportion of total farm area in state(b)	Salinised land unable to be used for production	Proportion of land showing signs of salinity(c)	Proportion of total farm area in state(d)
	no.	%	'000 ha	%	'000 ha	%	%
NSW/ACT	3 108	7.4	124	0.2	44	35.6	0.1
Vic.	4 834	13.7	139	1.1	60	43.5	0.5
Qld	993	3.4	107	0.1	40	37.4	—
SA	3 328	21.6	*350	0.6	105	30.1	0.2
WA	6 918	51.3	1 241	1.1	567	45.7	0.5
Tas.	390	9.1	6	0.3	2	27.2	0.1
NT	8	2.0	2	—	2	97.3	—
Total Australia	**19 579**	**13.9**	**1 969**	**0.4**	**821**	**41.7**	**0.2**

(a) Farms with land showing signs of salinity as a proportion of total farms in the state/territory/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census. (b) Land showing signs of salinity as a proportion of total farm land in the state/territory/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census. (c) Salinised land unable to be used for production as a proportion of land showing signs of salinity. (d) Salinised land unable to be used for production as a proportion of total farm land in the state/territory/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census.

Source: ABS 2002b.

11.9 SALINITY MANAGEMENT STRATEGIES — Summary, by state(a)

State	Crops, pastures and fodder plants	Trees	Land fenced from grazing	Earthworks
	'000 ha	'000 ha	'000 ha	'000 km
NSW/ACT	1 096	91	17	43
Vic.	*680	40	40	37
Qld	331	126	*27	15
SA	452	14	29	*13
WA	633	500	352	98
Tas.	*7	5	1	*3
NT	*6	—	—	—
Australia	**3 205**	**776**	**466**	**208**

(a) Any land management practice undertaken wholly or partly for the management or prevention of salinity.

Source: ABS 2002b.

The main motivations for implementation of salinity management practices were: farm sustainability (66% of farmers implementing change saying this was of high importance); environmental protection (56%); and increasing or maintaining agricultural production (54%) (table 11.10).

The main barriers to changing land management practices were lack of financial resources and lack of time (35% and 21% of all farmers reporting these as very limiting, respectively). Lack of information or doubts about likely success were not considered by the majority of farmers to be barriers to change (only 6% and 7% of all farmers reported these as very limiting, respectively) (table 11.11).

There are two types of salinity, dryland and irrigated. Dryland salinity is far more widespread. However, in both types of salinity, water imbalances are the fundamental cause of salinisation. Primarily to address the issue of dryland salinity, the Commonwealth and state and territory governments have adopted the NAP. The NAP has identified 21 high priority regions which are shown in map 11.12.

11.10 REASONS FOR CHANGING LAND MANAGEMENT PRACTICES, Australia(a)

Reason	Not a reason %	Low importance %	Medium importance %	High importance %	Total %
Increased productivity	18.6	6.7	20.5	54.2	100
Increased land value	28.8	15.4	27.7	28.1	100
Improved risk management	33.2	12.1	25.8	28.9	100
Farm sustainability	13.5	*3.9	16.3	66.3	100
Improved environment protection	12.6	5.1	26.8	55.6	100

(a) Farms managing for salinity and/or with land showing signs of salinity that have changed land management practices because of salinity or to prevent salinity.

Source: ABS 2002b.

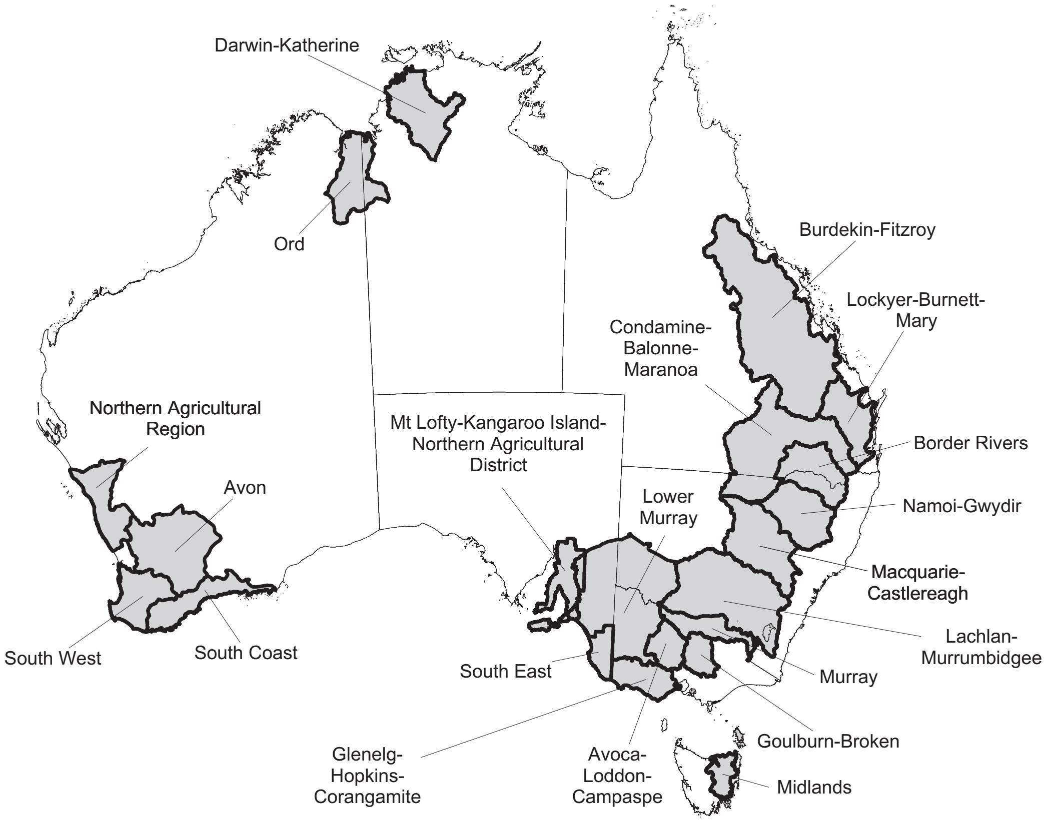
11.11 BARRIERS TO CHANGING LAND MANAGEMENT PRACTICES, Australia(a)

Barrier	Not a factor %	Not very limiting %	Limiting %	Very limiting %	Total %
Lack of financial resources	23.8	7.9	32.8	35.5	100
Lack of time	29.7	13.4	36.1	20.8	100
Insufficient or inadequate information	52.1	24.8	17.4	5.8	100
Doubts about likely success	51.8	23.1	18.3	6.8	100
Age or poor health	70.6	12.5	10.3	6.6	100

(a) Farms managing for salinity and/or with land showing signs of salinity.

Source: ABS 2002b.

11.12 REGIONS IDENTIFIED IN THE NATIONAL ACTION PLAN FOR SALINITY AND WATER QUALITY (NAP)



The 2002 Land Management and Salinity Survey was designed to produce estimates of the area affected by salinity, salinity management practices and driving factors for both irrigated and non-irrigated farms at the NAP region level. Tables 11.13 and 11.14 show the extent of land showing signs of salinity on irrigated and non-irrigated farms, by NAP region.

The NAP regions account for 17,000 farms or 87% of total farms showing signs of salinity and 1.3 million ha or 66% of the total area showing signs of salinity. The NAP region most affected by salinity was Avon (Western Australia) with 2,279 farms and 450,000 ha showing signs of salinity.

11.13 LAND SHOWING SIGNS OF SALINITY — Irrigated farms, by NAP region

NAP Region	Irrigated farms with land showing signs of salinity	Proportion of total irrigated farms in NAP region(a)	Land showing signs of salinity	Proportion of total irrigated farm area in NAP region(b)	Salinised land unable to be used for production	Proportion of land showing signs of salinity(c)	Proportion of total irrigated farm area in NAP region(d)
	no.	%	’000 ha	%	’000 ha	%	%
Avoca-Loddon-Campaspe	777	39.1	30	4.3	10	32.5	1.4
Avon	18	73.6	*1	8.9	*1	85.8	7.6
Border Rivers	*13	1.7	n.a.	—	n.a.	n.a.	0.3
Burdekin-Fitzroy	*56	4.0	1	0.1	*1	75.2	0.1
Condamine-Balonne-Maranoa	*13	1.2	*1	—	—	9.0	—
Darwin-Katherine	—	—	—	—	—	—	—
Glenelg-Hopkins-Corangamite	60	8.7	1	0.8	—	29.5	0.2
Goulburn-Broken	283	9.3	3	0.6	1	27.2	0.2
Lachlan-Murrumbidgee	353	14.6	*17	0.6	2	11.6	0.1
Lockyer-Burnet-Mary	87	3.3	1	0.1	—	38.4	—
Lower Murray	539	11.1	36	1.8	19	52.7	0.9
Macquarie-Castlereagh	*62	9.6	*2	0.3	**1	51.0	0.1
Midlands	130	15.1	2	0.4	—	19.9	0.1
Mt. Lofty-Kangaroo Island—Northern Agricultural District	*550	24.2	8	2.8	*3	31.8	0.9
Murray	202	12.2	8	0.4	2	20.2	0.1
Namoi-Gwydir	*51	8.1	*2	0.3	—	2.6	—
Northern Agricultural District	*10	7.8	**1	1.8	**1	96.0	1.8
Ord	*9	12.2	—	0.4	—	22.7	0.1
South Coast	74	40.3	1	1.5	1	47.9	0.7
South East	*57	5.4	*11	1.6	1	10.3	0.2
South West	112	8.9	3	1.4	1	22.6	0.3
Total NAP	*3 473*	*12.5*	*130*	*0.7*	*47*	*36.4*	*0.3*
Total non-NAP	*576*	*4.8*	*7*	*0.2*	*3*	*41.3*	*0.1*
Total irrigated farms	**4 049**	**10.2**	**138**	**0.6**	**50**	**36.6**	**0.2**

(a) Irrigated farms with land showing signs of salinity as a proportion of total irrigated farms in the NAP region/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census. (b) Land showing signs of salinity as a proportion of total irrigated farm area in the NAP region/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census. (c) Salinised land unable to be used for production as a proportion of land showing signs of salinity. (d) Salinised land unable to be used for production as a proportion of total irrigated farm area in the NAP region/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census.

Source: ABS 2002b.

11.14 LAND SHOWING SIGNS OF SALINITY — Non-irrigated farms, by NAP region

NAP Region	Non-irrigated farms with land showing signs of salinity	Proportion of total non-irrigated farms in region(a)	Land showing signs of salinity	Proportion of total non-irrigated farm area in region(b)	Salinised land unable to be used for production	Proportion of land showing signs of salinity(c)	Proportion of total non-irrigated farm area in region(d)
	no.	%	no.	%	'000 ha	%	%
Avoca-Loddon-Campaspe	*477	19.0	8	0.6	3	37.4	0.2
Avon	2 279	79.9	450	5.8	284	63.2	3.6
Border Rivers	*137	5.0	n.a.	0.2	n.a.	n.a.	0.3
Burdekin-Fitzroy	*96	3.0	**35	0.2	**20	55.8	0.1
Condamine-Balonne-Maranoa	*132	2.6	*28	0.2	**2	7.7	—
Darwin-Katherine	1	0.9	2	—	2	100.0	—
Glenelg-Hopkins-Corangamite	1 378	19.7	30	1.2	10	33.2	0.4
Goulburn-Broken	229	9.2	4	0.5	1	20.1	0.1
Lachlan-Murrumbidgee	1 124	14.8	*30	0.4	4	11.8	0.1
Lockyer-Burnet-Mary	168	3.8	*1	—	*1	54.4	—
Lower Murray	1 119	18.9	75	0.4	37	49.2	0.2
Macquarie-Castlereagh	435	8.4	7	0.1	*3	36.1	—
Midlands	*188	16.0	*3	0.4	**1	34.3	0.1
Mt. Lofty-Kangaroo Island—Northern Agricultural District	1 451	28.4	*51	1.2	*23	44.2	0.5
Murray	104	5.8	*3	0.2	—	14.4	—
Namoi-Gwydir	226	6.9	*5	0.2	*1	13.3	—
Northern Agricultural District	868	59.2	152	2.8	91	60.2	1.7
Ord	—	—	—	—	—	—	—
South Coast	1 354	63.6	74	2.4	42	57.4	1.4
South East	209	13.8	51	4.9	*9	18.3	0.9
South West	1 681	50.0	153	5.3	79	51.3	2.7
Total NAP Region	*13 658*	*19.8*	*1 171*	*0.9*	*624*	*53.2*	*0.5*
Total non-NAP	*1 873*	*5.9*	*660*	*0.2*	*147*	*22.3*	*0.1*
Total non-irrigated farms	**15 530**	**15.4**	**1 831**	**0.4**	**771**	**42.1**	**0.2**

(a) Non-irrigated farms with land showing signs of salinity as a proportion of total non-irrigated farms in the NAP region/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census. (b) Land showing signs of salinity as a proportion of total non-irrigated farm area in the NAP region/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census. (c) Salinised land unable to be used for production as a proportion of land showing signs of salinity. (d) Salinised land unable to be used for production as a proportion of total non-irrigated farm area in the NAP region/Australia. Source for the denominator is data from the ABS 2001 Agricultural Census.

Source: ABS 2002b.

Comparisons with other data

Farmer assessments of the extent of salinity may differ from assessments made by scientific means, but provide a rapid and cost effective indication of the level of salinity occurring on farms. The results from the 2002 Land Management and Salinity Survey show a lower level of saline land than other sources (see table 11.15). Factors most likely to be contributing to differences are the different concepts, assessment methods and coverage used in each study. While farmers' perceptions of the area will differ from scientific assessments, they are more or less consistent with the other studies, in terms of the relative area affected by salinity in each state and territory. In all studies, Western Australia is the state most affected by salinity and Northern Territory, Australian Capital Territory and Tasmania are the least affected.

It is important to note that the 2002 Land Management and Salinity Survey provides information for agricultural land only. Agricultural land occupies approximately 456 million ha, representing 59% of land use in Australia, but salinity and salinity management also occur on non-agricultural land. The latter was out of scope for the 2002 Land Management and Salinity Survey.

11.15 AREA AFFECTED BY SALINITY, Comparison of ABS results with other estimates

	PMSEIC 1999	NLWRA 2001	ABS 2002
	Area of salinity affected land(a)	Area at risk of salinity(b)	Area showing signs of salinity(c)
State	'000 ha	'000 ha	'000 ha
NSW/ACT	120	181	124
Vic.	120	670	139
Qld	10	n.a.	106
SA	402	390	*350
WA	1 802	4 363	1 241
Tas.	20	54	6
NT	—	—	2
Total Australia	**2 476**	**5 658**	**1 969**

(a) As determined by experts. (b) As estimated from water table heights. (c) As reported by farmers.

Source: ABS 2002b.

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12 Australia's biodiversity[1]

Biological diversity, or 'biodiversity', is the variety of all life forms — the different plants, animals and micro-organisms, the genes they contain and the ecosystems of which they form a part. Biodiversity is constantly changing; it is increased by genetic change and evolutionary processes and reduced by processes such as habitat degradation, population decline, invasion and extinction. Biodiversity covers terrestrial, marine and other aquatic environments and is considered at three interrelated and interdependent levels:

- ecosystem diversity: the variety of habitats, biotic communities and ecological processes
- species diversity: the variety of species on the Earth
- genetic diversity: the variety of genetic information in all of the individual organisms that inhabit the Earth. Genetic diversity occurs within and between the populations of organisms that comprise individual species as well as among species (Commonwealth of Australia 1996).

Species biodiversity

Australia is identified as one of 17 megadiverse countries. These countries have an exceptional total number of species, and a high degree of endemic species found exclusively in that country. As a consequence of Australia's size, relative age and isolation, its flora and fauna have evolved to become a globally significant centre of endemism, with over 80% of our mammals, flowering plants, reptiles, frogs, fungi, molluscs and insects known only to occur in Australia (Williams et al. 2001).

Estimates of the total number of species in Australia vary considerably, from about 500,000 to in excess of 10 million (Horwitz, Recher & Majer 1999). Table 12.1 presents the most recent estimates of the number of species currently known in Australia and the percentage of endemic species for each taxa. Only a few groups of species are thought to be entirely known, reflecting the limited state of our knowledge of Australia's biodiversity, particularly with respect to invertebrates and micro-organisms.

Many terrestrial and marine regions within Australia are globally significant centres of biodiversity (Williams et al. 2001). The south-west Western Australia region supports the eighth highest number of endemic vascular plant species in any one region (about 2,830 species), and contains over one-third of Australia's plant species. The Great Barrier Reef contains about 2,000 reef fish and 500 coral species, the highest concentration of the world's fish and coral species. The rainforests in the Wet Tropics of northern Queensland are also internationally identified as major centres of biodiversity.

Ecosytem biodiversity

Ecosystems are a dynamic complex of plant, animal and micro-organism communities which, together with the non-living environment, interact to maintain a functional unit (Commonwealth of Australia 1996). Ecosystems contribute to the maintenance of water cycles, photosynthesis, gene flow, soil production and protection, storage and cycling of nutrients, regulation of climate and carbon sequestration. Ecosystem diversity is defined by the variety of these processes, habitats and biotic communities, and is generally considered in terms of distinct vegetation types, or marine and freshwater habitats. On the basis of vegetation alone, Australia has a wide range of ecosystem types ranging from rainforests, eucalypt forests and woodlands, acacia and mallee to heath, mangroves and grasslands (see the section *Extent and clearing of native vegetation*).

1 From *Chapter 14, Environment* in *Year Book Australia 2003.*

For the purposes of analysing Australian ecosystems at the continental scale, the Interim Biogeographic Regionalisation of Australia (IBRA) (Thackway & Cresswell 1995) and the Interim Marine and Coastal Regionalisation for Australia (IMCRA) (IMCRA Technical Group 1998) have been developed. In Australia, IBRA and IMCRA have identified 85 terrestrial bioregions and 60 marine bioregions representing the major environmental units in Australia. These provide a framework for conservation planning and sustainable resource management within a bioregional context.

12.1 ESTIMATED NUMBER OF DESCRIBED SPECIES IN AUSTRALIA — 2000

Taxonomic group	Species described(a) no.	Estimated total species(a)(b) no.	Percentage described(b) %	Endemic %
Flora				
Fungi				
Fungi (other than lichens)	12 500	250 000	5	90
Lichens	2 877	5 000	60	(c)
Plants				
Vascular plants (flowering plants, cycads, conifers and ferns)	15 638	20 000–25 000	70	85
Algae	5 000	10 000–12 000	45	(c)
Mosses and allies (Bryophytes)	1 500	2 500	60	(c)
Total	*25 000*	*290 000*	*9*	*(c)*
Fauna				
Invertebrates				
Sponges (Porifera)	1 416	3 500	40	(c)
Corals, anemonies, jellyfish (Cnidaria)	1 270	1 760	70	(c)
Flatworms, parasites (Platyhelminthes)	1 506	10 800	14	(c)
Thorny-headed worms (Acanthocephala)	57	160	35	(c)
Roundworms, threadworms (Nematoda)	2 060	30 000	7	(c)
Squid, octopus, mussels, clams, snails (Mollusca)	9 336	12 250	75	90
Ringed worms, earthworms (Annelida)	2 125	4 230	50	(c)
Velvet worms (Onychophora)	56	56	100	(c)
Crayfish, crabs, prawns etc. (Crustacea)	6 426	9 500	70	(c)
Spiders, mites etc. (Arachnida)	5 666	27 960	20	(c)
Insects (Insecta)	58 532	83 860	70	90
Starfish, echinoderms etc. (Echinodermata)	1 206	1 400	85	(c)
Other invertebrates	2 929	7 230	35	(c)
Vertebrates				
Sea squirts, doliolids, salps (Tunicata)	536	735	70	(c)
Lancelets (Cephalochordata)	8	8	100	(c)
Lampreys, hagfishes (Agnatha)	5	10	50	(c)
Fish (Pisces)	4 150	5 250	80	90
Frogs (Amphibia)	176	176	100	93
Snakes, lizards (Reptilia)	633	633	100	89
Birds (Aves)	825	825	100	45
Mammals (Mammalia)	369	369	100	83
Total	*99 287*	*200 000*	*50*	*(c)*

(a) Data on species numbers, collected by the Australian Biological Resources Study Environment Australia. (b) Estimates are approximations. (c) Unknown.

Source: Williams et al. 2001.

Conservation of biodiversity

The loss of biodiversity is considered one of the most serious environmental problems in Australia. The clearance of native vegetation is a significant threat to terrestrial biodiversity (see the section *Extent and clearing of native vegetation*). Other key threats to biodiversity include invasive species (i.e. pests and weeds; see the section *Invasive species*), dryland salinity, pollution, nutrient loading and sedimentation of waterways and coastal areas, altered hydrological and fire regimes, and climate change. These processes pose a major threat to sustainable management of our ecosystems and the environment, as well as to the social and economic values of biodiversity.

The Commonwealth administers biodiversity conservation through the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)(EPBC Act 1999). This Act provides for: identification and listing of threatened species and threatened ecological communities; development of recovery plans for listed species and ecological communities; recognition of key threatening processes; and where appropriate, reducing these processes through threat abatement plans. In August 2002, 116 flora and fauna species were listed as extinct, and 1,488 species and 27 ecological communities were listed as threatened under the EPBC Act (table 12.2). At that time, 140 recovery plans had been adopted covering 183 of these listed species.

As a signatory to the International Convention on Biological Diversity, Australia is required to establish a system of protected areas. These areas are dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources. The EPBC Act (1999) is the principal Commonwealth legislation for establishing and managing protected areas, which are developed according to the *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia 1996). The strategy calls for a Commonwealth, state and territory cooperative program to ensure that Australia's terrestrial and marine protected area systems are comprehensive, adequate and representative.

In 2000, there were 5,251 protected areas in Australia, occupying 61.4 million hectares and accounting for 7.8% of the total land area. Of the six international (World Conservation Union) management categories, national parks (39%) and nature reserves (31%) comprise the largest proportion of Australia's total protected area (table 12.3). At present, the conservation reserve system does not represent all ecosystems equally, with about 40% of IBRA regions having less than 5% of their land represented in protected areas. Arid and semi-arid environments, native grasslands and wetlands are particularly poorly represented. Given the small proportion of many landscapes in protected areas, conservation outside formal reserves is an important mechanism for biodiversity conservation and requires the involvement of farmers, businesses, conservation groups, resource users, Indigenous peoples and the wider community.

12.2 THREATENED SPECIES AND COMMUNITIES(a) — 2000–02

	Extinct	Critically endangered	Endangered	Vulnerable	Conservation dependent
Ecological communities	—	—	27	—	—
Fauna					
Fish	—	2	14	17	—
Amphibians	4	—	15	12	—
Invertebrates	—	2	2	6	—
Reptiles	—	—	12	38	—
Birds	23	5	34	62	—
Mammals	27	1	33	51	1
Flora					
Plants	62	35	489	657	—
Fungi	—	—	—	—	—
Total	*116*	*45*	*599*	*843*	*1*

(a) As listed under the 'Environment Protection and Biodiversity Conservation Act 1999' (Cwlth).

Source: EA 2002b.

12.3 TERRESTRIAL PROTECTED AREAS, By (IUCN) World Conservation Union management category — 2000

IUCN category	Primary management intent	no.	ha
Category IA	Nature reserve: managed mainly for science	1 981	19 119 788
Category IB	Wilderness area: wilderness protection	49	3 918 965
Category II	National park: ecosystem conservation and recreation	598	23 909 090
Category II/IB	National park/wilderness area	5	1 295 335
Category III	Natural monument: conservation of specific natural features	660	271 713
Category IV	Habitat/species management area: conservation through management intervention	1 397	325 304
Category V	Protected landscape/seascape: landscape/seascape conservation and recreation	151	861 095
Category VI	Managed resource protected areas: sustainable use of natural ecosystems	376	11 720 773
None specified		3	29
To be announced		31	16 519
Total		**5 251**	**61 438 611**

Source: EA 2000.

Extent and clearing of native vegetation

Native vegetation is a key element contributing to Australia's biodiversity. Across Australia, 23 major native vegetation groups have been identified across Australia, which collectively comprise 'tens of thousands of plant species, thousands of vegetation communities and assemblages, and provide habitat to myriads of microorganisms and animal species' (NLWRA 2002). In general, the extent and distribution of native vegetation across Australia is determined by climatic variation and the physical landscape (i.e. landform, geology and soils). Rainforests and eucalyptus forests are limited to the higher rainfall areas across the tropical north, around eastern and south-western coastal regions, and across Tasmania. Australia's arid interior is dominated by grasslands and forblands. Regions between these climatic extremes are occupied primarily by woodlands, shrublands and Acacia forests.

Australia's landscape is dominated by a few plant genera ranging across a broad variety of structural vegetation types. Table 12.4 details the estimated pre-European and current extent of Australia's major native vegetation groups. At present, hummock grasslands cover 23% of Australia, existing primarily in the arid interior. Eucalypt woodlands (17%) and Acacia forests, woodlands and shrublands (17%) occupy the next largest proportion of Australia's landmass. Smaller areas of the continent are inhabited by shrubs and forblands (10%), tussock grasslands (7%), eucalypt forests (4%) and mallee woodlands and shrublands (3%). The remaining native vegetation types together comprise less than 4% of Australia's land area (NLWRA 2002).

Clearing of native vegetation

Since European settlement, large tracts of Australia's native vegetation have been cleared to facilitate human settlement and the expansion of agriculture. Extensive broadscale clearing continues to take place. Clearance of vegetation reduces the natural range of ecosystems as well as the diversity of habitats and ecological processes occurring within them. Consequently, native vegetation clearance has been identified as one of the most threatening processes for biodiversity loss and species extinction in Australia (SoE 2001). Broadscale vegetation clearance has other important implications for the state of the environment through its effect on dryland salinity, carbon cycling and changes in hydrological cycles.

According to the *Australian Native Vegetation Assessment 2001*, approximately 982,000 square kilometres, or 13% of Australia's native vegetation, have been cleared or substantially modified since European settlement (table 12.5). Clearing has been concentrated in the higher rainfall areas and where there are more fertile soils, generally excluding the arid interior and the tropical far north. In the intensively used areas of Australia (primarily the agricultural and urban zones), about 33% of native vegetation has been cleared (NLWRA 2002).

12.4 AREA OF PRE-EUROPEAN AND PRESENT NATIVE VEGETATION — 2001

Major vegetation group	Pre-European km²	Present km²	Proportion remaining %
Rainforest and vine thickets	43 493	30 231	70
Eucalypt tall open forests	44 817	30 129	67
Eucalypt open forests	340 968	240 484	71
Eucalypt low open forests	15 066	12 922	86
Eucalypt woodlands	1 012 047	693 449	69
Acacia forests and woodlands	657 582	560 649	85
Callitris forests and woodlands	30 963	27 724	90
Casuarina forests and woodlands	73 356	60 848	83
Melaleuca forests and woodlands	93 501	90 513	97
Other forests and woodlands	125 328	119 384	95
Eucalypt open woodlands	513 943	384 310	75
Tropical eucalypt woodland/grasslands	256 434	254 228	99
Acacia open woodlands	117 993	114 755	97
Mallee woodlands and shrublands	383 399	250 420	65
Low closed forests and closed shrublands	15 864	8 749	55
Acacia shrublands	670 737	654 279	98
Other shrublands	115 824	98 947	85
Heath	47 158	25 861	55
Tussock grasslands	589 212	528 998	90
Hummock grasslands	1 756 962	1 756 104	100
Other grasslands, herblands, sedgelands and rushlands	100 504	98 523	98
Chenopod shrubs, samphire shrubs and forblands	563 389	552 394	98
Mangroves, tidal mudflats, samphires and bare areas, etc.	112 063	106 999	96

Source: NLWRA 2002.

12.5 EXTENT OF NATIVE VEGETATION CLEARANCE SINCE EUROPEAN SETTLEMENT — 2001

	Cleared or modified km²	%
NSW	234 527	30
Vic.	142 633	60
Qld	304 043	18
SA	99 473	11
WA	183 887	7
Tas.	10 695	16
NT	6 055	—
ACT	738	31
Aust.	**982 051**	**13**

Source: NLWRA 2002.

The extent of clearing of major vegetation groups since European settlement is shown in table 12.4. The most affected groups include: 'eucalypt woodlands' and 'eucalypt open woodlands', where 31% and 25% of pre-European extent has been cleared, accounting for 32% and 13% respectively of all clearing; and 'inland acacia forests and woodlands', and 'mallee woodlands and shrublands', where approximately 15% and 35% of pre-European extent has been cleared, accounting for 10% and 14% respectively of all clearing. The extensive clearing of low closed forests, rainforest and heath communities is particularly important given that they were already highly restricted in their natural, pre-European distribution.

12.6 ESTIMATED ANNUAL CLEARANCE OF WOODY VEGETATION

	Area cleared in 1999(a) ha	Area cleared in 2000(b) ha
NSW	30 000	100 000
Vic.	2 450	2 500
Qld	425 000	425 000
SA	3 396	1 600
WA	3 738	6 000
Tas.	940	17 000
NT	3 320	12 700
ACT	—	—
Aust.	**468 844**	**564 800**

(a) 1999 data from AGO 2001. (b) 2000 estimates from ACF 2001.

Source: Cited in Hamblin 2001.

Recent estimates of annual native vegetation clearing rates in Australia vary markedly and are highly uncertain (table 12.6). Nonetheless, they are indicative of a relatively high rate of clearance. The extent of land clearance in the intensively used regions of Australia (38% of the continent) from 1990 to 1995 was estimated at

1.2 million hectares (Barson, Randall & Boardas 2000). The most recent estimates of annual native vegetation clearing in Australia include 468,844 hectares for 1999 (AGO 2001) and 564,000 for 2000 (ACF 2001). The latter figure is exceeded by only four other countries: Brazil, Indonesia, the Democratic Republic of Congo and Bolivia (ACF 2001, cited in Hamblin 2001). Most of Australia's recent vegetation clearance has been conducted in Queensland.

Greenhouse gas emissions from land clearing

Land clearing makes a significant contribution to Australia's greenhouse gas emissions and consequently has important implications for global climate change, global warming and associated policy mechanisms. Where vegetation is cleared for a different land use, the cleared vegetation is usually burned, leading to emissions of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere. CO_2 is also released from the soil and from decay of unburned aboveground biomass. Although significant quantities of CO_2 are sequestered from the atmosphere during vegetation regrowth, land clearing is a net emitter of CO_2 in Australia (AGO 2001).

Australia provides greenhouse gas emission estimates to the United Nations Framework Convention on Climate Change, including land use change, which is defined as the deliberate removal of forest cover by humans and replacement of it with pasture, crops, urban development or other land uses. Emissions from the clearing of other vegetation types (such as grasslands and shrublands) are excluded from the analysis of land use change emissions, unless it was reclearing (AGO 2002a).

The National Carbon Accounting System (NCAS) assists in monitoring land use change and its impact on Australia's emissions. According to NCAS, emissions from land use change were estimated to be 61 megatonnes (Mt) CO_2 in 2000, contributing 11% of Australia's total emissions in that year (AGO 2002b). However, all estimates of emissions from land clearing are subject currently to high degrees of uncertainty and are likely to change in the future.

Invasive species

An invasive species is 'a species occurring as a result of human activities beyond its accepted normal distribution and which threatens valued environmental, agricultural and personal resources by the damage it causes' (EA 2002a). Invasive species include feral animals, marine pests, weeds, non-native insects and other invertebrates, and diseases and parasites. Invasive species can be native or exotic. They may reduce farm and forestry productivity, threaten native species and contribute to land degradation. Invasive species are acknowledged by the World Conservation Union as the second most significant cause of biodiversity loss in the world, behind habitat loss and fragmentation.

Invasive animals (pests)

Many invasive animals have been deliberately brought to Australia for transport, food, sport and recreation, pets and pest control (Bomford & Hart 2002). Other animals, such as black rats and house mice, have been accidentally imported. Some species were legally released into the wild (e.g. rabbits and foxes), while others escaped domestication (e.g. feral goats and pigs) or were released illegally (e.g. Indian mynahs). At least 80 exotic vertebrate animal species have successfully established wild populations on mainland Australia and over 30 of these species are deemed to be pests (table 12.7). Furthermore, several native species may be considered pests, such as the laughing kookaburra, kangaroos and the crown-of-thorns starfish (Clarke et al. 2000).

12.7 EXOTIC VERTEBRATE ANIMAL SPECIES THAT HAVE ESTABLISHED WILD POPULATIONS — 2001

	No. of invasive species	Invasive species classified as pests
Mammals	25	European rabbit; feral goat, cat and pig; European red fox; house mouse; dingo/feral dog
Birds	(a)20	European starling; Indian myna
Reptiles	4	—
Amphibians	1	Cane toad
Freshwater fish	23	European carp; Mosquito fish; Mozambique tilapia

(a) A further seven invasive bird species are established on offshore islands.

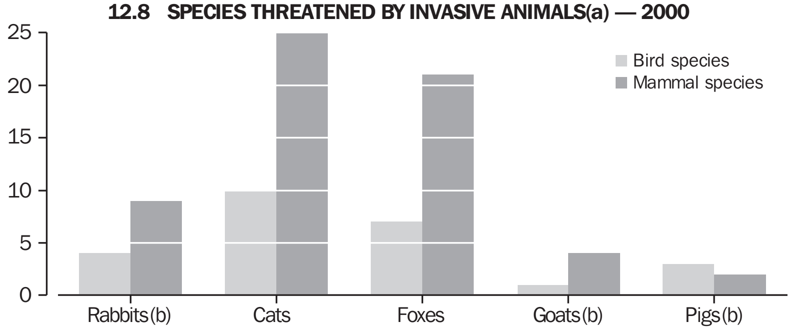
Source: Bomford and Hart 2002.

Australia's pest animals have direct impacts on Australia's livestock industries through predation and competition for pasture. Short-term agricultural costs attributed to the main exotic vertebrate pests in Australia have been estimated to total at least $420m per year (Bomford & Hart 2002). A further $60m per year is spent on controlling these vertebrate pests, while the costs of combating associated long-term land degradation are likely to be large. These estimates do not include environmental costs such as threats to the survival of native species.

Pest animals may damage vegetation and soils, foul water or compete with native animals for habitat and food. Along with the processes associated with their presence, several invasive species are listed as key threatening processes under the EPBC Act 1999. Listed threatening processes threaten or may threaten the survival, abundance or evolutionary development of a native species or an ecological community. Competition and land degradation by feral goats and rabbits; predation by feral cats and the European red fox; and predation, habitat degradation, competition and disease transmission by feral pigs are each recognised as key threatening processes (EA 2002b).

The number of bird and mammal species threatened by processes associated with these invasive animals is shown in graph 12.8. These invasive species also threaten a range of plants, amphibians and reptiles. Threat abatement plans have been prepared under the National Feral Animal Control Program and the EPBC Act 1999 for the European fox, cat, rabbit and goat (EA 2002b). These plans focus on strategic approaches to reducing, to an acceptable level, the effects of processes that threaten the long-term survival of native species and ecological communities.

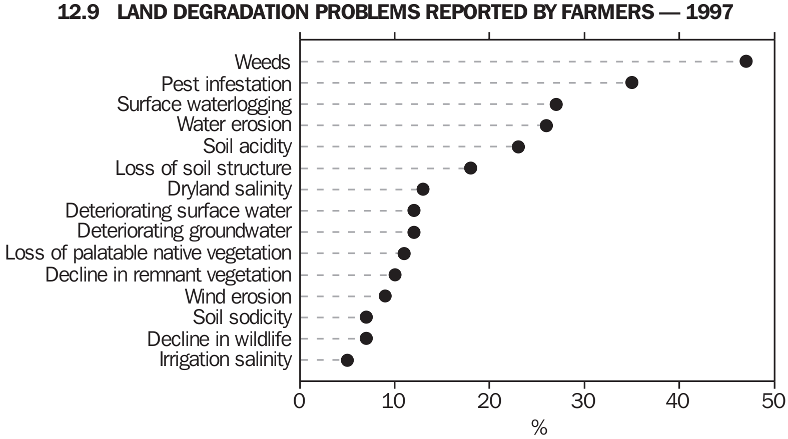
12.8 SPECIES THREATENED BY INVASIVE ANIMALS(a) — 2000



(a) Number of threatened species under confirmed or perceived threat from the relevant key threatening process listed under the 'Environment Protection and Biodiversity Conservation Act 1999' (Cwlth). (b) Threat includes associated threats such as land degradation.

Source: EA 2002b.

12.9 LAND DEGRADATION PROBLEMS REPORTED BY FARMERS — 1997



Source: Mues, Chapman and Van Holst 1998.

Invasive plants (weeds)

A weed is any invasive plant, native or introduced, that is deemed to be a problem or has the potential to be a problem on any area of land or water. Weeds reduce the productive capacity of agricultural systems (agricultural weeds) and pose a significant threat to natural ecosystems (environmental weeds). Surveys of landholders in Australia show that weeds are the most common land problem faced by farmers (graph 12.9), and the majority of farmers believe their weed problems are getting worse (Jones et al. 2000). In 1987, weeds were estimated to cost the Australian economy $3.3b annually, through lost agricultural production and control costs (Combellack 1987). Environmental weeds are considered one of the most serious threats to biodiversity and nature conservation in Australia (Williams et al. 2001).

There are over 3,000 weed species in Australia today (National Weeds Strategy Fact Sheet), of which over 370 species have been declared noxious (Lazarides, Cowley & Hohnan 1997). Management of these weeds is coordinated through the National Weeds Strategy, which aims to integrate the efforts of stakeholders, including governments, industry, land managers and the general public, to reduce the detrimental impact of weeds on the sustainability of Australia's productive capacity and natural ecosystems.

To help focus national efforts addressing the weed problem, a list of 'Weeds of National Significance' (WONS) has been compiled (Thorp & Lynch 2000). A final 'Top 20' weed species (table 12.10) were selected from an original list of 71 nominated weed species on the basis of their invasiveness and impact characteristics; their potential and current area of spread; and their primary industry, environmental and socioeconomic impacts. Of these top 20 WONS, six were classified as primarily a threat to the environment, another five as primarily a threat to agricultural systems and nine weeds have both environmental and agricultural effects.

12.10 WEEDS OF NATIONAL SIGNIFICANCE, Current and potential distribution — 1999

Common name	Origin of weed	Current distribution '000 km^2	Potential distribution '000 km^2
Alligator weed	Argentina	30	500
Athel pine	North Africa, Arabia, Iran and India	80	3 646
Bitou bush/boneseed	South Africa	231	1 258
Blackberry	Europe	691	1 425
Bridal creeper	South Africa	385	1 244
Cabomba	United States of America	35	181
Chilean needle grass	South America	14	242
Gorse	Europe	233	870
Hymenachne	Central America	73	415
Lantana	Central America	389	1 052
Mesquite	Central America	410	5 110
Mimosa	Tropical America	73	434
Parkinsonia	Central America	950	5 302
Parthenium	Caribbean	427	2 007
Pond apple	North, Central and South America and West Africa	27	181
Prickly acacia	Africa	173	2 249
Rubber vine	Madagascar	592	2 850
Salvinia	Brazil	383	1 376
Serrated tussock	South America	171	538
Willows	Europe, United States of America and Asia	63	135

Source: Agricultural and Resource Management Council of Australia and New Zealand, Australia and New Zealand Environment and Conservation Council and Forestry Ministers 1999; Thorp and Lynch 2000.

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13 Energy resources, production, trade and use[1]

Energy resources

Australia has large identified resources of fossil fuels and uranium. It is ranked in the top six countries in the world for economic demonstrated resources (EDR) of black and brown coal, and has the world's largest EDR of uranium. Australia also has significant reserves of natural gas and crude oil.

Australia has substantial resources of high quality black coal. Most of these resources are located in New South Wales and Queensland. Small but locally important coal resources occur in Western Australia, South Australia and Tasmania (map 13.1). Brown coal occurs mainly in Victoria with other known resources in Western Australia, South Australia and Tasmania (AGSO 2000a).

13.1 COAL RESOURCES — 2000

Produced by LANDINFO the Spatial Division of Sinclair Knight Merz NL10506.5

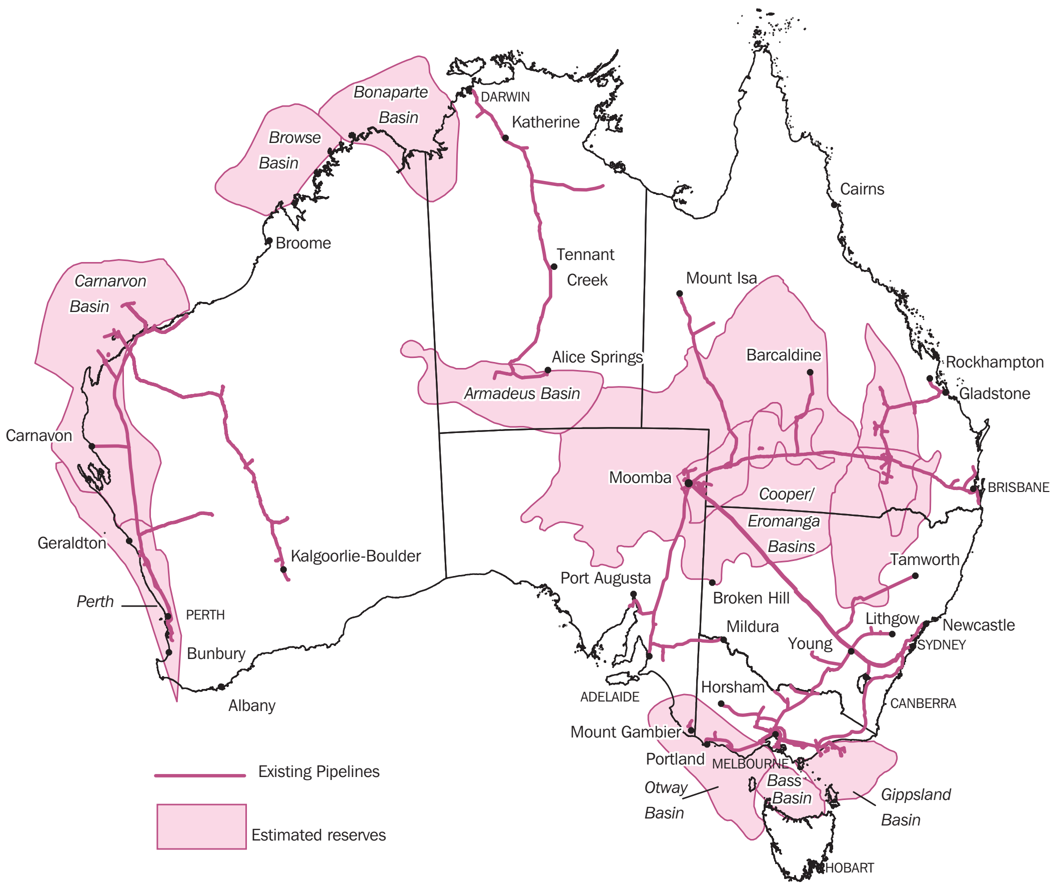
Source: LANDINFO.

1 From *Chapter 15, Energy* in *Year Book Australia 2003.*

In 2001, Australia accounted for 6% of the world's recoverable EDR of black coal and ranked sixth after the United States of America (27%), Russia (19%), China (12%), India (9%) and South Africa (7%). Australia has about 20% of the world's recoverable brown coal EDR, second behind Germany (22%) (AGSO 2000a).

Map 13.2 shows the extent of access to gas resources in Australia. Known natural gas reserves in Australia are less extensive than coal reserves, although it is expected that natural gas will increase its share of the domestic energy market in the short- to medium-term. The total length of Australia's transmission pipeline system has increased from 7,670 kilometres a decade ago to over 15,600 kilometres in 2001 (ANZMEC 2001). Since 1960, remaining gas reserves have increased more than eight times, mainly due to discoveries of major gas resources on the North West Shelf.

13.2 GAS RESOURCES — 2000



Source: The Australian Gas Association.

EDRs of non-renewable energy assets were estimated at 1.9 million petajoules (PJ) in 2001 (table 13.3). Black coal accounted for 59%, followed by brown coal (19%) and uranium (16%). Australia has the world's largest resources of uranium in the low cost (EDR) category, with 29% of the world's total EDR (recoverable at <US$80/kg U). Other countries with significant EDR of uranium include: Kazakhstan (19%), Canada (14%), South Africa (10%), Brazil (7%), Namibia (6%), the Russian Federation (6%) and the United States of America (5%).

Changes in EDRs can be due to various factors, one of which is production activity. Others include discoveries and reclassification of resources due to reassessments (such as with black and brown coal in 1999, when some resources previously considered economic were reclassified as subeconomic).

13.3 ECONOMIC DEMONSTRATED RESOURCES(a)

Fuel	1991 '000 PJ	2001 '000 PJ	Change %
Black coal	1 387.8	1 152.8	–16.9
Brown coal	404.5	365.7	–9.6
Crude oil	9.5	8.4	–11.6
Condensate	4.4	10.4	136.4
LPG	3.4	6.9	102.9
Natural gas	26.9	86.5	221.6
Uranium	222.8	307.4	38.0
Total energy assets	**2 059.3**	**1 938.1**	**–5.9**

(a) Non-renewable resources only.

Source: Australian National Accounts: National Balance Sheet (5241.0.40.001).

Table 13.4 shows the net present value (NPV) of demonstrated energy assets within Australia. The NPV is the expected value of the resource based on current market value, with some modifications based on depletion and economic forces. At mid 2001 total subsoil assets had an NPV of just under $173b, of which 70% was attributed to the NPV of energy assets (over $121b). The two most significant energy assets were black coal and natural gas which accounted for 33% and 28%, respectively. The increase in the value of energy resources between mid 1991 and mid 2001 was primarily due to increases in the NPV of black coal and natural gas over this period.

13.4 NET PRESENT VALUE OF ENERGY AND SUBSOIL ASSETS

Fuel	30 June 1991 $m	30 June 2001 $m	Change %
Black coal	5 408	40 566	650.1
Brown coal	168	633	276.8
Crude oil	12 888	22 888	77.6
Condensate	2 395	14 139	490.4
LPG	1 713	5 725	234.2
Natural gas	14 036	33 555	139.1
Uranium	2 531	3 701	46.2
Total energy assets	**39 139**	**121 207**	**209.6**
Total subsoil assets	56 388	172 873	206.6

Source: Australian National Accounts: National Balance Sheet (5241.0.40.001).

Energy production

The production of primary fuels in Australia grew significantly between 1990–91 and 1998–99, with an overall increase of about 34% (table 13.5). Significant increases in production occurred in uranium, black coal and, to a lesser extent, natural gas. Black coal continues to dominate the pattern of energy production (as it has done for at least the last 20 years), accounting for nearly half of total energy production in 1998–99. Uranium accounted for 24% of total production, followed by natural gas at 11%, and then crude oil at 8%.

Over two-thirds of energy produced in Australia is exported (mainly black coal and uranium, and these two products are expected to continue to dominate the pattern of both energy production and trade. Domestically, most coal produced is used to generate electricity. Other uses include coke-making for the iron and steel industry, and as a source of heat in the manufacture of cement.

Australia's total production of uranium reached a record high in 1999, 22% higher than for 1998. This was due to a significant increase in uranium production from the Ranger and Olympic Dam mines (AGSO 2000a).

Production depletes crude oil resources at about 3.7% a year, condensate at 1.7% a year and natural gas at 0.9% a year. In the longer term, increases in the real price of oil and advances in technology are likely to lead to exploration which could discover large amounts of petroleum not presently classified as resources (AGSO 2000b).

13.5 PRODUCTION OF PRIMARY FUELS

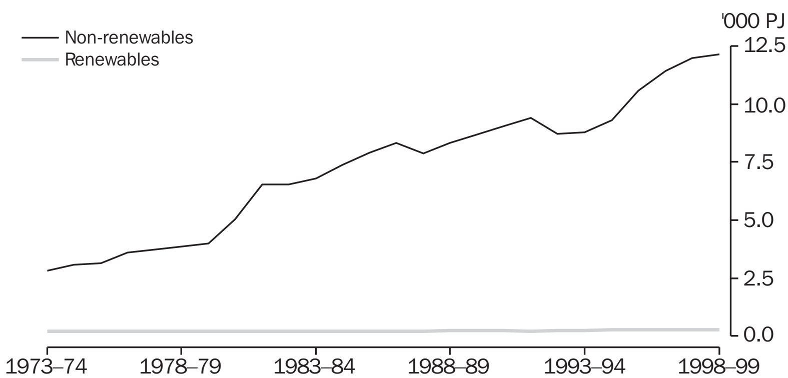
Fuel	1990–91 PJ	1994–95 PJ	1998–99 PJ	Change since 1990–91 %
Black coal	4 396.0	5 173.2	6 051.1	37.7
Brown coal	484.1	492.0	647.3	33.7
Crude oil and LNG	1 182.3	1 154.0	1 032.2	–12.7
LPG	94.0	95.6	103.5	10.1
Natural gas	840.4	1 174.9	1 306.1	55.4
Uranium	2 062.8	1 236.6	3 001.4	45.5
Wood	100.1	108.9	108.3	8.2
Bagasse	78.2	91.4	109.6	40.2
Hydro-electricity	58.0	58.5	60.5	4.3
Solar	2.4	3.4	3.8	58.3
Total	**9 298.3**	**9 588.5**	**12 423.8**	**33.6**

Source: ABARE, electronic datasets.

Graph 13.6 shows the production of non-renewable and renewable energy sources between 1973 and 1998. Over this period, the production of non-renewable fuels has shown an upward trend. In contrast, production of renewable energy sources (wood, bagasse, hydro-electricity and solar) has remained relatively stable, therefore reducing their share of total production over the period.

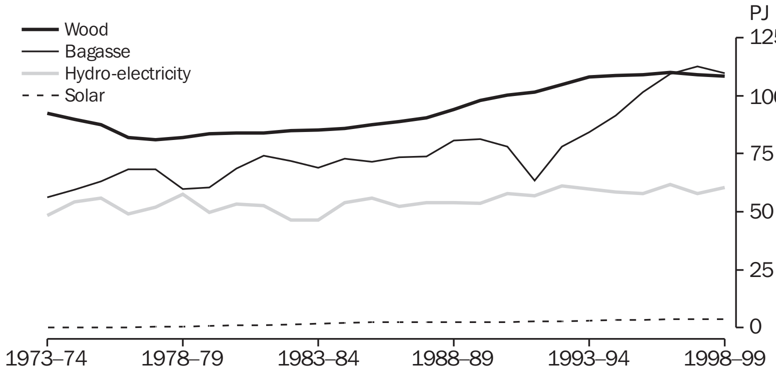
Although production of renewable fuels increased by 18% between 1990–91 and 1998–99, their share of total energy production fell from 2.6% to 2.3% over this period. The production of renewable fuels between 1973 and 1998 is shown by type of fuel in graph 13.7. (It should be noted that there is a limit to the possible increase in bagasse's share of renewable energy, which is related to the production of sugar cane.)

13.6 PRODUCTION OF PRIMARY FUELS



Source: ABARE, electronic datasets.

13.7 PRODUCTION OF RENEWABLE FUELS



Source: ABARE, electronic datasets.

Australia's international trade in energy products

In 2001–02, 10,509 PJ of total energy production in Australia were exported (table 13.8). The largest contributors were black coal (51% of total energy exports) and uranium (33%). Crude oil and natural gas contributed 8% and 4%, respectively. Total energy exports (primary plus secondary) increased by 65% between 1993–94 and 2001–02. Among primary exports, uranium increased sharply (by 84%) and exports of black coal increased by 53% over this period.

Imports of energy products are relatively small by comparison (1,286 PJ in 2001–02) and are dominated by crude oil. Imports of this product increased by over a third between 1993–94 and 2001–02. Graph 13.9 shows the sharp contrast between exports of energy products from and imports of these products into Australia over more than 25 years.

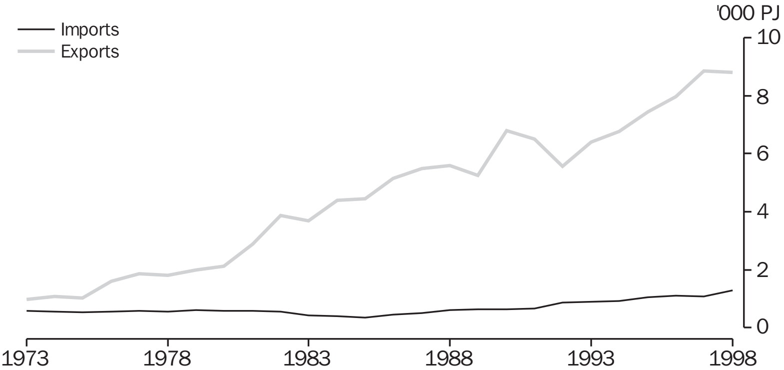
13.8 ENERGY PRODUCTS, Volume of exports and imports

	Exports			Imports		
	1993–94	1997–98	2001–02	1993–94	1997–98	2001–02
Fuel	PJ	PJ	PJ	PJ	PJ	PJ
Primary energy products						
Black coal	3 484.5	4 390.5	5 339.5	4.9	3.0	1.1
Crude oil and ORF(a)	352.9	547.0	892.1	781.3	967.0	1 057.1
LPG	38.7	83.6	94.8	4.1	13.0	14.9
Natural gas(b)	327.8	415.8	(c)435.9	—	—	—
Uranium	1 877.2	3 015.1	3 462.0	—	—	—
Total	*6 081.1*	*8 452.0*	*10 224.3*	*790.3*	*983.0*	*1 073.1*
Secondary energy products						
Automotive gasoline	30.5	52.0	42.6	4.0	12.1	49.4
Aviation gasoline	54.6	83.5	44.2	3.9	2.4	0.2
Aviation turbine fuel	58.1	90.8	89.8	2.6	1.4	8.3
Kerosene	2.0	1.2	0.6	—	—	(d)
Gas oil or fuel oil	59.2	39.8	60.3	38.0	32.2	22.3
Other petroleum products(e)	53.3	69.7	45.0	29.8	31.3	24.9
Coke	14.3	4.8	2.2	2.6	2.3	1.3
Total	*271.9*	*341.9*	*284.6*	*80.9*	*81.7*	*106.4*
Total	**6 353.0**	**8 793.9**	**10 508.9**	**952.1**	**1 146.4**	**1 285.9**

(a) Other refinery feedstock. (b) ABARE estimate. (c) 2000–01 value. (d) From 30 January 1998 kerosene is included in Gas and fuel oils. (e) Also includes lubes and greases, bitumen and other bituminous products, solvents, waste oils and diesel.

Source: ABS data on request, International Trade Special Data Service; ABARE 2001.

13.9 EXPORTS AND IMPORTS OF ENERGY PRODUCTS



Source: ABARE, electronic datasets.

Table 13.10 shows that the large volumes of exported energy products contributed significantly to Australia's export earnings. The export of energy products contributed about 21% towards Australia's total export earnings in 2001–02, up from 18% in 1993–94. Black coal accounts for by far the largest share of the total value of energy exports (52.2%), followed by crude oil (25.2%) and liquid natural gas (10.3%). Uranium contributes only 1.4% of the total value of energy exports. Imports of energy products (mainly crude oil) made up only 7.5% of the total value of imports in 2001–02. It is important to emphasise that although the quantity of energy exports (by energy yield) increased by 65% from 1993–94 to 2001–02, the value of energy exports increased by 126%, a key factor of which is the decline of the Australian dollar relative to the US dollar, decreasing by 28% in value from US$0.73 in 1993–94 to US$0.52 by 2001–02.

Energy use

Total energy consumption in 1998–99 was 4,858 PJ, of which about two-thirds was delivered to end use consumers and one-third lost in conversion, transmission and distribution. Graph 13.11 shows Australian energy consumption over the 25 years 1977–78 to 1998–99. Growth rates in total energy consumption over recent years (after a slowdown in the early 1990s) have been above the long-term average for the 25-year period. Annual fluctuations are, to a significant extent, attributable to changes in Australia's rate of economic growth.

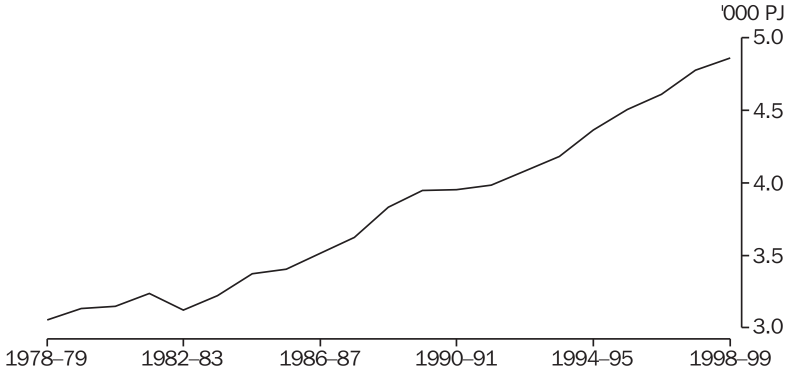
13.10 ENERGY PRODUCTS, Value of exports and imports

	Exports			Imports		
	1993–94	1997–98	2001–02	1993–94	1997–98	2001–02
Fuel	$m	$m	$m	$m	$m	$m
Black coal(a)	7 161	9 531	13 323	—	—	—
Crude oil and ORF(b)	1 424	2 251	6 422	2 803	3 697	7 454
LPG	138	367	720	19	68	117
LNG	1 047	1 599	2 636	—	—	—
Uranium	193	288	361	—	—	—
Automotive gasoline	172	304	405	750	93	450
Diesel fuel(c)	210	270	315	153	149	413
Other refinery products	964	1 079	1 321	392	431	596
Total	**11 309**	**15 689**	**25 503**	**4 117**	**4 437**	**9 030**
Total trade in goods and services	64 548	87 768	121 176	64 470	90 684	119 681

(a) Coking plus steaming. (b) Other refinery feedstock. (c) Includes automotive diesel oil and industrial and marine diesel fuel.

Source: International Merchandise Trade, Australia (5422.0); ABARE, electronic datasets.

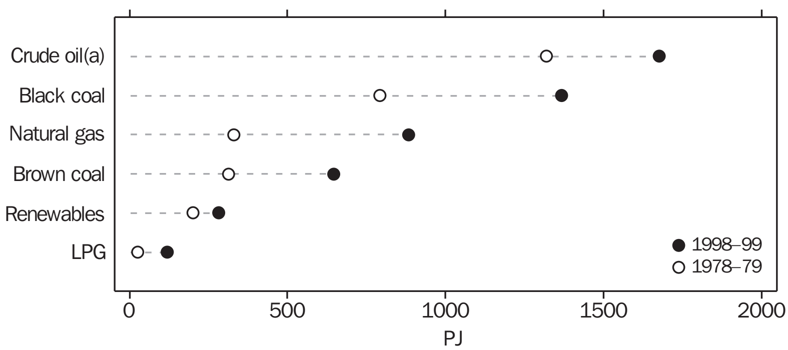
13.11 ENERGY CONSUMPTION



Source: ABARE, electronic datasets.

Natural gas has been the fastest growing primary energy over the 20 years 1978–79 to 1998–99 (graph 13.12). The growth rate for coal (black and brown) has also been above the overall trend, due primarily to the strong growth in electricity generation over the period (graph 13.13). The consumption of crude oil has also grown significantly, reflecting the heavy use of petroleum products in the transport sector. The annual growth in consumption of renewable energy sources has declined over the years (ANZMEC 2001).

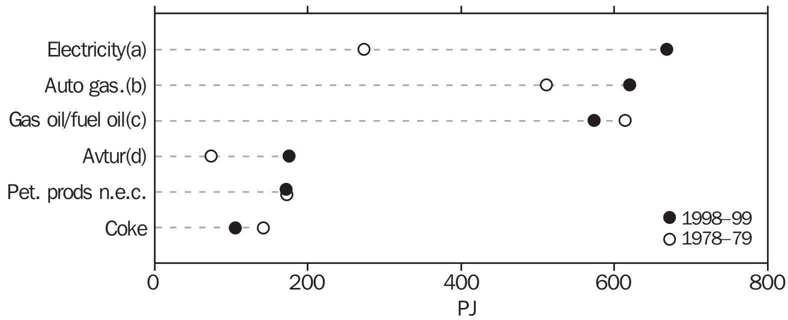
13.12 PRIMARY ENERGY PRODUCTS USED



(a) Refinery feedstock.

Source: ABARE, electronic datasets.

13.13 SECONDARY ENERGY PRODUCTS USED



(a) Excludes hydro-electricity. (b) Automotive gasoline. (c) Includes: heating oil; automotive diesel oil; fuel oil; and industrial diesel fuel. (d) Aviation turbine fuel.

Source: ABARE, electronic datasets.

Direct energy use by sector

In 1998–99, 78% of total energy consumption was accounted for by three major sectors: electricity generation; transport; and manufacturing (table 13.14). Electricity generation is the largest energy consuming sector. The strong growth in energy consumption in that sector is attributed to increased electrification in all end use sectors; rapid growth in a number of industries in which electricity is the prime fuel source, such as the commercial and non-ferrous metal sectors; and technological innovation encouraging the use of new electrical appliances in all sectors (ANZMEC 2001).

The transport sector accounted for 25% of total energy consumption in 1998–99, and is the second largest energy user. Within the transport sector, road transport accounted for about 78% of energy consumed, of which two-thirds is attributed to passenger vehicles and the remainder to light commercial vehicles, trucks, and buses. Air transport grew rapidly in the late 1980s and much of the 1990s, resulting from the rapid growth of tourism and increased use of air travel in response to the improved competitiveness of air fares compared with other transport modes.

Strong growth in the mining sector reflects the rise in energy consumption in oil and gas mining, and in particular the development of a liquid natural gas industry in the late 1980s; the expanding demand for natural gas and for increased production of crude oil, condensate and liquid petroleum gas; and strong energy demand in other mining activities.

13.14 ENERGY CONSUMPTION(a), By sector

	1990–91	1994–95	1998–99	Change since 1990–91
	PJ	PJ	PJ	%
Agriculture	57.7	64.4	70.1	21.5
Mining	164.6	213.1	264.5	60.7
Manufacturing	1 073.9	1 132.4	1 177.0	9.6
Electricity generation	1 065.0	1 162.6	1 398.3	31.3
Construction	37.2	44.3	50.3	35.2
Transport(b)	1 003.0	1 139.3	1 231.2	22.8
Commercial(c)	156.8	179.2	210.5	34.2
Residential(d)	327.8	359.5	386.0	17.8
Other(e)	64.1	70.6	70.3	9.7
Total	**3 949.9**	**4 365.3**	**4 858.3**	**23.0**

(a) Fuels consumed less derived fuels produced. (b) Includes all transport use, including household motor vehicle use. (c) Includes wholesale and retail trade, communications, finance and insurance, property and business services, government administration and defence, education, health and community services, cultural and recreational services, and personal and other services, along with water, sewerage and drainage. (d) Transport use by households is included in transport. (e) Includes lubricants and greases, bitumen and solvents, as well as energy consumption in the gas production and distribution industries.

Source: ABARE, electronic datasets.

The strong growth in the commercial sector is attributed to the relatively fast growth of the sector. The effect on consumption of increased energy efficiency of individual appliances, applications and processes is being offset by the increased use of electrical equipment (ANZMEC 2001).

Australian energy consumption allocated to final use

While the previous section showed the direct use of energy by industries and households, this section looks at the amount of energy used, both directly and indirectly, by the final users of the goods and services. These final users may not necessarily use energy directly, but they are considered to be using energy indirectly through their consumption of products (goods and services) that contain embedded energy (i.e. the energy used in production).

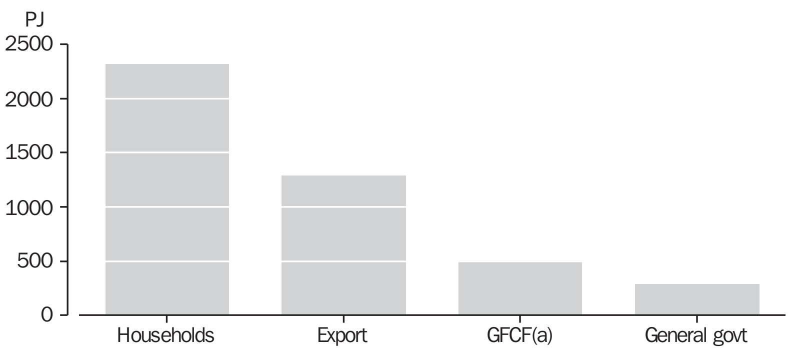
In 1994–95, over half of Australian energy consumption allocated to final use (53%) was by households, either directly or indirectly through the consumption of products (graph 13.15). Goods and services produced for export made up a further 29%; gross capital formation was responsible for 11% (e.g. energy embodied in buildings, road, rail, and pipeline infrastructure); and the remaining 7% was attributed to government final consumption (mainly government administration and the provision of services such as education, health and community services).

Households as direct and indirect consumers of energy

In 1994–95, the use of petroleum products — mainly motor vehicle fuels — was the biggest contributor to household consumption of energy (25% of total household consumption of energy), followed by household electricity use (21%), and various other sources of direct energy consumption by households (11%). Approximately two-thirds of household electricity use is attributed to conversion losses in the production of this electricity (mainly from coal). Indirect consumption of energy through the consumption of (non-energy) goods and services made up about 43% of total household energy use. The largest of these indirect sources was household consumption of wholesale and retail goods and services and of repairs (9%). Main products contributing to final household consumption of energy are shown in graph 13.16.

Relative to its gross domestic product (GDP) Australia has a very high level of motorisation, and a high level of total personal travel. Other than the North Americans, only Italians are more motorised than Australians (OECD/IEA 2001). Per capita road transport use in Australia increased 10% from 1990–91 to 1998–99 (see table 13.20). Table 13.17 shows that the number of persons driving to work or study in Australia increased by 9% between 1996 and 2000. Some 76% of adults aged 18 years and above drove to work or study in 2000.

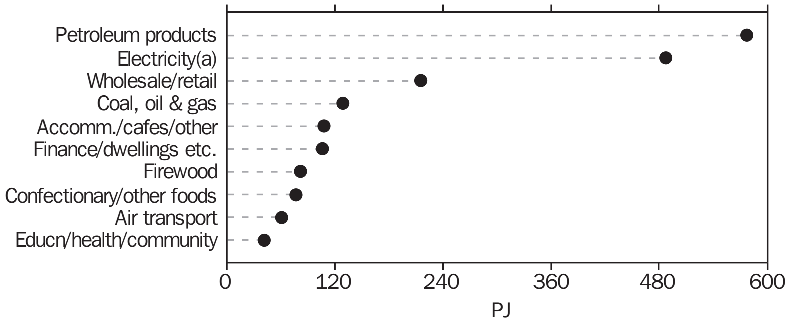
13.15 ENERGY CONSUMPTION, By final use — 1994–95



(a) Gross fixed capital formation.

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

13.16 DIRECT AND INDIRECT HOUSEHOLD CONSUMPTION OF ENERGY, By product type — 1994–95



(a) Includes conversion loss from primary fuel to derived product.

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

13.17 TYPE OF TRANSPORT TAKEN TO WORK/STUDY, Number of persons travelling

	1996	2000	Change
	'000	'000	%
Train	654.5	623.6	–4.7
Bus	545.7	359.7	–34.1
Tram/light rail	(a)	50.1	. .
Ferry/boat	(a)	15.7	. .
Taxi	(a)	9.1	. .
Car/truck/van as driver	5 991.9	6 539.8	9.1
Car/truck/van as passenger	552.8	457.9	–17.2
Motorbike or motor scooter	99.4	66.0	–33.6
Bicycle	215.2	98.4	–54.3
Walk	487.4	378.7	–22.3
Other	153.1	24.2	. .
Total	**8 700.0**	**8 623.1**	**11.7**

(a) Included in Other.

Source: Environmental Issues: People's Views and Practices (4602.0).

Household electricity use was the other major contributor to energy consumption attributed to households. The 1970s and 1980s saw significant increase in the level of indoor comfort and amenities in Australian homes for space comfort, water heating and electric appliances. Natural gas and electricity are the key sources of space heating (table 13.18). In 1999 natural gas was the main heating source for 41% of residences that had space heating (up from 38% in 1994); electricity provided 35% and wood most of the remainder. Over the period, electricity lost share to gas. As comfort standards have increased, whole house heating rather than 'spot' heating increased and pipeline gas became more widely available (OECD/IEA 2001). Electricity is the major source of energy for both water (about 60% in 1999) and cooking (about 59%).

13.18 PRINCIPAL FUEL TYPES USED IN DWELLINGS, Number of dwellings by purpose

	Room heating			Water heating			Cooking(a)
	1994	1999	Change	1994	1999	Change	1999
Fuel type	'000	'000	%	'000	'000	%	'000
Electricity	1 906.4	1 997.3	4.8	3 999.3	4 253.8	6.4	4 181.1
Gas	2 044.3	2 349.6	14.9	2 153.8	2 526.7	17.3	2 887.0
Wood	1 130.4	1 118.3	–1.1	(b)	73.9	. .	51.4
Solar	3.8	*0.8	–78.9	317.1	344.7	8.7	—
Oil	200.0	156.3	–21.9	(b)	2.2	. .	0.9
Coal/coke	(b)	*2.7	. .	(b)	—	. .	—
Other	90.6	44.5	. .	141.9	12.4	. .	14.8
Don't know	(b)	*7.5	. .	(b)	36.9	. .	—
None	1 039.1	1 458.1	40.3	—	—	. .	—
Total	**6 414.5**	**7 135.2**	**11.2**	**6 612.1**	**7 250.6**	**11.2**	**7 135.2**

(a) Not collected in 1994. (b) Included in Other.

Source: Environmental Issues: People's Views and Practices (4602.0).

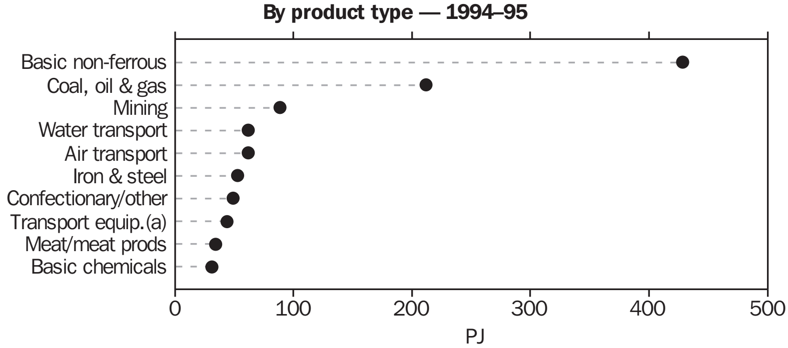
Energy consumed in the production of exports

Of the 29% of total energy consumed in the production of goods and services for export, a third is attributed to basic non-ferrous metals and metal products. Basic non-ferrous metals and products include products from alumina production, aluminium smelting and aluminium product manufacturing. These activities consume large amounts of electricity in their production. Energy consumed in the production of export products in 1994–95 is shown in graph 13.19.

Indicators of energy use in Australia

Between 1990–91 and 1998–99 Australia's total energy consumption increased by 23%. Over the same period, population increased by just under 10%, and GDP by over 34% (in chain volume terms). Aggregate energy intensity (energy consumed per unit of output) of the economy declined by around 9% from 1990–91 to 1998–99. Despite the high growth in electricity generation, total energy consumption grew at a slower rate than GDP, particularly over the more recent years shown (table 13.20).

13.19 ENERGY CONSUMED IN THE PRODUCTION OF EXPORTS, By product type — 1994–95



(a) Includes other machinery.

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

13.20 SELECTED ENERGY INDICATORS

	Energy consumption	Electricity generation	Energy use by road transport	Population	GDP(a)	Per capita energy use	Per capita electricity generation	Energy use/ GDP(a)	Road transport use per capita
	PJ	PJ	PJ	'000	$m	GJ/capita	GJ/capita	GJ/$m	GJ/capita
1990–91	3 949.9	1 065.0	796.6	17 284.0	439 783	228.5	61.6	8 981.5	46.1
1991–92	3 982.7	1 092.9	809.7	17 494.7	441 458	227.7	62.5	9 021.7	46.3
1992–93	4 081.8	1 096.5	829.1	17 667.1	457 735	231.0	62.1	8 917.4	46.9
1993–94	4 181.9	1 109.6	853.5	17 854.7	476 556	234.2	62.1	8 775.3	47.8
1994–95	4 365.3	1 162.6	878.0	18 071.8	498 113	241.6	64.3	8 763.7	48.6
1995–96	4 505.5	1 211.8	904.3	18 310.7	520 669	246.1	66.2	8 653.3	49.4
1996–97	4 611.0	1 244.1	921.3	18 524.2	540 379	248.9	67.2	8 532.9	49.7
1997–98	4 777.6	1 347.3	936.4	18 730.4	565 881	255.1	71.9	8 442.8	50.0
1998–99	4 858.3	1 398.3	960.7	18 937.2	591 546	256.5	73.8	8 212.9	50.7

(a) Chain volume measure. Reference year is 1997–98.

Source: Australian Demographic Statistics (3101.0); Australian System of National Accounts (5204.0); ABARE, electronic datasets.

References

ABS publications

Australian Demographic Statistics (cat. no. 3101.0).

Australian National Accounts: National Balance Sheet (cat. no. 5241.0.40.001).

Australian System of National Accounts (cat. no. 5204.0).

Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (cat. no. 4604.0).

Environmental Issues: People's Views and Practices (cat. no. 4602.0).

International Merchandise Trade, Australia (cat. no. 5422.0).

Other references

ABARE (Australian Bureau of Agricultural and Resource Economics) 2001, *Australian Commodity Statistics 2001*, Canberra.

Electronic datasets

AGSO (Australian Geological Survey Organisation) (now Geoscience Australia):

2000a, *Australia's Identified Mineral Resources 2000*, Canberra.

2000b, *Oil and Gas Resources of Australia 1999*, Canberra.

ANZMEC (Australian and New Zealand Minerals and Energy Council) 2001, *Energy Trends: An Analysis of Energy Supply and Use in the National Energy Market — 2000*.

OECD/IEA (Organisation for Economic Co-operation and Development/International Energy Agency) 2001, *Energy Use in Australia in an International Perspective: Comparison of Trends through the mid 1990s*, Paris.

Other sources

The following organisations also produce energy and greenhouse gas statistics:

Australian Greenhouse Office

Australian Institute of Petroleum

Commonwealth Department of Industry, Tourism and Resources

Electricity Supply Association of Australia

Joint Coal Board

LANDINFO, Sinclair Knight Mertz

The Australia Gas Association

State government departments and instrumentalities are also important sources of energy data, particularly at the regional level. A number of private corporations and other entities operating within the energy field also publish or make available a significant amount of information.

14 Renewable energy in 2003[1]

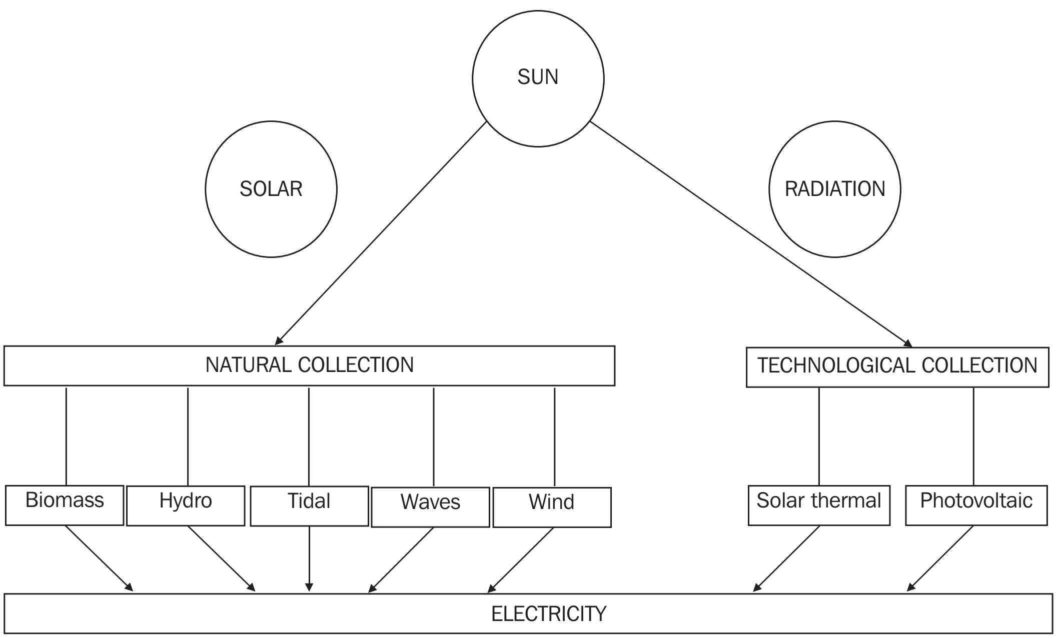
Introduction

Renewable energy is energy derived from a renewable or replenishable resource. Sources include sunlight or solar energy, and others such as wind, wave, tidal, biomass and hydro energy. Diagram 14.1 shows the sun as the origin of these renewable energy resources and their potential to be converted to electricity. Geothermal resources are derived from such a large energy source that the rate of depletion is negligible, and are therefore also regarded as renewable.

Two main reasons for renewable energy's rapid growth are the depletion of fossil and other non-renewable fuels, and concerns about the effects of greenhouse gas emissions. As well as being perpetually available, renewable energy sources are low polluting and produce very little or no net greenhouse gas emissions when operating. In Australia, government, industry and community support are driving renewable energy growth, particularly for electricity generation and transport use.

Although depletion of fossil fuels is far from being an issue for Australia, there are many environmental benefits to be gained from renewable energy development. However, there are potential negative as well as positive environmental impacts, specific to each renewable energy source. Careful planning and use of appropriate existing or new technologies may overcome many of the potential problems and so maximise the potential benefits.

14.1 SOLAR ENERGY CONVERSION PATHS



Source: Bioenergy Australia, 'Conference notes, December 2000'.

1 From *Chapter 15, Energy* in *Year Book Australia 2003.*

Renewable energy's role in sustainable energy development and greenhouse gas emissions reduction

Renewable energy, energy efficiency and use of cleaner fossil fuel technologies are key tools in a strategy for sustainable energy use and greenhouse gas emissions reduction. Energy use in Australia continues to rise due to economic development, an increasing number of energy intensive industries, population growth and rising standards of living that increase demand for energy and for energy intensive products. About 94% of domestic energy use comes from fossil fuels and the rest from renewable energy (ABARE 2001).

The structure of the Australian economy, and its heavy reliance on fossil fuels for its energy, translate to high emissions of carbon dioxide, the main greenhouse gas contributing to global warming. The energy sector accounted for 362.6 million tonnes (Mt) or 79.6% of total net national greenhouse gas emissions in 1999, an increase of 1.0% from 1998 and 21.7% from 1990. This compares with the total net national emissions increase of 17.4% (excluding land clearing) from 1990. Emissions associated with land clearing have decreased significantly since 1990. As a result, once emissions associated with land clearing are included in Australia's national greenhouse gas inventory, the overall growth in emissions since 1990 is expected to be significantly less than 17%. The Kyoto Protocol target for Australia restricts emissions to a maximum of 8% by the budget period 2008–12 (AGO 2001).

Within the energy sector, electricity generation and transport are the biggest energy consumers and contributed 37.5% and 16.1% respectively to total net national greenhouse emissions in 1999. This points to a need to increase renewable energy for electricity generation and transport as an effective means for Australia to constrain the growth in its greenhouse emissions.

The relatively low cost of fossil fuels has been a constraint on investment in renewable energy, and correspondingly there is currently a price premium attached to the use of renewable energy. Table 14.2 shows estimates of unit costs of electricity generation in 1998–99 by fuel type and gives an indication of this price premium (ABARE 2001). However there is mounting support for renewable energy from governments, industries and households.

14.2 UNIT COSTS OF ELECTRICITY GENERATION — 1998–99

Fuel type	Cost of existing power plants $ per '000 kWh	Cost of new power plants $ per '000 kWh
Black and brown coal, natural gas	32.66–36.04	30.11–32.70
Hydro-electricity	43.13	41.76
Wind energy	56.62	50.83
Biomass (including biogas)	108.53–122.88	46.87–60.32

Source: ABARE 2001.

Support for renewable energy

Commonwealth Government

A range of Commonwealth government initiatives and funding of $381m are in place to boost the uptake of renewable energy. These are part of the measures announced in the 1997 *Climate Change Statement* ($60m over five years) and the 1999 *Measures for a Better Environment* ($321m over four years). The majority of the funding was for power generation using renewable energy especially for remote areas, but there were small measures to assist the development of transport fuels from renewable sources. Additionally, in early 2002, the Australian Government announced a $50m bio-fuels initiative to enable renewable fuels such as ethanol to provide 2% of the country's transport fuel.

Among these government initiatives, the most significant market driver is the Mandatory Renewable Energy Target (MRET). The MRET places a legal requirement on electricity wholesalers and large energy users to purchase an additional quantity of electricity generated from renewable sources. In order to improve planning certainty, the requirement is for an additional 9,500 gigawatt hours (GWh) of renewable generation by 2010. The measure is phased in via a number of interim targets over the period 2001–2010, and the final 9,500 GWh target must be maintained between 2011 and 2020 (<http://www.orer.gov.au>). The measure applies nationally. All wholesale electricity buyers and retailers on grids of over 100 megawatt (MW) capacity in all states and territories must contribute to the measure.

In order to discharge their renewable energy liability, liable parties (electricity retailers or large energy users) must surrender an assigned number of Renewable Energy Certificates (RECs) to the Office of the Renewable Energy

Regulator (ORER). The requirement to purchase renewable electricity is determined by the ORER and allocated in proportion to the overall electricity purchases of liable parties.

RECs are generated by the production of renewable energy. Each megawatt hour (MWh) of electricity generated from an eligible renewable energy source creates one REC. The ORER issues the RECs to renewable generators — one REC for each MWh generated. New renewable generators obtain RECs for their entire output, whereas existing generators (mostly large hydro) receive RECs for generation above a base line set on 1997 production. Renewable generators can then sell their RECs to liable parties in order to discharge this liability. The purchasers' liability under the MRET for any year is met when they surrender the required number of certificates to the regulator.

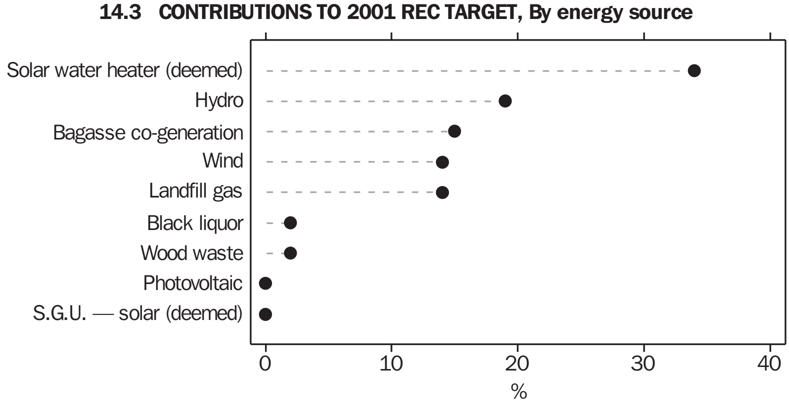
There is no option available to 'sign up', as the target is mandatory and a legal obligation on the part of liable parties is legislated. A penalty of $40/MWh is payable for each REC not purchased, effectively setting a price cap on compliance and capping the cost of the subsidy to electricity consumers.

RECs are traded on the Green Electricity market developed by the Australian electricity industry. Over 600,000 RECs were created in 2001, providing more than enough certificates to cover MRET's first year target of 300,000 RECs and a head start for 2002's larger target of 1.1 million RECs. Contributions to the 2001 target of 300,000 RECs from different renewable sources are shown in graph 14.3. This shows that wind and landfill gas, which were previously used in negligible amounts, could experience strong growth under the MRET scheme.

State, territory and local governments

Through participation in Commonwealth government programs and their own initiatives, state, territory and local governments are actively promoting renewable energy and assisting industries in the commercialisation and use of sustainable energy technologies. For example, New South Wales imposes mandatory reduction targets on its privatised electricity industry through the *Electricity Supply Act 1995* (NSW), and in mid 2002 the Victorian Government announced the Victorian Greenhouse Strategy, promising 59 actions to combat greenhouse gas emissions. Many initiatives involve providing information, guidelines and other practical help. As an example, the development of wind energy in New South Wales is aided by a Wind Monitoring Network set up by the New South Wales Sustainable Energy Development Authority (SEDA). This network incorporates twenty-five 40-metre monitoring towers across the state. A New South Wales wind atlas of the state's wind resource, based on data from these towers and other sources, is also available to the public.

14.3 CONTRIBUTIONS TO 2001 REC TARGET, By energy source



Source: OECD/IEA 2002.

Industry and R&D

The Renewable Energy Industry Action Agenda, launched in June 2000, was established by the Department of Industry, Tourism and Resources to build a partnership between industry and government to fast-track the growth of the industry. It aims to achieve annual sales of $4b of renewable energy technologies by 2010 (DISR 2000). Industry has identified many action points including the need to deliver products and services that provide cost effective and reliable 'energy solutions' to customers. A technology roadmap for the renewable energy industry has been developed to encourage greater collaboration between industry and the research community. Standards, training and accreditation initiatives are being developed to support improvement to product and service quality and reliability. There is general recognition that renewable energy has enormous growth potential and that export opportunities are the key to achieving economies of scale, which are important in lowering the cost of renewable energy.

Households

Households can directly contribute to the increased use of renewable energy for electricity generation through the Green Power program administered by SEDA. This is a national accreditation program that sets stringent environmental and reporting standards for renewable energy products offered by electricity suppliers across Australia. More than 55,000 households (and about 2,500 businesses or local councils) are customers of Green Power. By asking energy suppliers to provide them with electricity generated from renewable sources, these customers voluntarily pay a higher price for their electricity to support the use of renewable energy. An average home that has subscribed to 100% Green Power (including off-peak) is estimated to save eight tonnes of carbon dioxide annually, equivalent to taking just over two cars off the road. SEDA's National Green Power Audit showed that the total green energy sales increased by 50% from the previous year to reach 455 GWh in 2000–01. Over the four-year life of the Green Power program, demand for genuine renewable energy has increased tenfold from 40 GWh in 1997.

Renewable energy growth

The growing support for sustainable energy, including renewables, has yielded measurable results. Electricity generation increased by 4% from 1997–98 to 1998–99 while electricity emissions increased by 1.9%, an indication that a greater proportion of lower emission fuels, or cleaner fuel technologies, were used during 1998–99 to produce electricity. By contrast, in the previous year electricity generation increased by 6% and emissions increased by more than 10%.

In 1999, Australian Bureau of Agricultural and Resources Economics estimated that the 6% of total primary energy that came from renewable energy was largely from biomass in the form of bagasse (39%) which was used to generate electricity and steam, wood (39%) which was used primarily for home heating, hydro-electricity (21%) and solar (1%). Renewable energy contributed 11% to electricity generation, most of which was generated from large-scale hydro-electric schemes (ABARE 1999).

Environmental considerations in developing renewable energy

Australia is well endowed with renewable energy and is an international leader in a number of technologies, such as R&D for photovoltaic modules and fuel cells, solar thermal and remote area power systems. Momentum for renewable energy development in Australia is gaining rapidly due to the urgent need to stabilise greenhouse gas emissions. Large potential economic and social benefits are also expected to flow from renewable energy development. Among the economic benefits, particularly to rural and remote areas, are: cost-effective clean energy; renewable energy industry and market creation; R&D development; and export potential. Renewable energy facilities can be built near customers to reduce energy losses in electricity transmission, a particular advantage in transmission lines feeding rural areas. Availability of low-cost, clean and reliable energy, improved land, air and water quality, and job creation have positive impacts on people's health and wellbeing.

There are other environmental effects, negative as well as positive, specific to each type of renewable energy resource/technology. They include effects on air, water and soil quality; impact on biodiversity, flora and fauna; and noise and visual impact. Careful assessment of these impacts and the adoption of environmentally sound technologies and practices are an essential part of planning for renewable energy projects and their implementation. The remainder of this chapter discusses these environmental effects as they relate to different renewable energy resources, and presents case studies.

Hydropower

Hydropower is produced by the movement of freshwater from rivers and lakes. The most common form of hydropower plant uses a dam on a river to store water in a reservoir. Enormous quantities of water are involved and a large hydro-electric power system requires a very large dam, or a series of dams. In Australia hydropower is currently the largest source of renewable energy for electricity generation (over 8% of total supply) and is expected to retain this position, although its share is projected to drop to about 6% by 2019–2020 (ABARE 2001). Most of this hydropower is from the two largest plants, the Snowy Mountains scheme and the Tasmanian Hydro-Electric installation.

Although it is a renewable energy source, hydropower does carry a greenhouse gas penalty due to the production of methane, which arises from the rotting of underwater vegetation. The extent to which methane is produced in a hydro-electric dam depends on a variety of factors, including the original vegetation on the dam site, water temperature, and the area of the dam. Shallow warm tropical dams are more likely to be major emitters of methane than deep cold dams located in temperate regions. Recent studies from the Australian Coal Association Research Program on power generation in Brazil led the Commonwealth Scientific and Industrial Research Organisation to assign a greenhouse gas production value of 0.19 tonnes of carbon dioxide equivalent (CO_2-e) to each MWh of hydro-produced electricity. This is about one-third of the value assigned for electricity produced using natural gas and one-fifth the amount allocated to power stations burning black coal.

Fish injury and mortality from passage through turbines and detrimental effects on the quality of downstream water (hydro can cause low dissolved oxygen levels in the water which is harmful to riparian habitats) are also potential negative environmental effects of hydropower. Mitigating techniques are available, for example, upstream fish passage can be aided using fish ladders or elevators, and maintaining minimum flows of water downstream helps the survival of riparian habitats. An important determinant of environmental impacts is the size of hydropower plants, which ranges from micro to large.

Large-scale hydro is associated with significant negative environmental impacts, including detrimental effects on river flows and water supplies. The flooding of large areas of land often leads to the displacement of local residents and negative impacts on local fauna and flora. The 500 MW Tully Millstream project was shelved due to the potential inundation of a World Heritage rainforest.

Smaller hydro systems do not experience these problems, or experience them to a much lesser extent. In particular, micro hydro systems (less than 100 kilowatts (kW)) are preferable from an environmental point of view. Seasonal river flow patterns downstream are not affected and there is no flooding of valleys upstream. These systems operate by diverting part of the river flow through a penstock (or pipe) and a turbine, which drives a generator to produce electricity. The water then flows back into the river. Micro hydro systems are mostly ‘run of the river’ systems which allow the river flow to continue. They provide an attractive alternative or supplement to diesel systems in rural and remote areas.

Case studies

Mini hydro case study (*Australian Energy News*, December 2000)

The construction of a very cost effective mini hydro generator on the 11,000 megalitre Toonumbar Dam near Lismore in the north of New South Wales resulted from a 1998 study commissioned by SEDA which identified the potential to develop or upgrade hydro-electric plants on 32 dams in New South Wales. Toonumbar is an irrigation dam, and the generator runs only when water is released or when the dam is overflowing. It has a capacity to produce 400 MWh of hydro-electricity a year. The proximity to regional and rural electricity loads is a great advantage and transmission losses are minimised when power does not need to be transported over long distances.

Small hydro case study (*EcoGeneration Magazine*, December 2000/January 2001)

The hydro is constructed on an existing dam, the Pindari Dam near Ashford, Inverell in northern New South Wales. The dam is primarily used for irrigation purposes and has a storage capacity of 312,000 megalitres. The irrigation releases provide the means of generating electricity. The project is a small hydro (defined as having a size of 1 MW to 10 MW) construction with two horizontal Francis turbines rated at

2.8 MW each. The plant's long-term average energy output is estimated at about 16,300 MWh per annum, enough to supply approximately 4,000 households. The power is exported to the national grid via an 8 km 66 kilovolt transmission line. The project is expected to save 14,600 tonnes of CO_2-e per year during its 80-year lifetime.

Biomass

Biomass is derived from plant and animal material, and can be used in a variety of ways to supply energy (heat, electricity, liquid and gas fuels, charcoal) and various chemicals and other products. Sources of biomass fall into five main groups: wood and forest; agricultural residues; energy crops and short rotation forests; municipal and industrial wastes; and peat. A considerable biomass resource exists in Australia including woody weeds, field crop residues, bagasse from large sugar mills, cotton and rice residues, residues from large forest and plantation operations (eucalypts and radiata pine), waste from sawmills and the pulp and paper industry, and landfill gas.

The potential of biomass to supply energy and reduce greenhouse gas emissions is large. On a world scale the International Energy Agency estimates that biomass energy sources have the potential to meet 40% of all present energy consumption. It has been estimated that, if biomass was to contribute 1,000 MW of Australia's electricity generating capacity, net carbon dioxide emissions would fall by about 7.4 Mt a year.

There are many environmental benefits as well as negative impacts from the use of biomass. Relative to other renewable energy sources, the much wider range of environmental effects associated with biomass reflects the large variety of biomass sources, conversion processes and products.

Additional environmental benefits offered by biomass are many, the major one being in solving waste disposal problems. By far the greatest source of feedstocks for biomass-to-energy schemes is by-products of existing agricultural, industrial and urban processes. Recycling, combined with advanced waste-to-energy combustion or gasification, reduces the need for landfill disposal. A follow-on benefit can be reduced problems with waste leaching into groundwater. Decaying of waste in landfills produces methane, the emission of which has higher global warming potential than carbon dioxide. It has been estimated that one tonne of methane from ruminant enteric fermentation has 21 times the global warming potential of one tonne of carbon dioxide over a 100-year period. Similarly, nitrous oxide released from animal wastes is 310 times as potent as carbon dioxide.

Processing of biomass can lead to improvement to the local environment (odour control, air and water quality). Treating waste in an anaerobic digester, rather than allowing it to decay naturally, improves local air quality. The biogas piped off is a valuable energy source, and the waste is substantially sterilised. Digestion of animal manure kills pathogens; the residue can then be spread safely as an agricultural fertiliser. Sewerage effluent treatment prior to discharge to waterways or oceans improves water quality. Unlike coal and oil, biomass contains no sulphur, or negligible quantities; sulphur is the main cause of acid rain.

Biomass can play a significant role in land care. Trees planted for energy can assist with the reduction of soil salinity and acidity, and the mitigation of soil erosion, the use of wastewater, the sequestration of atmospheric carbon and enhanced biodiversity. The ash left after combustion of most biomass contains negligible amounts of toxic metals, and so can be used as a soil conditioner.

Biofuels can be used for transport fuels. Other renewable energy sources could potentially be used to produce hydrogen or electricity for use in motor vehicles, although these applications are far from being economic or available for general use yet.

On the other hand, there are many more issues to be considered in the assessment of biomass projects than those for other sources of renewable energy. This is in part due to the variety of biomass material available as well as issues associated with its use. If biomass resources are to be maintained on a sustainable basis, it will be important to ensure that the rate of harvesting of these resources does not exceed the rate at which they are grown. It will also be necessary to ensure that the use of biomass resources does not adversely impact on biodiversity.

Sawdust and wood waste make sawmills a very attractive site for biomass-to-energy investment. Not only are large sites producing thousands of tonnes of material a year that would otherwise produce methane and carbon dioxide as it decomposed or burned, but the sawmills are also substantial users of electricity and in some cases process heat as well. These conditions make biomass-to-energy investments at large sawmills a likely part of any energy sector response to greenhouse gas reduction.

However, using waste for energy purposes could reduce the desirable incentives to minimise and recycle waste materials, if it is cheaper to burn it. Stack emissions from municipal solid waste-to-energy plants, and also possibly from wood-fired biomass plants, could contain toxic substances such as dioxins which would need to be controlled.

Other issues centre around the life cycle costs and benefits of the energy material: how was it produced and manufactured — what is the ecological footprint of the demand created by the bio-energy companies? Does the material have a higher beneficial use than simply a one-off energy exercise? Could it be better used to replace other virgin materials? Also, transport of large quantities of biomass to the power plants would result in increased traffic congestion, noise, dust, road damage and fuel use.

Other concerns surround the growing of 'energy crops'. Planting large areas with fast growing trees could reduce both water run-off and percolation into the groundwater, impacting on downstream users. Biodiversity could be further threatened and agri-chemical use could be increased. Soil nutrient levels could be depleted by continually removing large quantities of biomass material such as crop residues from the land. There is concern among some sections of the community that genetically engineered trees and crops could be developed specifically for use for bio-energy supplies. The use of land for energy cropping could reduce the area of land otherwise available for food and fibre production, resulting in land scarcity.

Case studies

Cronulla Sewerage Treatment Biogas Project (*EcoGeneration Magazine*, June/July 2001)

This Sydney water cogeneration project forms part of an upgrade of the Cronulla Sewerage Treatment Plant. Sewerage wastewater, when treated anaerobically (oxygen excluded), produces methane that in this project is collected and used to generate renewable power. Otherwise the methane would either be flared or vented to the atmosphere with adverse environmental impacts. Methane has 21 times the greenhouse gas impact of carbon dioxide.

The power produced by the biogas generation project displaces purchases of high value electricity from the grid. The unit produces about 2,470 MWh of power per year — approximately 10% of the power requirements of the Cronulla Treatment Plant. The heat produced by the engine exhaust and jacket is recovered and used to heat the sewerage sludge in the anaerobic digestion process, which assists the processing of the sludge and the production of the methane for the generation unit. The biogas cogeneration plant is designed to use 100% of the gas produced by the digesters and can be operated 24 hours a day, 7 days a week.

Producing power 'on site' increases the reliability of supply to the plant. The plant reduces greenhouse gas emissions arising from the processing of Cronulla's sewerage by 17,000 tonnes of carbon dioxide each year.

Construction of Anaerobic Digester at Camellia, New South Wales (*Bioenergy Australia Newsletter*, April 2002)

EarthPower Technologies Sydney, in association with Babcock and Brown and contractor McConnell Dowell Constructors (Aust) Pty Ltd, is constructing a state-of-the-art anaerobic digester at Camellia in Sydney's western suburbs.

The $30m facility will process food wastes and food processing wastes to produce 7 MW equivalent of methane gas and high nutrient organic fertilisers. It will have the capacity to process 82,000 tonnes per year of delivered waste (about 20,000 dry tonnes of digestible solids), representing about 10% of available organic waste in Sydney. Preliminary design work is also being carried out to include a 3.2 MW cogeneration unit, which will satisfy the requirements of the plant and export excess electricity into the grid.

The patented German BTA pre-treatment process already used in Europe and North America has been combined innovatively with Australian technology. The plant is scheduled for completion in October 2002 and should be in operation by the end of the year.

Wind energy

Wind energy is the fastest developing renewable energy source in Australia. This trend follows the growth in wind farms in other parts of the world. Europe is the leader in wind energy — since 1993 the market for wind turbines has grown by more than 40% per year. A wind turbine was first used to generate electricity in Denmark in 1891, while

Australia's first commercial wind farm, at Ten Mile Lagoon near Esperance in Western Australia, has been operating for only about 20 years. Until recently, the share of wind energy in Australia's total energy consumption was very small, with just 72 MW installed by the end of 2001. The Australian Wind Energy Association (AusWEA) expects installed wind generation capacity to triple by 2002, with 500 MW of wind projects currently at various stages of planning and development. There is keen interest in developing wind farms in most states, and wind energy's share in electricity generation is set to increase markedly, with annual growth estimated to be about 25% from 1998–99 to 2019–20. This compares to a 2.3% annual growth rate for total energy consumption (ABARE 2001).

There are abundant wind energy resources worldwide, estimated to be about 53,000 terrawatt hours (TWh) or more than four times the world's entire electricity consumption of 14,396 TWh in 1998 (world electricity production is predicted to be 27,325 TWh by 2020). This was reported in *Wind Force 10*, a plan prepared by an international alliance to achieve 10% of the world's electricity from wind power by 2020. Greenpeace and AusWEA are members of this alliance, and have launched an initiative to build an Australian wind-power manufacturing industry and install 5,000 MW of wind energy capacity in Australia by 2010 — a 50-fold increase in capacity in 10 years. This target is equivalent to approximately 15,000 GWh of electricity each year, meeting the needs of 2.5 million average Australian homes (Blue Wind Energy 2002).

Why is there such impetus to grow wind energy capacity? Australia has among the best wind resources in the world and wind energy has become the cheapest renewable energy technology. Its current cost is only two to three cents more per kilowatt hour (kWh) than the national electricity market pool prices, and this premium is reducing. Wind energy integrates well into the electricity grid, it is a proven technology and involves a short construction period. High quality modern wind generators are reliable, having an availability factor of 98%, and run during most hours of the year. This availability factor is beyond that of other electricity generating technologies.

Proponents of wind energy claim that it has many environmental advantages over other renewable sources. It is estimated by AusWEA that achieving the 5,000 MW target would cut Australia's total greenhouse gas emissions by more than 15 Mt or 3.3% of the nation's total 1999 emissions. Wind energy is an advancing technology and yields the most power per installed MW of capacity. It uses land resources sparingly, with generators and access roads occupying less than 1% of the area in a typical wind farm. In this respect a wind generator, using 36 square metres or 0.0036 hectares to produce 1.2 and 1.8 megakilowatt hours per year, compares favourably with solar cells requiring almost 400 times the area to produce the same amount of electricity. However, the relative land requirements of wind farms and solar installations depend on site-specific factors. While wind farms can be integrated with some land uses (e.g. grazing) as part of a multiple land use approach, they are not compatible with other land use options (e.g. farm forestry). Conversely, in some situations solar cells can be installed on buildings with no net requirement for land.

As well as producing zero pollutants (no waste products), wind energy generators have among the lowest energy 'payback periods'. The energy produced by a wind generator throughout its 25-year lifetime (in an average location) is 80 times larger than the amount of energy used to operate, dismantle and recycle it. In other words, on average, it takes only two to three months for a wind generator to recover all the energy required to build and dispose of it.

Other potential benefits of wind energy include enhancement of a clean and green image of the region and the potential for enrichment of habitat and re-establishment of indigenous vegetation. A better understanding of agriculturally impoverished flora and fauna species can be acquired through the process of assessing environmental impacts of wind farm proposals.

As with other energy sources, there are some adverse environmental impacts associated with the use of wind energy. While it is technically possible to have wind turbines on every hill, it would not be socially acceptable. Wind generators obviously have to be highly visible since they must be located in windy, open terrain to be effective. The loss of visual amenity is a critical issue in community acceptance of the high growth plans being proposed by wind energy developers, particularly in areas of great natural beauty such as those in coastal Victoria. Other issues are the impact on rare and endangered species such as the migratory orange-bellied parrots that are protected by Federal legislation, neighbours affected by noise and change in land values, radiation and interference with TV reception. One of the most critical issues is the lack of a coordinated approach on where future wind farms are going to be located.

Objections to some of these impacts are easier to overcome than others. Modern design and materials have greatly reduced the noise created by the turning blades, so that there is now less noise than the disturbance created by vehicle traffic along a highway. While older turbines with metal blades caused television interference in areas near the turbines, such interference from modern turbines is unlikely because many components formerly made of metal are now made from composites.

The impact on populations of birds and bats has been alleviated to a certain extent by developments in the turbines themselves — the bigger the turbine the better from the point of view of both birds and bats. Modern turbines are large, generally ranging from 660 kW to 1.5 MW, and turn quite slowly, making them far more visible and easy to avoid. The evolution of towers from a steel grid construction to a smooth steel tower has eliminated nesting opportunities for birds directly beneath the rotors, further reducing incidents of bird-strike. However it has been acknowledged that there has been a general lack of information on the migratory habits of Australian bird populations, and more work in this area is needed for the development of wind projects.

It is more difficult to overcome objections concerning land use and visual impact because most of these are subjective. Helping people understand the overall environmental good of wind generated electricity could counteract these concerns; so could a perception that better design, careful choice of turbines, and careful visualisation studies before siting could improve the visual impact of wind farms. There is now substantial experience in minimising the ecological impact of construction work in areas such as coastlines and mountains, or in offshore locations. Furthermore, it is possible to restore the surrounding landscape to its original state after construction, and to reuse, or completely remove, the foundations of wind generators at the end of their useful life.

Case studies

Codrington wind farm, Victoria

(*EcoGeneration Magazine*, August/September 2001)

Codrington is the first fully private investment (project cost was $30m) in a wind farm in Australia. It was Australia's second largest wind farm at the end of 2001 with a combined capacity of 18.2 MW from 14 turbines. The turbines are mounted on tubular towers 50 metres high. Power is produced at a wind speed of between 10.8 and 90 kilometres per hour, and is generated at 690 volts and stepped up to 66,000 volts with a transformer for connection to the electricity grid. The turbines are connected through underground cables before being connected to the local grid. Power generated will be purchased by the electricity retailer Origin Energy for use in its Ecosaver Green Power Product, with any surplus going towards meeting Origin Energy's liability under the MRET.

The site, located on the coast near Port Fairy in south-west Victoria, is owned by two farmers who lease access to Pacific Hydro. The turbines take up less than 1% of the area of the farm, which continues to be used for sheep and cattle grazing, and farm activities are unaffected.

Prior to construction, the project went through a comprehensive consultation process which examined local environmental impacts including birds, flora and fauna, Aboriginal cultural issues and local visual and noise studies, as well as its socioeconomic impacts.

The Codrington wind farm produces enough energy to supply more than 14,000 homes, and it is deemed to have the potential to abate the equivalent of up to 88,000 tonnes of carbon dioxide per year.

Windy Hill wind farm, Ravenshoe, on the Atherton Tableland in Far North Queensland

(<http://www.stanwell.com/wind/windfarms/WindyHill>, last viewed on 21 May 2002)

As a wind farm, Windy Hill is ideally located, with good exposure to prevailing winds and close vicinity to electricity transmission and major load centres. It consists of 20 turbines with a combined capacity of 12 MW, enough to power 3,500 homes. Each turbine is placed on a tubular tower which stands about 46 metres tall. The turbine blades are each 22 metres long and rotate at about 30 revolutions per minute.

The wind farm is built on privately owned farmland used predominantly for dairy and beef farming. Operating the wind farm has minimal impact on the farming activity.

An educational centre, the Power by Nature Centre, to provide detailed information on wind farms and other renewable energy technologies, has been opened at Windy Hill. There are displays incorporating state of the art technology to allow visitors to see and interpret wind farm generation and activity as it happens.

The developer Stanwell Corporation Limited began investigating the site through a wind monitoring program in December 1998, and undertook additional studies and consultation on issues such as aesthetics, compatibility with telecommunication systems, noise and impact on wildlife.

Local firms and expertise have been used where possible during the construction and approximately 15% of the total cost of around $20m were spent on local fabrication and construction. Of the 17 contracting firms, 9 were based in Cairns or the Atherton Tablelands area. Long-term employment was made possible because local people will maintain the turbines.

By replacing non-renewable energy sources such as coal, Windy Hill prevents at least 25,000 tonnes greenhouse gas emissions per year.

Solar thermal and photovoltaic

Solar energy is Australia's largest energy source: the average amount of solar energy that falls on Australia is about 15,000 times the nation's energy use. In all parts of Australia, except southern Victoria and Tasmania, solar resources are good to very good. Sunlight can be used to generate electricity, to provide hot water, and to heat, cool and light buildings.

The much higher cost of solar power installation relative to energy output, compared to other renewable as well as non-renewable energy sources, has been a major limiting factor in its uptake in Australia. A 1.5 kW solar power system has an area of about 11 square metres and generates around 1,800 kWh of electricity. Such a system typically costs around $20,000. Technological breakthroughs are, however, helping to bring this price down.

By its nature, solar energy is an intermittent and diffuse source. It is not available on cloudy days or at night, and it is not concentrated. Sunlight therefore has to be collected and/or converted for use. A range of commercially proven solar energy technologies is available:

- Solar power systems convert sunlight into electricity, either directly via the photovoltaic effect, or indirectly by first converting the solar energy to heat or chemical energy. The simplest photovoltaic cells power watches and calculators and the like, while more complex systems can light houses and provide power to the electricity grid.
- Concentrating solar power technologies use reflective materials such as mirrors to concentrate the sun's energy. This concentrated energy is then converted into electricity.
- Solar hot water heaters use the sun to heat either water or a heat-transfer fluid in collectors. A typical system will reduce the need for conventional water heating by about two-thirds. High-temperature solar water heaters can provide energy-efficient hot water for large commercial and industrial facilities.

In Australia, solar power has traditionally been used in remote areas where electricity grid is not available. Such systems store electricity in batteries for use when the sun is not shining and are called stand-alone power systems. Telecommunication, for example, railway signalling systems, is a major market. Other industrial markets are also important, including navigational aids, cathodic protection, water pumping, street lighting, and remote refuelling (aviation) installations. Industry accounts for well over half the market. However solar power is now appearing more in urban areas, especially where government rebate (Australian Greenhouse Office's Photovoltaics Rebate Program launched in January 2000) and other assistance help to reduce the cost of installing solar energy systems to consumers.

Solar power systems give off no noise or pollution, making them ideal renewable energy suppliers. Their disadvantages, other than the high cost relative to energy output, lie in their relatively large structures and the reflective materials used by some technologies. These have implications for land use, aesthetics, and visual and other disturbance to the local community and to animals. Because of the advanced technologies and the materials involved, solar systems have relatively high payback period, in terms of the energy they produce and the energy required to produce and to operate them. It would seem that technological development would be the most important determinant in solar energy's uptake and in reducing its negative impacts.

Solar water heaters in Australia

In 1999, about 5% of Australian households used solar water heaters, with the majority of these systems (92%) using an electric booster. The highest proportion of hot water systems using solar energy occurred in the Northern Territory (44%) and Western Australia (20%) (ABS 1999). The average amount of hot water that can be gained from solar heating for home use ranges from 50% in southern states to more than 90% in northern Australia. However, energy (and money) saved by a properly sized system is roughly the same across Australia. The initial temperature of the water to be heated is lower in southern states, making energy supplied from the sun more 'valuable' in the heating process.

There are substantial environmental benefits with solar hot water systems. By replacing fossil fuel energy from burning coal or gas with solar energy, solar hot water systems can reduce the amount of greenhouse gas generated. As an example, if one were to replace an electric hot water system with a gas-boosted solar unit, one could reduce the amount of greenhouse gases produced by water heating by over 75%. The annual saving in greenhouse gas emissions would be around two tonnes, which is equivalent to driving a small car from Sydney to Perth and back again. Solar hot water systems may not always be the most environmentally friendly option for heating water, depending on the location and boosting method used. An electric-boosted solar water heater can produce more greenhouse gas emissions than a high-efficiency gas-only water heater in cooler climates where a solar system is more reliant on boosting. This means that replacing a gas water heater with an electric boosted solar water heater may create a detrimental effect on the environment (AGO 2002).

Case study

Solar power system on Lord Howe Island and Singleton solar farm (SEDA through the Australian Institute of Energy web site <http://www.aie.it>)

The SEDA owns a solar power system on Lord Howe Island. This 8 kW system is mounted on the airport roof and provides residents of this World Heritage-listed island with clean electricity. The islanders therefore avoid the high cost of generating electricity from diesel, as well as associated air and noise pollution. The Lord Howe Island solar power system is attractive and without adverse environmental impacts, and contributes significantly to the Island's power supplies.

The Singleton solar farm was commissioned in 1998 with the support of a grant from SEDA. Each year the 400 kW capacity farm produces 550,000 kWh of electricity used to supply public demand for Green Power. The clean solar power produced by the farm will eliminate the need to produce 550 tonnes of carbon dioxide each year from the traditional means of electricity production. The Singleton solar farm has been warmly welcomed by the community, as much for the interest it creates as for the environmental benefits it will bring for many years to come.

Wave power, tidal energy and geothermal energy

Wave power is sourced from winds blowing on oceans, tidal energy by the gravitational pull of the moon on the ocean, and geothermal energy is heat from the earth. These renewable energy resources are clean and sustainable, and all are abundant in Australia. However they are at early stages of research and development, and it may be many years before they become commercially viable.

Case study

Wave power system on the breakwater at Port Kembla
(<http://www.energetech.com.au>)

Australian wave power developer Energetech's wave power system is powered by an oscillating water column driving air back and forth through a turbine mounted on a shoreline structure such as breakwaters. The first 300 kW Energetech system is under construction on the breakwater at Port Kembla. Wave power has enormous potential, with studies suggesting that many billions of dollars could be invested in this form of electricity generation over the next two decades. Energetech's shore-mounted system driving the novel Denniss Turbine is well regarded by international observers as having the best potential for economic wave energy development (*Australian Energy News*, March 2002).

The future of renewable energy

Australian governments are strongly supporting the surge in renewable energy development. While renewable energy's share of total energy consumption will remain small relative to non-renewable sources for a long time to come, its capacity is expanding enormously from a small base.

Continuing government funding and support in providing information and practical assistance will facilitate the renewable energy growth. The recent release of the Wind Energy Handbook and guidelines for preparation of an environment impact statement for wind farms are signs of increasing inter-governmental support, beginning at the planning phase for these projects. Businesses are increasingly aware of the economic potentials of renewable energies and are actively building industry capacities and exploring export opportunities. Households are contributing by indicating their preference for 'green electricity' through participating in the Green Power program and installing solar power in their dwellings.

Each renewable energy source has unique characteristics, making them suited to a wide range of purposes, sites and situations. In general they are all better for the environment than non-renewable energy sources, and technological advances will continue to assist in reducing the negative impacts.

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15 Energy and the environment[1]

Greenhouse gas emissions

As mentioned in *Chapter 16, Greenhouse gas emissions*, fossil fuel combustion is the major contributor to Australia's greenhouse gas emissions. Table 15.1 shows that the electricity supply industry accounts for nearly half of total energy-related emissions, and that emissions in this industry grew by 25% between 1992–93 and 1997–98. Direct emissions by households contributed around 13% in 1997–98, with most of these emissions due to motor vehicle use. Other significant direct emitters of greenhouse gases included manufacturing of iron and steel; mining; manufacturing of basic non-ferrous metals and products; air and space transport; and road transport (excluding household motor vehicle use). Combined emissions from this group of industries accounted for nearly 20% of energy-related emissions in 1997–98.

While table 15.1 presents the direct generation of greenhouse gases by the energy-using industry group or sector, graph 15.2 shows that, in 1996–97, the bulk of Australia's energy-related greenhouse gases were emitted in the production and consumption of goods and services for the purpose of household final consumption (about 56%). A further 25% of energy-related emissions were generated in the production of goods and services for export. Other final use categories (general government final consumption, and gross fixed capital formation) were responsible for the remaining emissions.

15.1 PRODUCTION OF ENERGY-RELATED GREENHOUSE GASES(a), By industry

	1992–93	1993–94	1994–95	1995–96	1996–97	1997–98	Change 1992–93 to 1997–98
	Gg CO_2-e(b)	Gg CO_2-e(b)	Gg CO_2-e(b)	Gg CO_2-e(b)	Gg CO_2-e(b)	Gg CO_2-e(b)	%
Agriculture; hunting and trapping; forestry and fishing	6 053	6 252	6 518	6 737	6 988	7 188	18.8
Mining	10 986	11 237	12 295	13 271	14 596	15 136	37.8
Manufacturing	52 431	52 934	55 665	56 603	55 437	57 166	9.0
Electricity and gas	135 987	137 164	142 412	148 256	153 611	169 562	24.7
Construction	4 293	4 419	4 582	4 809	4 819	4 958	15.5
Transport	25 443	26 332	29 111	30 708	31 415	30 939	21.6
Services	7 781	7 997	8 325	8 610	8 823	9 063	16.5
Household production	42 194	42 990	44 051	44 361	45 286	45 587	8.0
Total	**285 168**	**289 325**	**302 959**	**313 355**	**320 975**	**339 597**	**19.1**

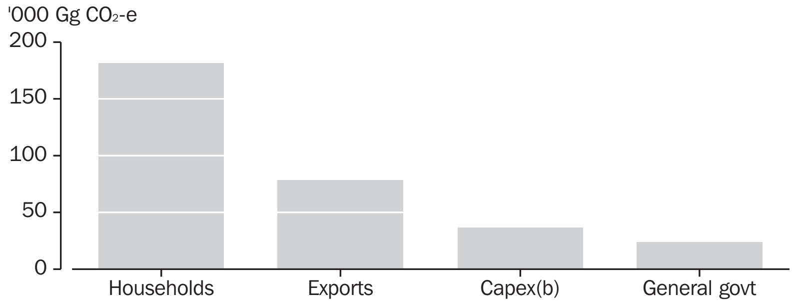
(a) Excludes fugitive emissions. (b) Gigagrams of carbon dioxide equivalents (CO_2-e).

Note: Due to varying classification systems, definitional differences, and various states of revision of data sources, figures will not necessarily reconcile with other data sources. Statistics of greenhouse gas emissions are also available for 1999 from AGO 2001.

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

1 From *Chapter 15, Energy* in *Year Book Australia 2003.*

15.2 GREENHOUSE GAS EMISSIONS(a), By final use — 1996–97

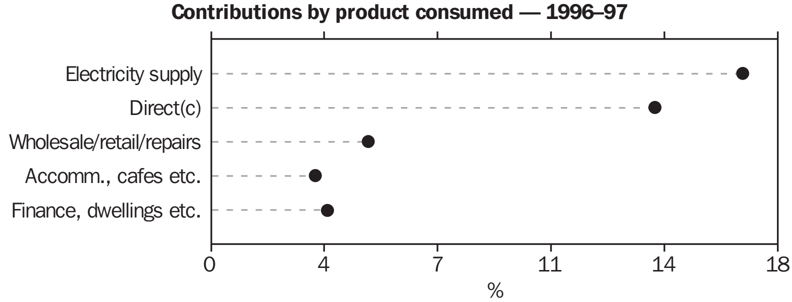


(a) Energy-related emissions produced either directly or indirectly, by category of final use.
(b) Gross fixed capital formation.

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

Graphs 15.3–15.5 show the contributions that the production or consumption of various goods and services make towards Australia's greenhouse gas emissions. The consumption of electricity by households indirectly produced the greatest amount of energy-related greenhouse gas emissions (17%). This was followed by direct emissions by households (14%), most of which is due to the consumption of motor vehicle fuels (graph 15.3). The most significant contributor to energy-related greenhouse gas emissions resulting from production of goods and services for export is basic non-ferrous metals and products (6% of total energy-related greenhouse gases) (graph 15.4). A significant proportion of emissions is also attributed to buildings and other construction, such as roads, irrigation systems, oil refineries, and water and gas supply systems, that contain high levels of embodied energy (about 7% of total greenhouse gas emissions) (graph 15.5).

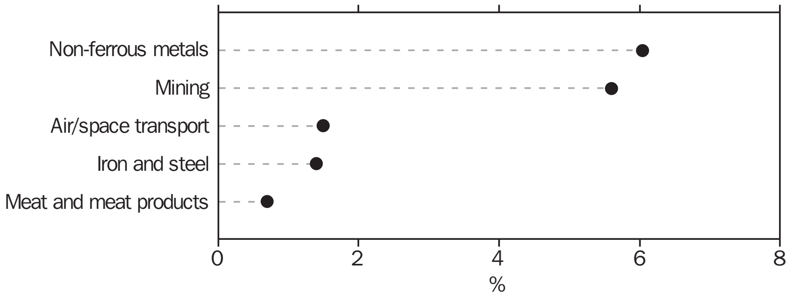
15.3 GREENHOUSE GASES(a) INDUCED(b) BY HOUSEHOLDS, Contributions by product consumed — 1996–97



(a) Energy-related greenhouse gases only. (b) Produced either directly or indirectly through the consumption of products. (c) Direct production by households, mainly through motor vehicle use.

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

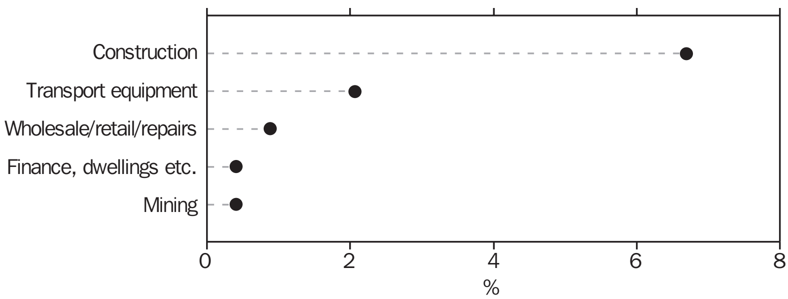
15.4 GREENHOUSE GASES(a) INDUCED(b) BY EXPORTS, Contributions by producing industry — 1996–97



(a) Energy-related greenhouse gases only. (b) Produced indirectly through the production of goods and services for export.

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

15.5 EMISSIONS(a) INDUCED BY OTHER FINAL USES(b), Contributions by final use — 1996–97



(a) Energy-related greenhouse gases only. (b) Produced indirectly by government final consumption of products or gross capital formation.

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

References

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16 Greenhouse gas emissions[1]

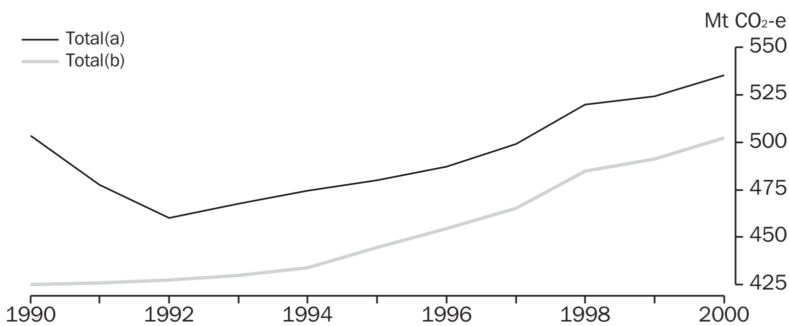
There is widespread national and international concern that it is human activities which have contributed to changes in atmospheric activity (Watson 1999). Carbon dioxide (CO_2) and other greenhouse gases are released into the atmosphere from the use of fossil fuels, and stored carbon has also been released through the clearing of vegetation. It is thought that increasing the concentration of greenhouse gases increases the atmosphere's ability to absorb heat energy (UNEP & UNFCCC 1999). This has been termed the 'greenhouse effect' or 'enhanced greenhouse effect'. Some projections indicate that annual average temperatures in Australia could be 0.4–2.0 degrees higher by 2030 and 1.0–6.0 degrees higher by 2070 (CSIRO 2002a). These estimates are based on world emissions scenarios produced by the Intergovernmental Panel on Climate Change (IPCC).

However, these scenarios have recently been challenged by Ian Castles, a former Australian Statistician. As reported in *The Australian* (20 August 2002), Castles wrote to the IPCC chairman that 'the economic projections used in the IPCC's emissions scenarios are technically unsound'. Castles found what he considered to be significant errors in the IPCC's Special Report on Emissions Scenarios, and he believes the IPCC's projections of emissions and therefore of temperatures are based on unrealistic assumptions and as a result have overestimated the level and impact of future economic activity.

According to the National Greenhouse Gas Inventory, Australia's total net emissions of greenhouse gases increased by 32 megatonnes (Mt) of carbon dioxide equivalent (CO_2-e) (6.3%) between 1990 and 2000. The decline of emissions during the early 1990s is due to land use changes (graph 16.1) (AGO 2002).

As amounts of greenhouse gas emissions continue to increase, they are being reflected in the findings from atmospheric measuring stations. In the past 25 years, a steady increase in the level of CO_2 has been recorded at the Cape Grim Baseline Air Pollution Station in Tasmania (graph 16.2).

16.1 GREENHOUSE GAS EMISSIONS

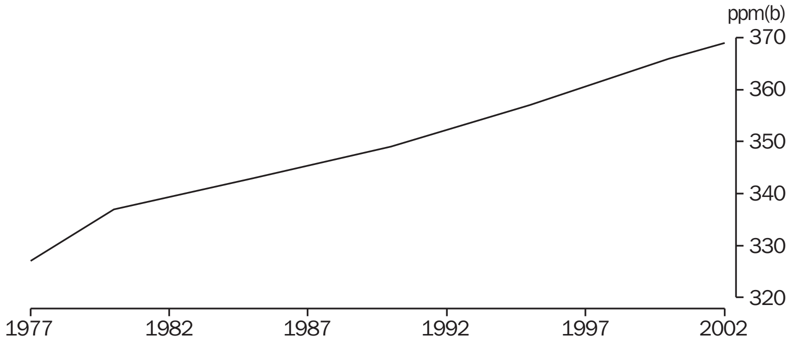


(a) Total (with net CO_2-e emissions/removals). (b) Total (without CO_2-e from land use and forestry change).

Source: AGO 2002.

1 From *Chapter 14, Environment* in *Year Book Australia, 200.3*.

16.2 CARBON DIOXIDE MEASUREMENTS(a)



(a) Recorded at Cape Grim Baseline Air Pollution Station, Tasmania. (b) Parts per million.

Source: CSIRO 2002b.

While total CO_2-e emissions increased by 6.3% between 1990 and 2000, the emissions of individual greenhouse gases that make up this total varied significantly. Emissions of CO_2 increased by 25.5%, methane emissions by 1.0% and those of nitrous oxide by 30.8% (table 16.3). Perfluorocarbons (PFC) and sulphur hexafluoride were the only greenhouse gases to record a decrease in emissions over the period (76.2% lower in 2000 than in 1990). As a result of these changes, CO_2 increased its share of total emissions from about 64% to 68%.

The United Nations Framework Convention on Climate Change (UNFCCC) established the first international treaty dealing with climate change and laid the basis for global action to 'protect the climate system for present and future generations' (UNEP & UNFCCC 1999).

Governments recognised the need for legally binding commitments to greenhouse gas emission limitations and reductions, which were subsequently reflected in policy terms in the Kyoto Protocol. Developed countries are committed to reducing their greenhouse gas emissions by at least 5% from 1990 levels by 2008 to 2012. In recognition of the fact that all developed countries have different economic circumstances and differing capacities to make emissions reductions, each developed country has a specific, differentiated target (AGO 2002). Australia negotiated to restrict its emissions increases to 8% above 1990 levels by this time. Australia's 8% target includes a one-off benefit of land clearing, where reduced emissions compensate for large increases in transport and power generation.

16.3 GREENHOUSE GAS EMISSIONS, By gas (UNFCCC accounting)

Greenhouse gases	1990 Mt CO_2-e	2000 Mt CO_2-e	Change Mt	Change in emissions %
Carbon dioxide	356.0	379.9	23.9	6.7
Methane	118.9	121.1	2.2	1.8
Nitrous oxide	23.3	31.9	8.7	37.6
Perfluorocarbons and sulphur hexaflouride	4.1	1.0	–3.1	–75.6
Carbon dioxide equivalent(a)	1.2	1.5	0.3	25.2
Total	**503.3**	**535.3**	**32.0**	**(b)6.3**

(a) Includes confidential carbon dioxide and nitrous oxide data from ammonia production and nitric acid. (b) According to the 108% Kyoto target accounting provisions, the change in emissions between 1990 and 2000 is 5%.

Source: AGO 2002.

The Kyoto Protocol is an international treaty under which developed countries (those listed in Annex B of the Protocol) have agreed to limit net greenhouse gas emissions. Many countries, including Australia, have signed (but not ratified) the Protocol. Other countries that have not ratified include New Zealand, and the United States of America (UNFCCC 2002). To enter into force the Protocol must be ratified by at least 55 countries that account for at least 55% of the total CO_2 emissions of developed countries in 1990. All European Union member states have either ratified, accepted or assented to the Protocol. Japan has accepted and most Pacific island states have ratified the Protocol. In September 2002, Canada, Mexico, Russia, India and China used the Earth Summit in Johannesburg to support or indicate their intention to ratify the Protocol. By August 2002, 21 of the 37 Annex I countries had ratified, accepted or assented to the Protocol. Annex I countries (including Australia, New Zealand, Japan, United States of America and the European Union) must report greenhouse gas emissions more often and in more detail.

Sources that need to be counted in the 1990 baseline are all emissions from energy, industrial processes, solvent and other product use, and changes in agriculture, waste and for some countries, including Australia, land use changes (emissions from land clearing) are also included. Approximately one-third of Australia's greenhouse gas emissions arise from the land-based sectors. The Protocol allows countries with a net source of emissions from land use change and forestry in 1990, such as Australia, to include emissions from land use change in the baseline used for calculating their assigned amounts. This mechanism was included in the Kyoto Protocol in recognition that land clearing contributes a substantial proportion of Australia's total emissions. The trigger mechanism will allow Australia to obtain credit for efforts made to reduce emissions from land clearing.

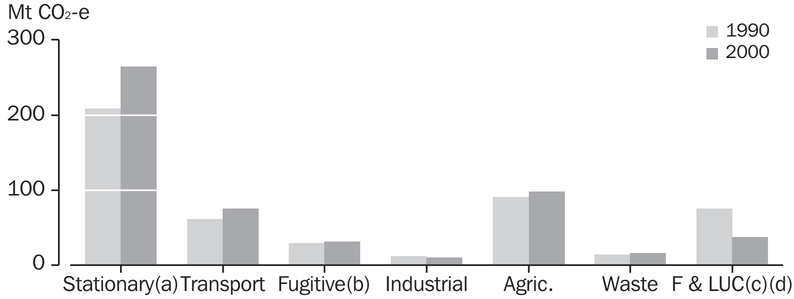
In February 2002, the Minister for the Environment and Heritage, Dr David Kemp, announced the establishment of the Australian/US Climate Action Partnership. The Partnership would focus on such issues as emissions measurement and accounting, climate change science, stationary energy technology, engagement with business to create economically efficient climate change solutions, agriculture and land management, and collaboration with developing countries to build capacity to deal with climate change (Kemp 2002).

Greenhouse gas emissions and the Australian economy

The Australian economy is highly dependent on energy consumption. The combustion of fossil fuels is the major contributor to Australia's greenhouse gas emissions (around 64% of net emissions from stationary and transport energy combustion in 2000) (AGO 2002). Fossil fuels provide around 90% of Australia's energy needs, a higher proportion than for most other countries or regions. The stationary energy sector (emissions from fuel combustion in energy industries such as the electricity industry) is the biggest contributor of greenhouse gases (graph 16.4), accounting for 49.3% of net emissions in 2000, with electricity generation accounting for the majority of this sector's contributions (264 Mt of CO_2 equivalents). Energy use and resulting greenhouse gas emissions from the stationary energy and transport sectors are described in further detail in *Chapter 15, Energy and the environment*.

The industrial processes sector (emissions resulting from production processes) recorded a decrease in emissions in this period, from 12 Mt of CO_2-e in 1990 to 10.3 Mt in 2000 (almost entirely a result of reduction in PFC emissions from aluminium production).

16.4 GREENHOUSE GAS EMISSIONS (CO_2-e), By sector



(a) Stationary energy. (b) Fugitive emissions from the production and distribution of coal and gas. (c) Estimated emissions from land clearing. These assessments should be treated as indicative only due to high uncertainties in emissions estimates. (d) Forestry and land use change.

Source: AGO 2002b.

Vegetation plays an important role in reducing the level of greenhouse gases in the atmosphere, as trees and other plants absorb CO_2 from the air and store it as carbon. Under ideal conditions, one million hectares of new forest could absorb about 25 Mt of CO_2 a year, which would lower Australia's present CO_2 production by about 9% (CSIRO 2001). The forestry sector (including commercial forestry) is an emitter (source) and an absorber (sink) for CO_2. Emissions from the forestry sector are affected by both timber harvest and forest regrowth rates. In 2000, carbon removals through the growth of forests were 23.7 Mt with forest and grassland conversion causing 64.7 Mt of emissions. Land use change and forestry provided a total of 7.1% of total net national emissions (AGO 2002).

Current best estimates of land clearing model the emissions from burning cleared vegetation, decay of slash and below ground decay of roots, and loss of soil carbon. These estimates are highly uncertain and likely to change in the future (see the section *Extent and clearing of native vegetation* in *Chapter 12, Australia's biodiversity*).

National Pollutant Inventory (NPI)

For about a decade, the Australian public has been more concerned about air pollution than about any other environmental problem. Poor air quality may lead to a number of negative impacts: it can cause health problems, damage infrastructure, reduce crop yields and harm flora and fauna. Overall, air quality in Australia is relatively good and has generally improved during the 1990s (ABS 2002).

The NPI is an Internet database designed to provide the community, industry and government with information on the types and amounts of certain substances being emitted to the environment. The NPI is not exhaustive in its reporting of emissions, in that only emissions over a threshold from certain industries are counted. However, it does provide some quantitative measure of the amount of substances entering the environment. For example, 690 Mt of carbon monoxide, 690 Mt of nitrous oxides and 1.3 gigatonnes of sulphur dioxide were reported as released into the atmosphere for 2000–01 (table 16.5). The database also provides information about the substances listed on the NPI. It explains what the substances are derived from, what they are used for, and the risks to human health and the environment associated with them. As reporting procedures improve, this will provide for more comprehensive coverage of pollutants, allowing industry, the community and local governments to meet the interests and needs of Australians.

16.5 SELECTED POLLUTANTS REPORTED ON THE NPI(a) — 2000–01

Pollutant	Mt
Carbon monoxide	690
Arsenic and compounds	0.17
Benzene	1.7
Cyanide (inorganic) compounds	4.2
Hydrogen sulfide	0.057
Lead and compounds	0.5
Oxides of nitrogen	690
Sulphur dioxide	1 300

(a) Not all industries report to the NPI.

Source: NPI 2002.

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17 Climate change[1]

This chapter was contributed by Professor John W Zillman AO. Professor Zillman has been Director of Meteorology since July 1978. He has served as Principal Delegate of Australia to the Intergovernmental Panel on Climate Change since 1994 and has been President of the World Meteorological Organization since 1995.

There is a lot of confusion in the world about climate change. The first purpose of this chapter is to explain what is meant by 'climate' and 'climate change' in order to understand why so much of the discourse on the subject seems like the dialogue of the deaf — why the proponents of alternative perspectives still appear to be talking past each other on even very basic issues of climate science and policy; and why it has proved so difficult to achieve consensus on practical strategy for reducing whatever adverse long-term impacts humans may be having on climate and helping the world to prepare for whatever future the global climate system delivers over the coming decades and coming centuries.

The second purpose is to look back over the 20th century and show how Australian climate has changed in the past; and then to summarise what can, at present, be said, and what can not be said, about how it might change over the century ahead.

The meaning of climate change

We all have an intuitive sense of what we mean by climate. It is both our synthesis of the weather we have experienced in the past and our expectation of what it will be like in the future, at a particular place and time of year. Our recollections of the past are not so much of the monthly or yearly averages of temperature, humidity, cloud, wind and rainfall, but of the impacts on significant occasions in our lives of their hour-to-hour, day-to-day and week-to-week variability; and especially of the extreme events — the severe storms, the gales, the heatwaves and the droughts and floods — from which these long-term averages derive. We remember that we have had both hot and cold summers in the past and we sense that we must expect them again in the future. Those with long memories recall the years of widespread drought in the 1960s just as they do the floods of the 1970s and 1990s. And there are few Australians over fifty who have not asserted that 'the weather these days isn't like it was when I was young'.

The statistics of Australia's meteorological records tend to bear out these subjective impressions and, in a very real sense, the climate has always been changing — from year-to-year, decade-to-decade, and century-to-century. We also know from proxy — mainly geological — evidence that it has been changing also on much longer timescales, from thousands to millions of years, as the Earth moved into and out of the great ice ages of the past before returning to the more benign climates of the present ten-thousand-year-long Holocene 'interglacial'.

Contemporary Earth system science can explain most of the features of present-day climate and how it has changed over time: why the tropics are warm and the polar regions cold; how the 'greenhouse effect' of water vapour, carbon dioxide and other trace gases in the atmosphere keeps the Earth's surface some 70°C warmer than it is 10 kilometres above, where jet aircraft fly, and some 33°C warmer than it would be, on average, if there were no radiatively active gases in the atmosphere; how the large-scale distribution of the continents modifies the north-south overturning of the atmosphere and oceans that is driven by the solar heating of the equatorial belt; and, perhaps most significantly of all, how the instabilities in the jet streams generated by the north-south overturning provide the energy source for most of the day-to-day weather phenomena that make up our climate. Because of the differing natural timescales of the atmosphere and ocean and the strength of the coupling between them, the explanation of the mechanisms of climate

1 From *Chapter 1, Geography and climate* in *Year Book Australia 2003.*

involves an integrated scientific understanding of the entire Earth system, consisting of the atmosphere, the oceans, and the land surface and inland waters and of all the physical, chemical and biological processes that take place within them.

If this is the nature and origin of climate, what then do we mean by 'climate change'? Until a few decades ago, the term 'climate change' was mostly taken to mean the major astronomically-induced shifts from ice-age to interglacial on timescales of tens to hundreds of thousands of years or, less usually, systematic change of the long-term (by international convention, 30 years) statistics of the climate elements (temperature, pressure, wind, rain, etc.) sustained for several decades or longer.

The situation became greatly confused in the early 1990s as a result of the emerging concern that, in addition to the natural variability of climate on all timescales, the build-up of greenhouse gases in the atmosphere from the burning of fossil fuel and other human activities may be leading to systematic long-term increase of globally-averaged surface temperature (via an enhanced greenhouse effect) and other irreversible changes in climate. With its focus on human interference with the working of the climate system, the United Nations Framework Convention on Climate Change, signed by more than 150 countries at the 1992 Rio Earth Summit, defined climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

Thenceforth, to those who speak and listen in the language of the Convention, any statement that climate change is occurring has meant that it is attributable to human activity. The scientific community, however, has taken a different approach. The Intergovernmental Panel on Climate Change (IPCC), the assessment body set up in 1988 by the World Meteorological Organization and the United Nations Environment Programme to provide objective, expert assessment of the state of understanding of the science, impacts and response strategy for climate change, has defined climate change as 'any change in climate over time whether due to natural variability or as a result of human activity'. It is this (IPCC) usage which is adopted here with the purpose of summarising what can be said about past and future climate change in Australia as a result of both natural variability and human interference with the global climate system.

The controls on Australian climate

The broad-scale controls on Australian climate are shown schematically in figure 17.1. The two major influences are:

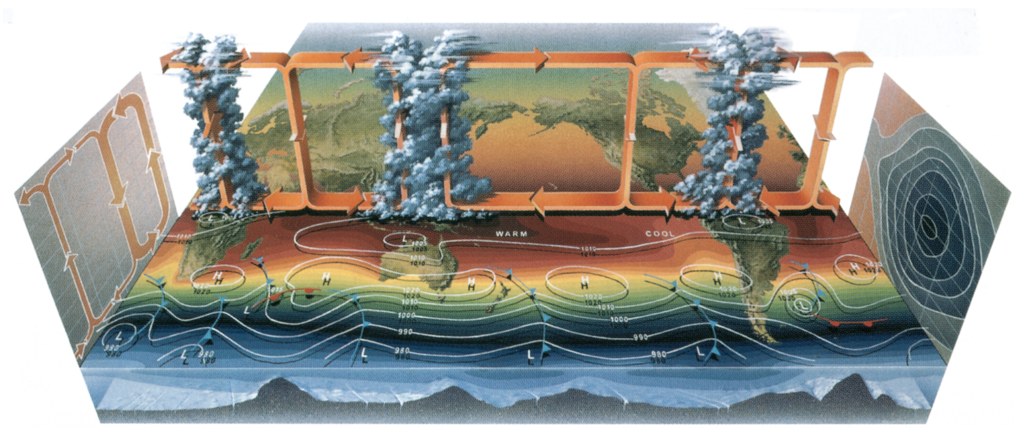
- the north-south overturning of the atmosphere that generates the mid-latitude jet stream and the succession of 'highs' and 'lows' that move across southern Australia from west to east, bringing the never-ending succession of fronts, troughs, warm northerlies, cold southerlies, rain and fine weather
- the slow east-west overturning of the atmosphere across the tropical Pacific that is driven by the ocean temperature differences between the warm western Pacific and cool eastern Pacific Ocean, and which fluctuates on an approximately two to seven-year timescale as the central and eastern Pacific warms and cools with the irregular cycle of El Niño and La Niña events.

In El Niño years, when the central and eastern Pacific are warm, the ascent and cloudiness over the western Pacific are suppressed and there is a lower probability of rain-bearing systems affecting northern and eastern Australia. La Niña events, on the other hand (which are characterised by an unusually cold eastern Pacific and a warm western Pacific), usually mean a higher probability of rain-bearing systems and flooding over northern and eastern Australia.

Climate change over the past century

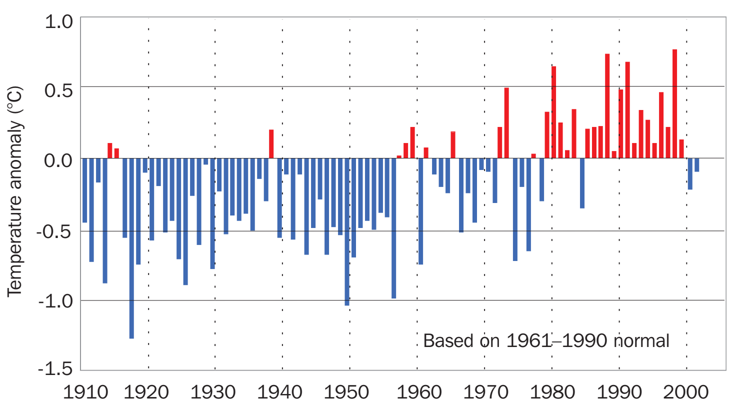
The 20th century witnessed some major fluctuations and trends in Australian temperature and rainfall as well as in a host of other characteristics of Australian climate. Graph 17.2 shows the annual mean temperature averaged across Australia on the basis of a network of high-quality observing stations and presented in terms of anomalies (departures) from the 1961–90 'normal'. It is evident that, with the notable exception of 2000 and 2001, most years of the past two decades have been above the 1961–90 normal and approximately half a degree warmer than the average for the first half of the century. The general warming trend over the 20th century is evident in both summer and winter temperatures as well as in daily maxima and minima, with night-time minimum temperatures generally rising faster than daytime maxima. The distinct warming trend of the past half-century, evident in graph 17.2, which is of the same general magnitude as the observed globally-averaged warming described in the recent Third Assessment Report of the IPCC (IPCC 2001a) is not, however, uniform across Australia as can be seen in map 17.3. Whereas parts of Queensland have warmed by more than one degree over the past 50 years (with the greatest warming evident in the night time minima), parts of New South Wales and Victoria and large areas of north-west Australia have experienced only minimal warming, or have actually cooled, over the period.

17.1 LARGE-SCALE CONTROLS ON AUSTRALIAN CLIMATE



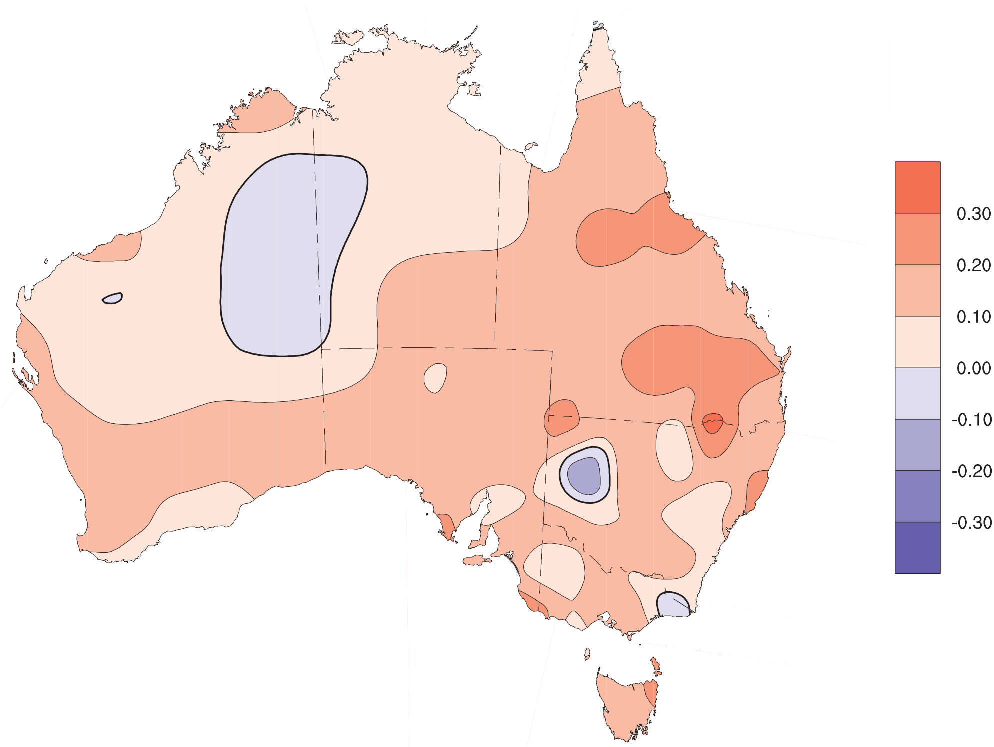
Note: The solar heating of the tropics drives the north-south (Hadley) overturning of the atmosphere (shown schematically on the left), which generates the meandering westerly jet stream (wind speed cross section shown on the right with wind speeds of a few hundred km per hour in the jet core) and the migratory weather-producing lows and highs of the middle latitudes. The east-west (Walker) circulation of the tropics is driven primarily by the temperature differences between the warm western and cool eastern Pacific Ocean. Its season-to-season and year-to-year fluctuations (and occasional reversal) exert a major influence on the occurrence of cloud and rain producing systems in Australian longitudes.

17.2 CHANGES OF ANNUAL MEAN TEMPERATURE



Note: The changes of annual mean temperature (°C) averaged over Australia since 1910. Temperatures are shown as departures from the 1961–90 'normal'.

17.3 AVERAGE TREND IN ANNUAL MEAN TEMPERATURE (°C/10 yrs) — 1950–2001



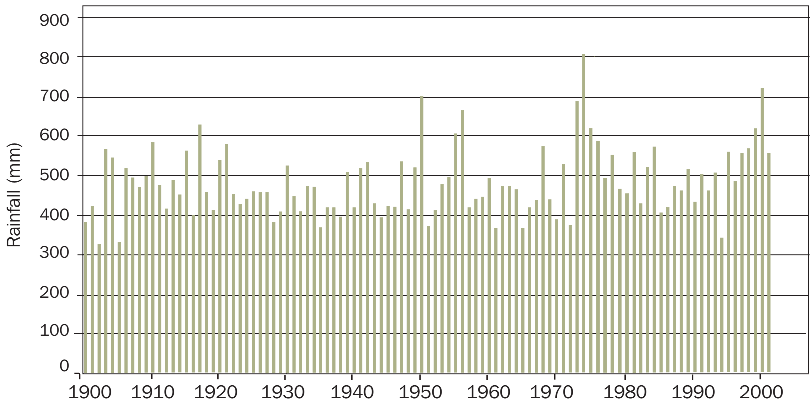
Note: Pink and red areas have experienced average warming over the period while blue areas have experienced a cooling trend.

The long-term record of area-average rainfall over Australia is shown in graph 17.4, which highlights the large year-to-year and decade-to-decade variability of rainfall with long, dry periods following Federation and again in the 1920s, 1930s, 1940s and 1960s, and above-average rain in the mid 1950s and 1970s and for most of the past decade. While there is a very slight long-term trend towards increased rainfall for Australia as a whole, the pattern is highly variable from region to region and, over the past 50 years, most of central and north-west Australia has got wetter, while south-west Western Australia, Victoria and much of New South Wales and Queensland have got drier (map 17.5).

The cause of the observed change

Much of the Australian and international climate research effort over recent decades has been aimed at developing sufficiently reliable models of the global climate system to enable scientists to find out how much of the observed change over the past century is the result of various forms of natural variability and how much can be attributed confidently to the influence of human activities; and then to use those models to provide an indication as to how climate might evolve over the next century, both as a result of natural processes and in response to human influences through greenhouse gas emissions or in other ways.

17.4 MEAN ANNUAL RAINFALL



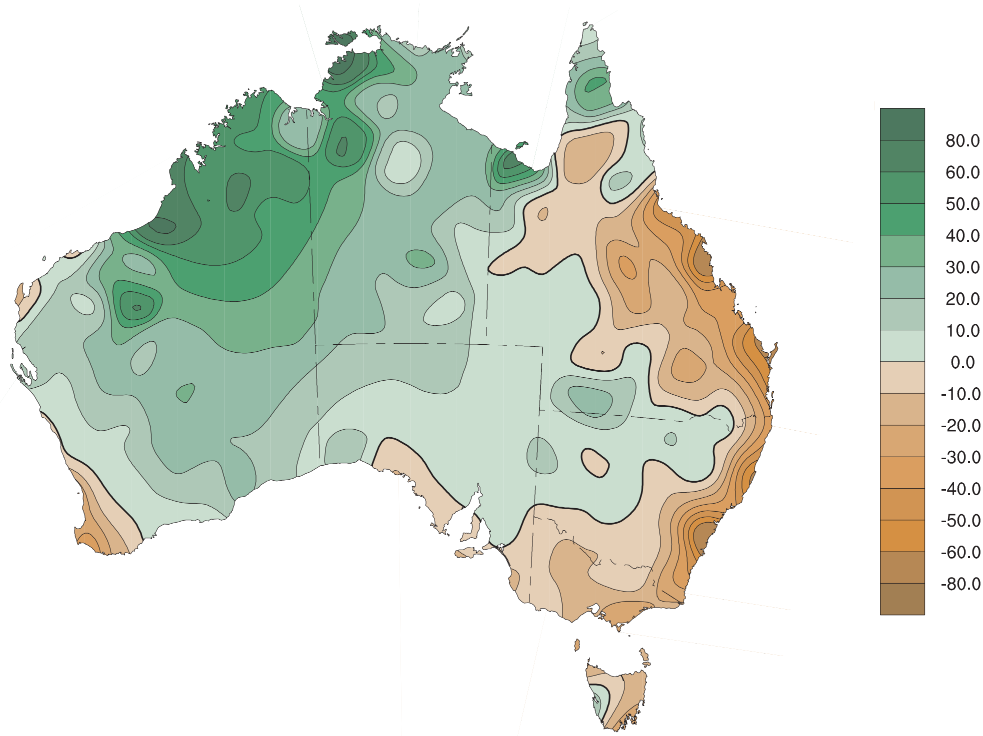
Note: It is evident that, for the country as a whole, the rainfall has changed markedly from year-to-year and decade-to-decade, with the very wet years of the 1970s and over the period 1997–2001 suggesting a slight long-term trend towards a wetter Australia.

At the global level, the IPCC, in its Third Assessment Report, has concluded, on the basis of the longer and more closely scrutinised temperature record and new model estimates of both natural variability and climate system response to forcing by natural processes (e.g. volcanoes and changes in solar output) and human influences (especially emission of greenhouse gases and aerosols), that 'there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities' (IPCC 2001a).

Although it is more difficult to demonstrate on a sound scientific basis and there may still be extraneous influences (e.g. from the so-called 'urban heat island' effect) in even the high quality data sets on which graph 17.2 is based, there appears to be good reason to believe that the overall warming trend over Australia over the past half century is also largely a result of enhanced greenhouse warming. It is almost impossible, however, to separate out the effect of human influence from natural factors on smaller space and time scales in, say, explaining why Queensland has warmed more than parts of New South Wales (map 17.3). In the absence of any convincing basis for attribution of the geographic pattern of warming to human influence (albeit some plausible physical hypotheses have been advanced), the presumption must be in favour of natural processes as the primary explanation of the spatial variability of the observed rate of warming over Australia.

It is impossible to determine, with any confidence, at this stage whether the spatial pattern of trend in rainfall (map 17.5) is the product of processes associated with natural large-scale and long-term fluctuations in the oceanic and atmospheric circulation of the Southern Hemisphere (the so-called Antarctic circumpolar wave, natural long-term variability of the El Niño–Southern Oscillation mechanisms or the like) or whether the circulation changes causing these patterns of rainfall trend (and at least part of the associated pattern of temperature trends) are an early manifestation of the systematic shifts in climate patterns that some global climate models suggest should be expected from the build-up of atmospheric greenhouse gas concentrations over the past century. Some features of the pattern (drying in south-west Western Australia and Victoria) are, however, broadly consistent with the majority of presently available model projections under an enhanced greenhouse warming scenario.

17.5 AVERAGE TREND IN TOTAL RAINFALL (mm/10 yrs) — 1950–2001



Note: The average trend (mm/decade) in annual total rainfall over Australia over the past half century, showing the strong trend towards wetter conditions over north-west Australia and a drying trend over much of eastern Australia and the southwest corner.

Impacts of climate change

Considerable research has been carried out over the past century on the impacts of climate change on the Australian environment, economy and way of life (Gibbs 1978; Pittock et al. 1978; Maunder 1989); and in particular on Australian water resources and agriculture. One of the most important components has been the work on assessment of the probability and return periods of extreme rainfall events of various magnitude for design of dams and other long-term water resource-related infrastructure.

The Australasian chapter of the IPCC Special Report on Regional Impacts of Climate Change (IPCC 1998) and the corresponding section of the Third Assessment Report on Impacts, Adaptation and Vulnerability (IPCC 2001b) provide an overview of present knowledge of both past and prospective impacts of climate change in such sectors as water supply, ecosystems and conservation, food and fibre, settlements and industry, and human health.

It is clear from the experience of the past century that the challenge of living with climate change in Australia has not so much been that of adapting to long-term trends resulting from human activity, but rather that of planning and managing for the large natural year-to-year and decade-to-decade variability of rainfall and other characteristics of Australian climate. The lessons learned from this experience will be critical to the 21st century challenge of living with whatever human-induced long-term change is superimposed on the continuing natural variability.

Modelling anthropogenic climate change

The major challenge faced by climate scientists, called on to advise policymakers on how increasing anthropogenic emissions of carbon dioxide and other greenhouse gases will affect future global and regional climate, focuses on the construction of sufficiently soundly-based and demonstrably reliable global climate models to simulate how the real atmosphere and ocean would respond to a range of possible future emissions of greenhouse gases and aerosols through the 21st century. The IPCC's Third Assessment Report (IPCC 2001a, b) has indicated that some 20 to 30 models around the world have reached a sufficient level of sophistication and reliability to justify confidence in their assessment of the sensitivity of the large scale features of global climate (global mean temperature, rainfall etc.) to increasing greenhouse gas emissions, but that it is still not possible to attach much confidence to the models' projections of the anthropogenic component of climate change at the regional level.

The use of these climate models to explore possible future anthropogenic climate change is based on the rigorous, but widely misunderstood, methodology of feeding a range of emission *scenarios* (not *predictions*) into atmospheric chemistry models to produce concentration *scenarios* (not *predictions*) which are then used, in turn, to produce corresponding *projections* (not *predictions*) of how the enhanced greenhouse effect would be expected to modify the real climate. This methodology avoids the impossible task of trying to predict a future which would itself be significantly influenced by society's response to the prediction. It enables us to gain an understanding of the sensitivity of the global climate system to increasing (or decreasing) emissions without making any assumption about the actual likelihood of one future emission profile relative to another. A schematic summary of the global warming and sea level projections for the 21st century included in the IPCC's Third Assessment Report (IPCC 2001a) is shown in graph 17.6.

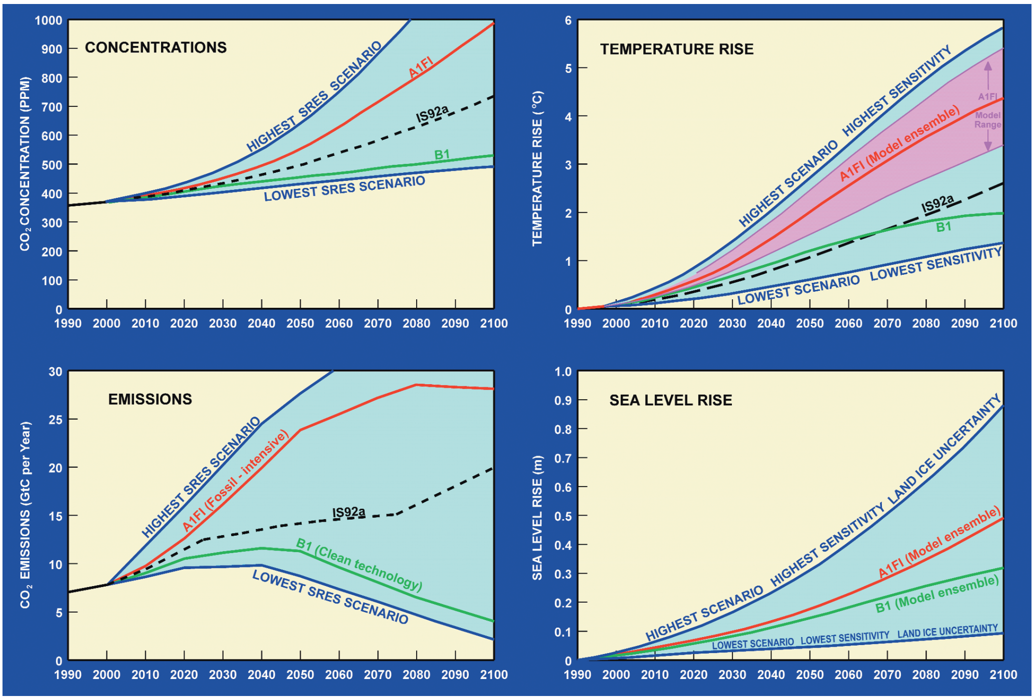
The current state of knowledge

The current state of the science of climate change is reported comprehensively in the Third Assessment Report (IPCC 2001a). The key conclusions, which the IPCC includes in its Summary for Policymakers, are the following:

- An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.
- Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate.
- Confidence in the ability of models to project future climate has increased.
- There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.
- Human influences will continue to change atmospheric composition throughout the 21st century.
- Global average temperature and sea level are projected to rise under all IPCC SRES (Special Report on Emissions Scenarios) scenarios.
- Anthropogenic climate change will persist for many centuries.

Despite the exhaustive process of peer review and the IPCC policy of explicitly identifying areas of uncertainty and disagreement in its reports, there is a substantial body of sceptical literature taking issue with its main conclusions (e.g. Lomborg 2001). While much of this appears to be based on misunderstanding of the IPCC reports (e.g. confusion between the IPCC and Convention definitions of 'climate change', failure to understand the significance of the difference between scenarios, projections and predictions and even failure to understand the implications of the basic physics of the greenhouse effect), other critics have focused on perceived inconsistencies in the observational record and the various well-known sources of uncertainty in physical processes and model limitations[1]. While it is expected that the Fourth Assessment Report, due in 2006–07, will bring both new confidence and new sources of uncertainty, the conclusions of the Third Assessment Report remain the most up-to-date and most reliable summary of the state of knowledge of the science of climate change (Zillman 2001).

17.6 MODELLED SENSITIVITY OF GLOBAL MEAN TEMPERATURE AND SEA LEVEL TO GREENHOUSE GAS EMISSIONS



Note: The graphs show, for a wide range of emission scenarios (the lowest, highest and two ‘illustrative’ scenarios — A1FI (fossil intensive) and B1 (clean technology) — published in the IPCC Special Report on Emission Scenarios (SRES) (IPCC 2000)), the carbon dioxide emission profiles to 2100 (bottom left), the resulting carbon dioxide concentrations (top left), the model projections of global mean temperature rise (top right) and sea level rise (bottom right). The temperature panel provides an indication of the range of uncertainty of the *projections* resulting from the different climate sensitivities of the individual models (pink shading) as well as the model mean projections for the A1FI and BI scenarios and the envelope of climate change projections associated with the envelope of emission scenarios included in the IPCC Report.

Future climate change over Australia

By contrast with short-term weather prediction which has achieved increasingly high levels of skill over the past 50 years, climate prediction is still in its infancy as a science (WMO 2002). While a number of empirical systems for assessing the probability of above or below normal rainfall and temperature are employed operationally (e.g. by the National Climate Centre of the Commonwealth Bureau of Meteorology) for producing usefully skilful seasonal climate outlooks, and coupled atmosphere–ocean models are now available which can predict the broad evolution of ocean temperature and other climate patterns for six to twelve months ahead, most of the forecast skill runs out beyond a year or so and it is not possible to indicate likely climate patterns, either globally or for individual geographic regions, with much confidence on longer timescales.

Given contemporary understanding of the mechanisms of global and regional climate, the most confident statement that can be made about the next decade and the next century is that Australia must expect to continue to experience the major El Niño- and La Niña-associated multi-year fluctuations of temperature and rainfall which have earned it its reputation for climate extremes and its image as a land of ‘droughts and flooding rains’. There is, as yet, no sound scientific basis for predicting any specific change to this year-to-year and decade-to-decade variability, which must be expected to continue to be the dominant climatic influence on Australia’s environment, economy and way of life. But it is certainly possible that some large-scale fluctuation, outside the range of experience of the past two hundred years of instrumental records, will manifest itself in Australian climate patterns over the next century.

The next most confident thing that we can say about future climate change in Australia is that there seems likely to be a general warming trend, as a result of the inevitable continued build up of greenhouse gases in the atmosphere, of up to perhaps a few degrees over the century, superimposed on whatever temporal and spatial change (including short-term variability) occurs as a result of natural processes. While the IPCC Third Assessment Report (IPCC 2001a) has indicated that, *for the full range of greenhouse gas emission scenarios considered by the IPCC*, and allowing for uncertainties in the climate models 'the globally averaged surface temperature is projected to increase by 1.4 to 5.8°C over the period 1990 to 2100' and that 'it is very likely that nearly all land areas will warm more rapidly than the global average', it is clearly not possible, at this stage, to know how *actual emissions* will increase (or decrease) over the next hundred years, and therefore how large will be the globally averaged temperature rise due to enhanced greenhouse warming. It is even more difficult, given the possibility of significant rearrangement of the large-scale circulation (e.g. through changes in the behaviour of the El Niño–La Niña cycle) to predict the actual temperature rise (and any associated change in rainfall) over Australia as a whole. And it is quite impossible, given all these uncertainties and the still substantial limitations of the climate models, to indicate what the enhanced greenhouse effect might mean by way of *regional* changes of rainfall patterns for the individual states and territories. While the IPCC Third Assessment Report (IPCC 2001a) includes some broad indications of the extent and nature of inter-model consistency in the projections of temperature and rainfall trends for northern Australia (north of 28°S) and southern Australia separately, for two different SRES emission scenarios (A2 and B2 which fall broadly within the envelope of the A1FI and B1 scenarios of graph 17.6, with A2 producing larger concentrations and greater warming than B2) for summer and winter (table 17.7), it seems that little can be said, with any confidence, about future climate change on the scale of the individual states of Australia at this stage.

While other, higher resolution, assessments have been undertaken for a range of global emission scenarios and using a number of different models to indicate the corresponding range of projected changes in regional climate (e.g. Whetton et al. 2002), which provide a basis for sensitivity studies as an aid to planning for adaptation to future climate, these regional model *projections* should *not* be interpreted as *predictions* of the human-induced component of future climate change and certainly not as predictions of future climate. It may still be decades before that is likely to be done with confidence, and it is not yet possible to say whether it will ever be done with reliability.

The challenges ahead

The attribution of observed climate change to human activities and the projection of human impacts on future climate are likely to remain controversial, but progress in both areas will be essential to planning for efficient adaptation to future climate. Until, for example, we know whether the recent systematic drying of the south-west corner of Australia (Indian Ocean Climate Initiative Panel 2002; see also map 17.5) is due to some natural long-term fluctuation in (say) the southern ocean — in which case we would expect rainfall to increase again in the future; or whether it is a manifestation of large-scale geographically-anchored circulation changes forced by enhanced greenhouse warming — in which case we would expect the drying trend to continue — it will be very difficult to provide a reliable basis for planning for adaptation on the century timescale. The importance and urgency of better monitoring and modelling of Australian climate cannot be overstated.

17.7 INTER-MODEL CONSISTENCY OF THE PROJECTIONS OF FUTURE TEMPERATURE AND RAINFALL CHANGE — Northern and southern Australia

	Summer		Winter	
Scenario	Temperature	Rainfall	Temperature	Rainfall
Northern Australia				
A2	0	0	+	–
B2	0	0	+	–
Southern Australia				
A2	0	+	0	–
B2	0	0	0	–

Note: A summary of inter-model consistency of the projections of future temperature and rainfall change separately for northern Australia (north of 28ºS) and southern Australia for the IPCC A2 and B2 emission scenarios. The results are from nine models used by the IPCC. A '0' means that there is little consistency between models on the size or sign of the projection. In the case of temperature, this means that the model projected *regional* warming may be either above or below the model projected *global* warming and, in the case of rainfall, it means that some models project a rainfall increase and others a rainfall decrease. A '+' sign means that at least seven of the nine models agree on greater than global average warming (for the model concerned) or a small projected rainfall increase (between 5 and 20%). Similarly a '–' sign means that at least seven of the nine models agree on a small (between 5% and 20%) decrease in rainfall.

Endnote

1. *Chapter 16, Greenhouse gas emissions* refers to even more recent concerns raised about some of the underlying assumptions associated with the scenarios outlined in the Third Assessment Report (ed.).

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18 Manufacturing and the environment[1]

Introduction

The manufacturing industry consumes natural resources such as energy and water to provide goods and services to households and businesses, and for export. As a direct result of this consumption process, waste is disposed of into the atmosphere, rivers and oceans, or as landfill. All of this places pressures on the environment. Increasingly, such pressures result in governments creating policies which influence the behaviour of manufacturers. Manufacturers react to these regulatory and social pressures through environmental plans and expenditure on environment protection.

Use of natural resources: energy and water

Both primary and secondary energy sources are consumed by the manufacturing industry. Primary energy sources can be renewable or non-renewable. Renewable energy sources include solar, wind, wood and bagasse. Non-renewable sources include raw materials (such as coal, oil and gas) and uranium concentrates.

Secondary energy sources are those derived from a primary energy source such as thermal electricity. Thermal electricity is derived mainly from coal and refined petroleum products (e.g. automotive petrol) which in turn is derived from crude oil. Renewable energy currently accounts for a small proportion of these secondary sources, the principal type being hydro-electricity.

In 1997–98, energy use by the manufacturing industry was 2,489 petajoules (PJ) of primary energy and 521 PJ of secondary energy (table 18.1). This accounted for 19% of total primary energy use and 21% of total secondary energy use in Australia. Renewable energy contributed 160 PJ or 6% of primary and 4% of secondary sources. Of the primary energy used, manufacturing produced 1,696 PJ or 68% of secondary energy supply.

Over the period 1992–93 to 1997–98, primary energy use by manufacturing increased by 11% and secondary energy by 9%. For the same period, all users increased their use of primary energy by 36% and their use of secondary energy by 13%.

The manufacturing industry was the sixth highest water user in Australia, consuming 1% of water extracted (727 gigalitres (GL)) in 1996–97. By 2000–01 this use had increased to 793 GL (one and a half times the volume of Sydney Harbour). The majority of water intake for this industry was mains supplied (70%), reflecting the tendency for manufacturing industry to be located around urban communities.

18.1 ENERGY USE

	Manufacturing		All users(a)	
	Primary energy	Secondary energy	Primary energy	Secondary energy
	PJ	PJ	PJ	PJ
1992–93	2 244	478	9 727	2 203
1993–94	2 303	494	9 865	2 253
1994–95	2 367	513	10 410	2 319
1995–96	2 414	514	11 787	2 387
1996–97	2 464	502	12 676	2 435
1997–98	2 489	521	13 250	2 489

(a) Industries, household and exports.

Source: ABS 2001.

1 From *Chapter 19, Manufacturing* in *Year Book Australia 2003.*

Manufacturing as a source of pollution and waste

Most manufacturing businesses do not generate waste in quantities significant enough to report in the National Pollutant Inventory. However, 675 manufacturing locations (approximately 1% of all manufacturing locations) reported particulate emissions (dust particles smaller than 10 micrometres) amounting to 11% of the estimated total particulate emissions for 2000–01. Depending on the type of dust, particulate matter can be a hazardous material which can cause irritation of the mucous membrane, allergic reactions, fibrosis and cancer.

In 1997–98, the manufacturing industry released 57,166 gigagrams of carbon dioxide equivalent emissions (CO_2-e), accounting for 17% of total CO_2-e by Australian industries (table 18.2). Manufacturing is the second highest source of greenhouse gas emissions after the electricity industry. The level of emissions reached in 1997–98 represented a 9% increase over the 1992–93 level. The majority of emissions are carbon dioxide, with a marginal amount of nitrous oxide and methane.

18.2 GREENHOUSE GAS EMISSIONS

	Manufacturing	All sources
	Gg CO_2-e	Gg CO_2-e
1992–93	52 431	285 168
1993–94	52 934	289 325
1994–95	55 665	302 959
1995–96	56 603	313 355
1996–97	55 437	320 975
1997–98	57 166	339 597

Source: ABS 2001.

Response by government for environment protection

Governments react to environment pressures exerted by manufacturing activity through legislation and partnership programs. These programs are based on reducing greenhouse emissions, waste minimisation, resource recovery and reducing material inputs to the manufacturing process.

Government regulations concentrate on protecting the environment. Regulations range from licence fees for pollution emissions to the environment, to compulsory reporting requirements through legislation such as the *Corporations Act 2000* (Cwlth), and fines from prosecutions.

Voluntary programs promoted by the Commonwealth Government and state governments focus on the provision of reporting measures for businesses such as *A Framework for Public Environmental Reporting: An Australian Approach* (Environment Australia 2000) and eco-efficiency agreements (relating to waste minimisation, energy minimisation and an overall reduction of materials into the manufacturing industry). Targets are set by government and industry collaboration on the basis of which indicators are agreed upon, measuring the extent to which businesses meet those targets.

More recently, the Global Reporting Initiative program (Global Reporting Initiative 2001) details a series of environment, social and governance measures for companies to report on.

Response by manufacturing on environment protection

Manufacturers react to regulatory and social pressures by establishing environmental plans or policies and by expenditure on environment protection. Their expenditure in 2000–01 is shown in table 18.3 in respect of the following domains: solid waste management; liquid waste management; air emissions management; other environment protection including protection of soil resources, biodiversity and habitat; and administration of the environment.

18.3 ENVIRONMENT PROTECTION EXPENDITURE — 2000–01

Domain	Current $m	Capital $m
Solid waste	284.0	90.3
Liquid waste and waste water management	183.5	176.1
Air emissions	34.5	124.0
Other	32.7	47.7
Administration	133.8	. .
Total	**668.5**	**438.1**

Source: ABS 2002a.

Current environment protection expenditure for the manufacturing sector of $669m was about 0.3% of total current expenditure of the sector. The highest expenditure was on waste management ($502m), in the fields of solid waste management ($284m), liquid waste and waste water management ($184m) and air emissions management ($35m).

Capital environment protection expenditure for the sector of $438m was about 4% of its total capital expenditure. The highest expenditure was again on waste management ($390m), in the fields of liquid waste and waste water management ($176m), air emissions management ($124m) and solid waste management ($90m).

Approximately 13% of manufacturers had an environmental plan in place at 30 June 2001. Of these businesses, 54% constructed a voluntary environment management system or code of practice and 52% had a written policy or environmental plan (table 18.4). However, of businesses with 100 or more employees, 64% had environmental plans; the great majority of these (87%) had a written policy or plan.

Barriers to environment protection

A number of barriers can prevent businesses from implementing environment management measures. Such barriers include lack of time, resources or knowledge on environment management.

Approximately 46% of manufacturers had no barriers to improving environment protection expenditure for the financial year 2000–01 (table 18.5). The main reasons for not improving environment protection were reported to be the likely costs involved (28% of businesses), and lack of time and staff resources (26%).

About 44% of manufacturing businesses sought some form of environment management information in 2000–01. Some 21% obtained information from state government and 19% from their industry and professional associations (table 18.6).

18.4 BUSINESSES WITH ENVIRONMENT PLANS — 2000–01

Employment size (persons)	With environment plans %	Without environment plans %	Written policy or plan %	Public Environment Report %	Voluntary EMS(a) %	Certified EMS(a) %
0–19	10.2	89.8	39.4	(b)10.4	57.9	(b)9.8
20–99	28.3	71.7	72.0	(b)7.1	39.2	(b)7.3
100 or more	63.3	36.7	86.0	21.1	58.0	24.2
All businesses	**13.4**	**86.6**	**52.0**	**(b)11.0**	**54.0**	**(b)11.0**

(a) Environment management system. (b) Standard error of more than 10%.

Source: ABS 2002a.

18.5 BARRIERS TO ENVIRONMENT PROTECTION — 2000–01

	Proportion of manufacturing businesses
	%
Lack of time/staff resources	26
Lack of expertise within the business	11
Likely costs involved	28
Lack of market demand	7
Risks involved (e.g. interfering with product/service quality)	4
Lack of evidence of likely benefits	21
Lack of awareness of potential for environmental improvements	7
Lack of government assistance	12
Other barriers	5
No barriers	46

Source: ABS 2002a.

18.6 SOURCES OF ENVIRONMENT INFORMATION USED — 2000–01

	Proportion of manufacturing businesses
	%
Internet or world wide web	12
Commonwealth government agencies	9
State government agencies	21
Industry and professional associations	19
External consultants	6
Seminars and conferences	5
Other businesses	12
Parent company	3
Other sources	4
Information on environment management not sought	56

Source: ABS 2002a.

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19 Construction and the environment[1]

Introduction

Construction of residential buildings, commercial buildings and other infrastructure has significant impact on the environment. Direct impacts include use of land, materials and energy; this use in turn leads to greenhouse gas emissions and the production of other wastes. Indirect impacts depend on a range of factors including location (whether the development is in an ecologically sensitive area), the use of the building throughout its life span and the urban form created through construction. The layout of towns and cities leads to further environmental impacts from activities such as transport (see *Chapter 23*, *Environmental impacts of Australia's transport system*). This chapter focuses on the direct environmental impacts of construction.

Use of land and materials

A direct impact of construction activity on the environment is its use of resources. The actual impacts vary depending on the amounts and types of materials used.

There has been growth in consumption of construction materials over at least the last 50 years. A 'boom period' at the end of WWII was sustained for almost a quarter of a century. In 1997, Australia produced 98 million tonnes of construction materials, 99% of which were consumed within Australia. This amounted to an average of just over 5,200 kilograms per person. As well as being the main final consumer of construction materials, the building and construction industries also use 55% of timber products (mainly for residential buildings), 27% of plastic products and 12% of iron and steel (Newton et al. 2001). (See *Chapter 20, The use of forest products*.)

A trend in construction that clearly has consequences for resource use is an increase in the number and size of buildings being constructed. During the five years ending June 2001, there was a steady increase in the number of building approvals across Australia. During this time, there were about 717,000 residential dwelling approvals in Australia, representing a 10% increase from the level of approvals in 1996 (ABS 2001b).

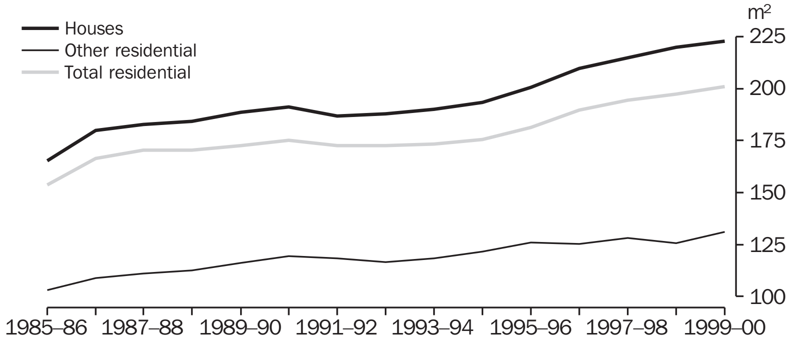
Although the average number of people in a household has declined, from 3.3 persons in 1976 to 2.6 persons in 1996, the average floor area of new houses has steadily increased over the last 15 years (Newton et al. 2001; ABS 2001a). The average floor area of new dwellings increased by 28% during this time, from 155.6 square metres to 199.5 square metres (graph 19.1), increasing in all states and territories. The average floor area of new houses in capital cities is higher than in regions outside capital cities (e.g. in 1999–2000 the average floor area was 19.4 square metres higher in capital cities). This is significant considering that some 60% of the population live in big cities (Newton et al. 2001).

The materials selected for building also influence the environmental impact of construction. The main factors determining the level of impact are the source of materials and the way they are processed. Similar materials can have greatly different environmental impacts depending on these factors. Important factors influencing selection of residential construction materials are their durability compared to intended life span, lifecycle energy consumption, source and environmental impact of all component materials and processes, recycling potential, and distances required for transportation of components.

The harvesting of many materials used in building a home can cause adverse impacts on biodiversity, including extinction of species, destruction of natural systems and habitat, degradation of ecosystems and fragmentation of habitat and populations. For example, harvesting of timber for construction from native forests can reduce the habitat of native species (AGO 2002c).

1 From *Chapter 20, Construction* in *Year Book Australia, 2003.*

19.1 AVERAGE FLOOR AREA OF NEW RESIDENTIAL BUILDINGS(a)



(a) Includes private dwellings only.

Source: ABS 2001a.

These impacts are rarely apparent at the point of use, so it is difficult for builders to take them into account when selecting construction materials. More information is becoming available to help builders in selecting environmentally preferred materials. Choosing an appropriate combination of materials to build houses, taking into account the climate and location, will increase thermal comfort, lower costs and reduce the overall environmental impact (AGO 2002a).

As well as using more materials and, in some cases, more land, increased construction activity can lead to increased production of waste, use of energy and greenhouse gases emissions.

Waste

Australians generate on average about one tonne of solid waste per person per year, which goes to landfill (AGO 2002d). Construction and demolition of buildings contributes 30–40% of this waste (table 19.2). This equates to about eight million tonnes nationwide, or 430 kilograms per year per capita (Newton et al. 2001). The impacts of landfill disposal include use of land that could be used for other purposes, release of methane from the decomposition of organic wastes, and greenhouse gas emissions through the transportation of wastes to landfills, which are mostly on the fringes of cities (Newton et al. 2001). Other environmental implications of disposing of construction waste can include depletion of natural resources and wastage of energy required to produce materials.

The main type of waste is soil rubble, followed by concrete-based masonry and clay-based waste such as bricks and tiles (graph 19.3). Some types have greater impact than others. For example, gypsum plasterboard disposed of in landfill produces poisonous hydrogen sulphide (AGO 2002d).

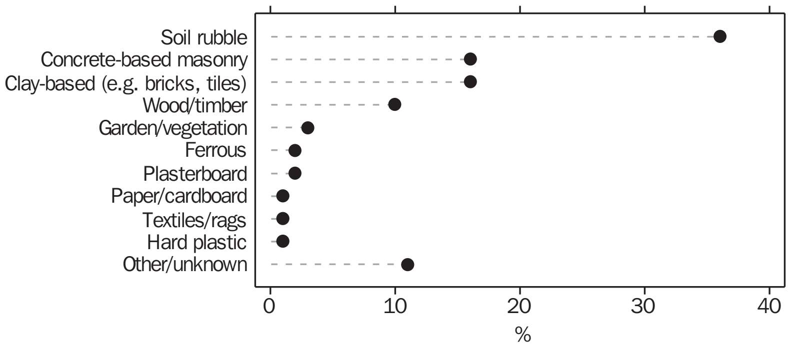
19.2 COMPOSITION OF SOLID WASTES IN METROPOLITAN AREAS

	Inner Sydney(a)	Sydney metro(b)	ACT(c)	Brisbane(d)	Melbourne(e)	Perth metro(f)	Tasmania(g)	Average(h)
	%	%	%	%	%	%	%	%
Municipal	14	36	40	51	34	28	50	40
Commercial and industrial	26	23	24	17	32	17	26	23
Construction and demolition	60	40	36	32	34	55	24	37

(a) 1996–97 (Inner Sydney Waste Board 2000). (b) Average 1995–99, data supplied by EPA NSW 2000. (c) Average 1994–99, domestic including private delivery (ACT Government 2000). (d) 1994 (EPA Qld 1999). (e) 1996–97 (EcoRecycle Vic. 1998a, 1998b). (f) Average 1997–2000 (Department of Environment Protection WA 2001). (g) Data supplied by Department of Primary Industries, Water and the Environment, Tas. 2000). (h) Excluding inner Sydney.

Source: Newton et al. 2001.

19.3 TYPES OF BUILDING WASTE(a) — 1997



(a) Proportion of total by weight.

Source: AGO 2002d.

The amount of waste is being reduced by construction companies using the following established hierarchy for waste minimisation: reducing consumption of resources where possible; reusing existing buildings and materials; and recycling resources that are left over or have reached the end of their useful life. Effective waste minimisation strategies are being agreed to and implemented by all parties involved in building at the design, construction and operation stages. Decisions on what to build, whether to demolish, what materials to use and how they might be recycled are now made from the earliest stages of design and incorporate waste minimisation strategies (AGO 2002d).

Chapter 21, The WasteWise Construction Program discusses in detail the coordinated responses to achieve waste reductions.

Energy consumption

Energy consumption impacts on the environment through its depletion of non-renewable resources and emission of greenhouse gases. The impact depends to a large extent on the energy source. This is discussed further in *Chapter 15, Energy and the environment.*

Energy consumption by the construction industry in residential, commercial and other developments is relatively low. In 1997–98, the industry consumed 73 petajoules (PJ) of energy, only 0.5% of total energy use. Primary energy (raw materials) used by the construction industry consisted of 2 PJ of natural gas and 2 PJ of liquefied petroleum gas. Secondary energy products (those that have been enhanced or changed before consumption) consisted of 7 PJ of automotive petrol, and 62 PJ of gas oil or fuel oil (ABS 2001c).

Despite the low direct energy use by the construction industry, once buildings have been constructed they become high consumers of energy. An understanding of energy consumption and the associated greenhouse gas emissions needs to take into account both embodied energy and operating energy.

Embodied energy

Embodied energy is the energy consumed by processes associated with the production of a building, from the acquisition of natural resources to final consumption including mining, manufacturing, transport and other functions.

The energy embodied in the existing building stock in Australia is equivalent to about 10 years of the total energy consumption for the entire nation. The embodied energy per unit mass of materials used in building varies enormously, from about two gigajoules per tonne for concrete to hundreds of gigajoules per tonne for aluminium. However, other factors also affect environmental impact, such as differing lifetimes of materials, differing quantities required to perform the same task and different design requirements. Materials such as concrete and timber have the lowest embodied energy intensities, but are consumed in very large quantities, whereas materials with high energy content such as stainless steel are used in much smaller amounts (Newton et al. 2001).

The principal material of the outside walls for dwellings in Australia is brick veneer (41% of dwellings) (ABS 1999). In brick veneer construction, the bricks have no structural role, but high embodied energy. Lightweight materials such as fibre cement have lower embodied energy but similar structure and thermal performance (AGO 2002a).

Embodied energy is becoming of greater significance as a proportion of whole-of-life energy consumption, particularly in the commercial building sector, due to several trends — more energy intensive materials such as aluminium and stainless steel are being used in buildings; these are often bigger and therefore require greater quantities of materials; buildings are being refurbished more frequently, requiring more materials; more machine intensive techniques that require energy derived from fossil fuel sources are used in construction; and building materials are transported greater distances, so that transport energy is likely to be greater (AGO 1999a).

Recycling building materials can reduce embodied energy substantially. For example, aluminium is 100% recyclable. Recycling aluminium reduces embodied energy by 95%, while recycling steel reduces embodied energy by 72% (AGO 2002d).

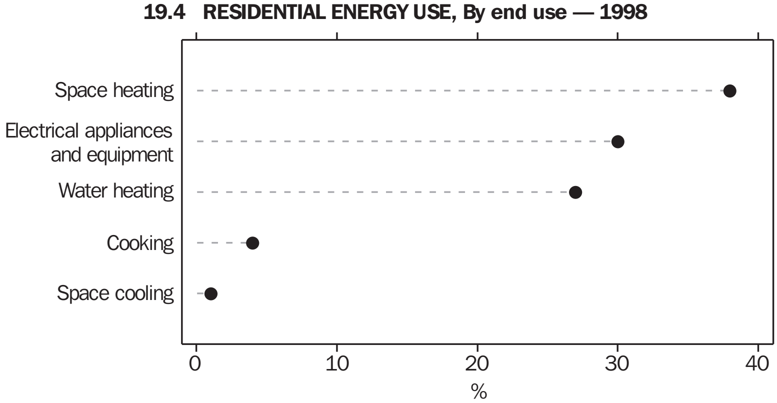
Operating energy

Operating energy is the energy consumed in maintaining and using a building throughout its life span. Levels of operating energy can be influenced by the design and materials initially used in construction.

In residential buildings, space heating and cooling accounted for 39%, or approximately 125 PJ, of total residential operational energy consumption in 1998 (graph 19.4). The main energy sources used in the residential sector are electricity, natural gas and wood. The vast majority of natural gas and wood consumption in Australia is for space heating. Firewood is often collected from areas where the fallen timber provides crucial habitat and food for native animals, and this practice can pose a threat to forest biodiversity (ANZECC 2001).

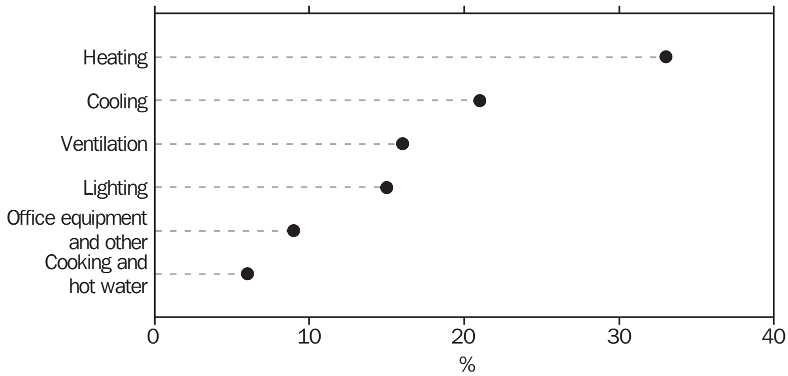
In commercial buildings, heating is the largest single end use of energy at 33% of total energy use in 1990 (graph 19.5). By type of energy, electricity accounted for 65% of energy used, followed by natural gas at 25% (AGO 1999a).

19.4 RESIDENTIAL ENERGY USE, By end use — 1998



Source: AGO 1999b.

19.5 COMMERCIAL BUILDINGS, Energy use by end use — 1990



Source: AGO 1999a.

Technologies for reducing operating energy are being developed and implemented. In the foreseeable future it is likely that buildings will generate some of their own operating energy, by devices such as photovoltaics, which may be integrated within the building fabric.

Greenhouse gas emissions

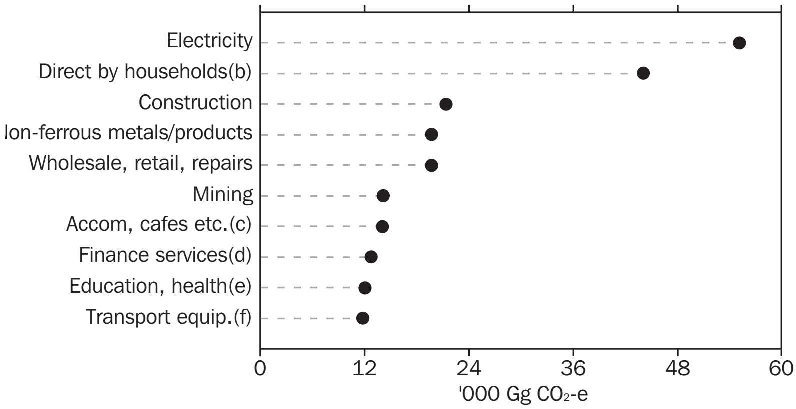
It is becoming widely recognised that human activities such as energy consumption are influencing global climate change through emissions of greenhouse gases such as carbon dioxide. See also *Chapter 16, Greenhouse gas emissions.*

Although the construction industry itself induces a fairly small amount of direct greenhouse gas emissions, buildings and other forms of construction contain high levels of embodied energy due to their use of building materials which are energy-intensive to produce, and therefore induce a large amount of greenhouse gases indirectly.

The direct greenhouse gas emissions from the construction industry were 4,958 gigagrams (Gg) of carbon dioxide equivalent (CO_2-e) in 1997–98, compared with the total emissions of all industries and direct emissions by households of 339,597 Gg CO_2-e. Greenhouse gas emissions can also be calculated indirectly. This method includes emissions from the extraction, harvesting, processing and transportation of materials used in the construction industry, as well as those produced by the industry itself. Construction produced 7.1% (21,397 Gg CO_2-e) of total indirect greenhouse gas emissions in 1994–95. This is the third highest overall level of energy-related domestic emissions after electricity and direct consumption by households (graph 19.6).

The average household's energy use is responsible annually for about eight tonnes of carbon dioxide, the main greenhouse gas. Space heating and cooling accounted for nearly 15% of residential sector greenhouse gas emissions in 1998 (graph 19.7). This is a lower share of greenhouse gas emissions than energy use (39%) because a large share of the energy used for heating and cooling is less greenhouse gas intensive (involving use of natural gas and wood rather than electricity).

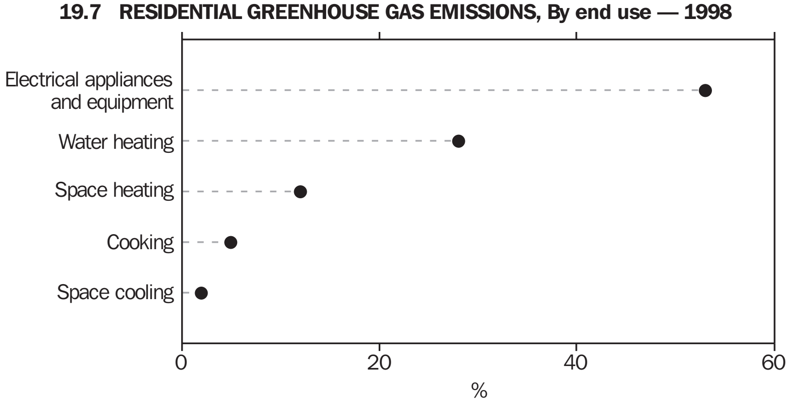
19.6 GREENHOUSE GASES INDUCED(a), By industry—1994–95



(a) Refers to energy-related greenhouse gas emissions only. Emissions produced indirectly via consumption of products, except direct emissions by households. (b) Direct production by households, mainly through motor vehicle use. (c) Includes restaurants, cultural and recreational services, personal and other services. (d) Includes insurance, ownership of dwellings, property and business services. (e) Includes community services. (f) Includes other machinery.

Source: ABS 2001b.

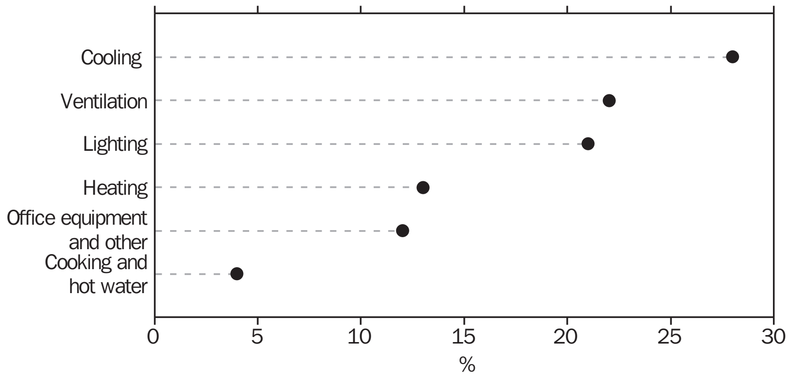
19.7 RESIDENTIAL GREENHOUSE GAS EMISSIONS, By end use — 1998



Source: AGO 1999b.

In commercial buildings, space cooling, ventilation and lighting were found in 1990 to be the three most significant causes of emissions, together accounting for 71% of the total (graph 19.8). The actual proportion applicable to a specific building type may vary substantially from this commercial sector average. A study assessing greenhouse gas emissions by commercial building type found offices to be the most significant, responsible for an estimated 27% of total sector emissions in that year. Hospitals formed the next largest group at 13% (AGO 1999a).

19.8 COMMERCIAL BUILDINGS, Greenhouse gas emissions by end use — 1990



Source: AGO 1999a.

Greenhouse gas emissions related to embodied energy were found to be less significant than those related to operating energy. In a study of four buildings, embodied energy emissions were found to be approximately 8–10% of greenhouse emissions by buildings, assuming a 40-year life span. This proportion would vary substantially for different building types; for those using less operating energy (e.g. warehouses, non–air conditioned offices) it would be much higher.

Energy efficiency

Many factors can contribute to reducing energy consumption and greenhouse gas emissions. Dwelling design can significantly affect the amount of sunlight entering a home. By siting the rooms that are principally used by the household (e.g. living areas and bedrooms) so that they face north, sunlight can be employed to heat the dwelling in winter. Insulation has a large impact on the heating and cooling requirements for buildings by creating a thermal barrier which reduces the rate of transfer of heat from and into a building. The use of insulation can reduce the amount of energy used to heat or cool a building.

Residential buildings in Australia are generally poorly insulated — 38% of houses have neither wall or ceiling insulation. Only one-fifth of all residential buildings have both wall and ceiling insulation and a further 42% have only ceiling insulation. In 1999, just over half of Australian households reported that their dwellings had some form of insulation. Achieving a more comfortable temperature was the main reason for insulation having been installed (87% of households), and cost was the main factor discouraging people from installing insulation (ABS 1999).

Improving the insulating qualities of new residential buildings goes a significant way towards meeting greenhouse gas emission reduction targets. Residential buildings potentially have a very long life — of the order of 50–100 years — and so any measure implemented will continue to have an impact on energy and greenhouse gas emissions for decades to come (AGO 1999b).

Energy efficiency measures in the Building Code of Australia (BCA)

The BCA is one of the main legislative methods available in Australia to ensure energy efficient buildings. The BCA sets minimum standards with which all buildings must comply. Individual builders may choose to use better performing systems. In 2000, the Commonwealth Government and the state and territory governments reached agreement to develop suitable national energy efficiency provisions for domestic and commercial buildings. The objective of the energy efficiency measures is to reduce greenhouse gas emissions by efficiently using energy. The proposed measures for buildings are intended to achieve significant improvement and eliminate worst practice, thereby reducing greenhouse gas emissions, while avoiding excessive technical and commercial risks and unreasonable costs. Performance requirements relate to building fabrics with an appropriate level of thermal performance, and to building services that use energy efficiently. The energy efficiency measures in the BCA Housing Provisions are expected to come into effect on 1 January 2003 and the commercial energy efficiency measures at a later stage (ABCA 2002).

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20 The use of forest products[1]

This chapter was contributed by A Yainshet, R Nelson and G Love, Australian Bureau of Agricultural and Resource Economics.

Domestic consumption of structural wood

The demand for structural wood is derived from the demand for building and construction, and to a lesser extent by the demand for furniture (Love, Yainshet & Grist 1999). Historically, rises or falls in new dwelling commencements show a close relationship with rises and falls in apparent consumption of sawnwood (graph 20.1).

Reflecting a number of influences such as low interest rates and increased grants for new home buyers, new dwelling commencements in Australia rose in 2001–02. However, with interest rates expected to rise, residential construction is forecast to be lower in 2002–03 and 2003–04, but begin to rise again thereafter.

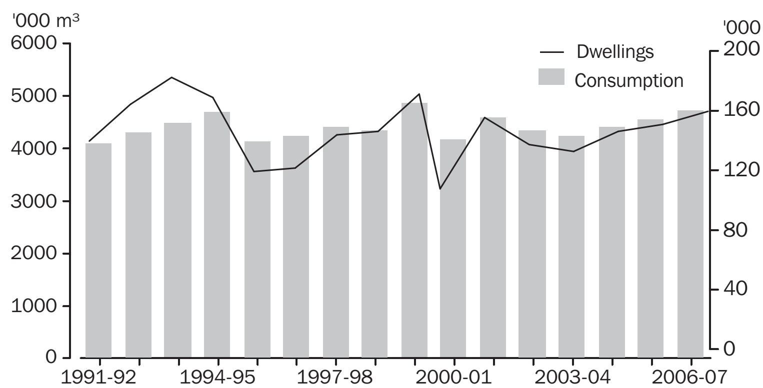
As a consequence, sawnwood consumption is projected to fall from 4.5 million cubic metres in 2001–02 to 4.1 million cubic metres in 2003–04, but rise to around 4.7 million cubic metres in the medium term.

The main macroeconomic and other assumptions underlying these projections are described in the next section.

Assumptions for structural wood consumption projections

Projections of structural wood consumption are based on the underlying demand for new dwellings, and other uses such as alterations and additions to existing homes, non-residential construction and furniture (Love, Yainshet & Grist 1999). Structural wood consumption is modelled from the number of new single-unit and multiple-unit dwellings, and income. The demand for new dwellings is projected from expected rates of household formation, with adjustment for replacement of housing stock, and vacancy rates. Rates of household formation are projected from the expected number of persons per household, and projections of population growth (table 20.2).

20.1 SAWNWOOD CONSUMPTION AND NEW DWELLING COMMENCEMENTS



1 From *Chapter 20, Construction* in *Year Book Australia 2003.*

In the past decade, reduced availability of hardwood sawlogs and increased availability of softwood sawlogs and pulpwood resulted in significant changes in the relative prices of these production inputs, and consequently in the production mix of structural wood products and their prices to consumers. Sawn hardwood prices rose strongly relative to sawn softwood- and pulpwood-based products such as wood-based panels (graph 20.3).

With these trends projected to continue throughout the current decade, sawn hardwood consumption is projected to decline from 1.2 million cubic metres in 2000–01 to 1.0 million cubic metres in 2006–07, while sawn softwood consumption is projected to rise from 2.9 million to 3.7 million cubic metres.

Consumption of wood-based panels and reconstituted wood products is also projected to rise in the medium term, from 1.5 million cubic metres in 2000–01 to 1.7 million cubic metres in 2006–07 (graph 20.4).

The projected lower rate of increase in consumption of wood-based panels and reconstituted wood products relative to that of sawn softwood reflects expectations that higher sawn softwood production will increase the availability of low-priced soft sawnwood, and that, while reconstituted structural wood products will remain competitively priced, their use will continue to be constrained to niche markets by building preferences.

20.2 MACROECONOMIC AND DEMOGRAPHIC ASSUMPTIONS

	Units	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
Population	'000	19 622	19 820	20 015	20 206	20 395	20 579
Households	'000	7 532	7 658	7 784	7 910	8 036	8 162
New dwellings	'000	154	138	134	146	150	158
Ratio of detached to total dwellings	ratio	0.71	0.69	0.69	0.69	0.68	0.68
Annual real GDP growth	%	3.8	3.8	3.8	3.5	3.5	3.5
Interest rates(a)	%	7.9	8.3	8.5	8.5	8.5	8.5

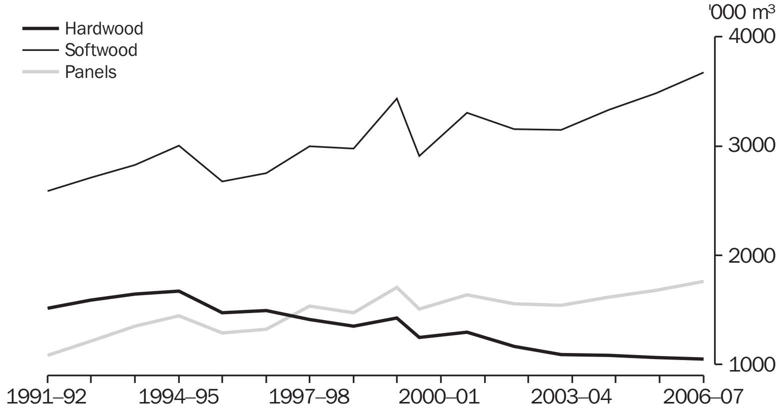
(a) Prime lending rates to large businesses.

Source: ABS 2000; Love, Yainshet and Grist 1999.

20.3 STRUCTURAL WOOD PRICES, Price indexes(a)

(a) Reference base year 1989 = 100.

20.4 STRUCTURAL WOOD CONSUMPTION, Past and projected



Structural wood production

Australia produced 5.3 million cubic metres of structural wood in 2000–01, consisting of 1.2 million cubic metres of sawn hardwood, 2.3 million cubic metres of sawn softwood and 1.8 million cubic metres of wood-based panels (graph 20.5).

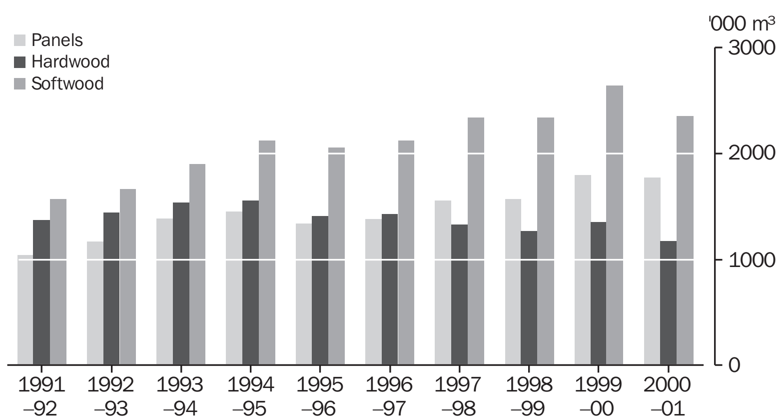
The average recovery rate (the ratio of sawnwood produced to the volume of sawlogs milled) is estimated to be around 40% from plantation sourced softwood logs and 33% from native forest sourced hardwood logs.

Production of wood-based panels includes reconstituted structural wood products that are direct substitutes for sawn timber, such as laminated veneer lumber and composite beams.

If all of the sawlog component of the industrial roundwood supply projected for the period 2005–06 to 2009–10 were to be processed into sawn timber, then reduced hardwood sawlog availability from native forests could result in annual sawn hardwood production falling by around 15–20% to average 1.0 million cubic metres, and sawn softwood production rising by around 60–70% to average 4.1 million cubic metres a year.

The increased supply of pulpwood directly and as mill residue could also reduce the cost of producing wood-based panels and reconstituted structural products, the combined production of which could potentially average 2.2 million cubic metres a year in the period 2005–06 to 2009–10 (see graph 20.5).

20.5 PRODUCTION OF STRUCTURAL WOOD PRODUCTS



Structural wood imports and exports

There has been a long-term decline in the share of imports in structural wood consumption, as domestically produced sawn softwood has become more competitive with imports.

At the same time, the share of wood-based panels imports in total wood-based panels consumption has been rising, reflecting the availability of low cost imported wood-based panels and reconstituted structural wood products.

Future trends in Australian trade in soft sawnwood (both imports and exports) will depend largely on the international competitiveness of softwood processing in Australia. Although the share of sawn softwood imports in Australian sawn softwood consumption is expected to continue to decline, it is expected that imported special applications timbers such as Douglas fir and western red cedar will continue to hold around 10–15% of the market.

In the reconstituted structural wood market, imports represent a high share of total consumption and are likely to continue to do so, as the size of the mills required for economic production of many of these products exceeds the likely requirements of Australia's relatively small domestic market.

While some of the projected additional sawn softwood production (see next section) is likely to be absorbed by the domestic market (probably at lower prices), a large proportion would be available for export. However, the ability to export sawn softwood will depend on Australia's international competitiveness in Pacific Rim markets.

To compete, Australian sawmillers will need to be able to produce and transport sawn softwood to export markets at a lower cost than competing nations. This may prove increasingly difficult as sawn softwood from plantations in other nations such as Argentina and New Zealand also comes on stream in the latter half of the current decade.

Plantations and structural wood markets

Forest plantations have provided progressively more of Australia's structural wood resources in recent years. Some recent revisions to projected wood supplies from both forest plantations and native forest, however, suggest that this process is occurring more quickly than previously expected. It is now possible that forest plantations could be providing 75% of domestic industrial wood supplies by 2010, compared with expectations of only around 62% several years ago.

The forecast net increase in wood flow is also much larger than previously expected — at around 5.5 million cubic metres — after expected decreases in flows from native forest are taken into account. The potential increase in plantation wood supplies will have many implications for Australia's wood and paper industries.

If all of the sawlog component of the industrial roundwood supply projected for the period 2005–06 to 2009–10 were to be processed into sawn timber, then sawn hardwood production in Australia would fall by 15–20% and sawn softwood production would rise by 60–70% relative to current levels. This would represent a significant addition to domestic sawn softwood availability.

The issues relating to the potential to export the increased stock of sawn softwood that is not required for domestic consumption were discussed in the previous section. Large increases in domestic production of sawn softwood would also likely alter the relative prices for, and therefore the domestic use of, sawn softwood, sawn hardwood, wood-based panels and reconstituted wood products.

Industrial roundwood removals

Reflecting steady increases in wood flows from forest plantations in the past decade, Australia's production of industrial roundwood reached 24.2 million cubic metres in 2000–01. Hardwood plantations have emerged as a 'third source' of industrial roundwood, alongside native forests (which provide mainly hardwood) and the softwood plantations established mainly during the two decades from around the mid 1960s to the mid 1980s.

Recently revised figures for industrial wood flows indicate expected lower wood flows from native forests over the next decade, but a further steady increase in wood flows from softwood plantations and large increases in wood flows from relatively recently established hardwood plantations (graph 20.6).

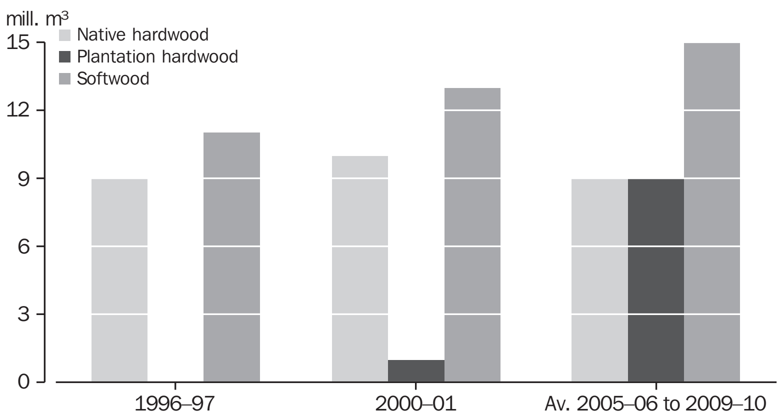
For native forests, the recently announced intentions by the governments of Victoria and Western Australia to reduce the volume of wood being harvested are expected to reduce Australia's annual removals of industrial roundwood from native forests to an average of 8.2 million cubic metres in the period 2005–06 to 2009–10, compared with estimated removals of 10.2 million cubic metres in 2000–01.

In comparison, potential log availability from softwood plantations is projected to average 15.0 million cubic metres a year in the latter half of this decade, significantly higher than previously projected (Ferguson et al. 2002).

The supply of plantation hardwood pulplogs is also expected to rise significantly as existing hardwood plantations approach the end of their first 10-year rotation. Wood flows from hardwood plantations are projected to rise from 1.0 million cubic metres in 2000–01 to an average of 9.2 million cubic metres a year in the latter half of the current decade (Ferguson et al. 2002).

Consequently, total industrial roundwood removals could potentially increase from 24.2 million cubic metres in 2000–01 to average 32.4 million cubic metres a year in the latter half of the current decade.

20.6 ROUNDWOOD REMOVALS, Actual and projected



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21 The WasteWise Construction Program[1]

This chapter was contributed by the Environmental Stewardship Team, Sustainable Industries Branch, Environment Australia.

Introduction

Australians currently send approximately one tonne of waste per person per year to landfill. Construction and demolition (C&D) wastes can make up to 40% of this waste.

C&D wastes are potentially valuable recoverable resources being wasted. Materials include metals, concrete and bricks, glass, fittings and fixtures from demolished or refurbished buildings, wood and wall panelling.

In 1995 the Australian and New Zealand Environment and Conservation Council (ANZECC) approached five major Australian construction companies to pioneer best practice waste reduction in the industry in an effort to reduce the amount of C&D waste going to landfill. ANZECC negotiated a voluntary industry waste reduction agreement incorporating waste reduction and recycling targets, known as the WasteWise Construction Program.

Phase I of the program

Waste management is the responsibility of state and territory governments. WasteWise was established to assist the Commonwealth establish and promote a cohesive national approach to waste reduction. The $5m Waste Management Awareness Program is administered by Environment Australia under the Natural Heritage Trust.

Through WasteWise, participating construction companies conducted the first detailed assessment of waste reduction opportunities from supply through to production and recycling.

The original WasteWise Memorandum of Understanding (MoU) stated:

> It is a national program to encourage best practice approaches to waste minimising construction and demolition waste.
>
> A best practice approach to environmental management can protect the environment, save resources; avoid waste, increase reuse and recycling of materials, and reduce the amount of waste going into landfill.
>
> The application of waste minimisation principles to project operations will facilitate the contribution of the construction and demolition industry to the national waste reduction target.

Five leading construction companies signed up for Phase 1 (November 1995–98), and funded their own participation in order to adopt a best practice approach to environmental management. They all achieved significant waste reduction within the bounds of normal commercial imperatives, and found that waste reduction could be increased by:

- recognising the 'bottom line' benefits of waste minimisation
- participating in the development of a national approach
- conducting waste reduction trials in their operations
- addressing coordination issues and barriers so that industry can work to overcome them
- being involved, through industry representative groups or as key stakeholders, in the development of future arrangements
- accepting, adopting and promoting best practice waste reduction.

A review of the program was undertaken in 1997 and published in the *WasteWise Construction Program Review*, which details the individual successes of the five partners.

Subsequently, the *WasteWise Handbook (1998)* became a 'how to' booklet with examples and company achievements and procedures from their waste reduction manuals. Both of these publications informed the development of the *Waste Reduction Guidelines (2000)*, which provided organisational tools for adoption.

1 From *Chapter 20, Construction* in *Year Book Australia 2003.*

Phase II of the program

Phase II commenced in late 1998, running until the end of 2001. The intention was to widen participation in best practice waste minimisation to other scales of construction and other industry members. While the new MoU had a common statement of commitment for all participants, separate schedules for industry sub-sectors identify their waste roles and responsibilities. All such industry sub-sectors were invited to participate, including:

- architects and designers
- material suppliers
- C&D companies
- waste collectors for recycling
- industry organisations.

Fourteen leading companies and peak industry organisations committed themselves to the Phase II WasteWise Construction Program by signing the MoU.

Highlights of the WasteWise Construction Program 1995–2001

For the participating organisations the WasteWise program has successfully decreased the amount of waste going to landfill, sometimes by more than 90%. While the individual performance of WasteWise partners varied from year to year and from project to project, some of the highlights are summarised below:

- Barclay Mowlem Construction diverted over 80% of its total waste from landfill in 2000.
- Bovis Lend Lease recycled 98% of material from the State Office Block site in Sydney in 1997. In 2001, 87% (280,790 cubic metres) was reused, recycled or reprocessed on all Bovis Lend Lease sites.
- The John Holland Group avoided, recovered, reused or recycled 83% (8,851,000 kilograms) of waste generated on all its sites in 2001.
- Multiplex Constructions recycled 60% of site waste at the Homebush Bay Olympic Stadium site between April and August 1997, and 87% (1,250 tonnes) of waste from the Campbelltown Hospital site was recycled in 2001.
- Project Coordination (Australia) recycled 68% (240 tonnes) of waste material generated at the Canberra Hospital Pathology Building Refurbishment and the Calvary Hospital Redevelopment by separating waste streams at their source.
- Thiess recycled or reused 94% waste generated at the Royal Prince Alfred Hospital site in 2001. A total of 32,641 cubic metres of waste was diverted from landfill, resulting in waste removal cost savings of around 40%.
- Fletcher Construction reused or recycled 43% of all waste from the Dandenong Police and Court Buildings, saving 55% of the company's waste removal costs. Waste reduction techniques developed under WasteWise have been used by the company in the United States of America, New Zealand, Sweden, and the United Kingdom.

22 Attitudes of residential builders to energy issues and usage[1]

This chapter was contributed by Paul Giles, Senior Project Manager, BIS Shrapnel.

The bulk of Australian building companies believe that mounting pressure by regulators will compel the industry to build energy efficient housing within five years.

A study by BIS Shrapnel, *Attitudes of Residential Builders to Energy Issues and Usage in Australia, 2001–02*, demonstrates that most builders are sympathetic to the concept of the 'clean, green' home, but are deterred by perceived higher building and installation costs. Further, builders believe that greater community education of the benefits of energy efficient housing is required. The study involved interviews with 121 building firms in all the mainland state capital cities.

It found substantial increases over the past 12–24 months in the installation of building products with a significant bearing on energy efficiency and usage, including air conditioners, floor and wall insulation, hot water temperature controls, water efficient shower heads, and even solar hot water systems, where the level of acceptance has been low.

The study also identified substantial differences in attitude and product usage between the states, and between sectors of the building industry. For example, small builders tend to be more sympathetic to environmental considerations in housing design than their larger colleagues, who are much more likely to cite competitive price advantage for a lukewarm attitude.

But the industry is almost unanimous in its view that change will be driven by the regulators, and particularly by local authorities, with one builder commenting: 'Legislation is required …because people are not interested in more expensive options. Hence it must be forced'. The three most compelling reasons cited by builders for support of the concept are energy efficiency, long-term cost savings and reduced environmental impacts. Builders nominate increased construction costs as the standout reason for not recommending energy-efficient solutions. 'To be green is more expensive,' said one respondent. For example, only 3% of new homes have solar hot water heaters installed. Builders believe that only lower costs and/or rebates will result in an increase in this figure.

The study identifies and researches the incidence of 15 major building products which impact on energy efficiency (table 22.1).

1 From *Chapter 20, Construction* in *Year Book Australia 2003.*

22.1 INCIDENCE OF PRODUCT INSTALLATION — 2001–02

Selected products with a bearing on energy efficiency	Builders using product %
Dual flush toilets	99
Ceiling insulation	71
Wall insulation	63
Gas hot water systems	60
Hot water temperature control	56
Roof insulation	43
Water efficient shower heads	39
Electric hot water systems	38
Insulated hot water pipes	37
Air conditioning	27
Water efficient taps	24
Ducted gas heating	23
Ducted evaporative cooling	14
Floor insulation	6
Solar hot water systems	3

Source: BIS Shrapnel, 'Attitudes of Residential Builders to Energy Issues and Usage in Australia 2001–02'. Further information about this study can be found at <http://www.bis.com.au>.

The study discovers considerable variations between the states: New South Wales is the leading installer of air conditioning and well above average installer of ceiling insulation, wall insulation and gas hot water systems; Victoria is the leader in ceiling insulation, gas hot water systems, insulated hot water pipes, ducted gas heating and ducted evaporative cooling; Queensland leads in the installation of roof insulation and electric hot water systems, but lags well behind other states in wall insulation, gas hot water systems and air conditioning; South Australia is a high installer of energy-efficient products, and the leader in wall insulation, water efficient devices and floor insulation; Western Australia is the leading installer of hot water temperature control and solar hot water systems, but has a very low rate of wall insulation due to the prevalence of double brick housing.

Builders identified trade magazines as their main source of information on energy efficient products and developments, followed by trade representatives. The Housing Industry Association, government bodies and trade shows and seminars are also important sources.

23 Environmental impacts of Australia's transport system[1]

Overview

Australia has long suffered from the 'tyranny of distance' due to its geographical location and size. Australia's pattern of human settlement is characterised by high rates of urbanisation, low density cities and a high population density within 50 kilometres of the coast. In particular, there is high population density on the south-east and east coasts between Adelaide and Cairns and on the west coast south of Perth (Newton et al. 2001). This population distribution, along with the dispersed locations of its agricultural, mining and production centres, underlies Australia's heavy reliance on transport.

The environmental impacts of transport are diverse. Most attention is focused on the greenhouse gas emissions (GHG) associated with transport use. Indeed, emissions are one of the furthest reaching impacts of transport, as they impact on the global environment, whereas other impacts are more localised. Fuel use is closely associated with transport emissions. Much of Australia's fuel is from non-renewable sources, and there is concern that current technology for powering transport systems may be unsustainable in the long-term. The fuels used produce many of the emissions affecting the environment. Managing the use of fuels is a key part of minimising transport's impact on the environment.

This chapter discusses the environmental impacts directly associated with transport and the transport industry. Topics covered include the use of energy and GHG by the transport system, and the impact of transport on wildlife, biodiversity and aquatic environments. There are many indirect impacts of transport, such as air pollution and related illnesses, the reduced livability of urban environments and the environmental impacts of the materials used by the transport system. These impacts are theoretical and difficult to quantify, and it is beyond the scope of this chapter to discuss them in depth.

Energy use and greenhouse gas emissions by transport

Transport uses a large amount of energy, with some 970 petajoules (PJ) (a petajoule is 10^{15} joules) used in 1994–95. The key transport energy users are household passenger vehicles (525.3 PJ), air transport (162.7 PJ), commercial road transport (125.7 PJ) and water transport (62.2 PJ) (ABS 2001a). The energy used and emissions caused by the consumption of almost 25,000 million litres of fuel by motor vehicles in 2000 are considerable.

Energy is sourced primarily from non-renewable fossil fuels, an environmentally unfriendly source of energy. The use of fossil fuels for energy contributed significant amounts to Australia's GHG. Australia contributed a small amount of emissions in a global sense, but is one of the highest per capita contributors. Transport contributed just under 15% of Australia's total GHG for 2000 (AGO 2002).

In 1997, Australia had very high levels of transport-related emissions per capita, with 4,183 kilograms of carbon dioxide (CO_2) released per person by transport (table 23.1). Australia produces 1.5% of global transport-related CO_2, but it produces twice the per capita average for Europe (as calculated by the Organisation of Economic Co-operation and Development (OECD)), and over four and a half times the world average. However, Australia is not unique in its high per capita emissions; the United States of America, Canada and New Zealand have high levels of emissions as well.

1 From *Chapter 23, Transport* in *Year Book Australia 2003.*

23.1 COMPARISONS OF CO_2 EMISSIONS, Selected countries — 1997

	CO_2 emission for transport	Percentage increase since 1990	Proportion of total CO_2 emissions from fuel consumption	Per capita emissions by transport	Per capita emissions by road transport
	Mt	%	%	kg CO_2	kg CO_2
Australia	78	17.2	25.3	4 183	3 307
New Zealand	13	29.1	40.2	3 543	1 744
Canada	149	17.0	31.2	4 921	3 641
United States of America	1 685	13.4	30.3	6 216	4 979
Japan	267	24.4	22.8	2 116	1 753
OECD Europe average	985	14.3	24.6	1 936	1 614
World	5 208	15.3	22.7	901	660

Source: Energy and Greenhouse Gas Emissions Accounts, Australia, 1992–93 to 1997–98 (4604.0).

The contribution of GHG from Australia's energy sector, which includes transport emissions, was 372 megatonnes (Mt) of carbon dioxide equivalents (CO_2-e) or 69.5% of Australia's net national emissions in 2000 (table 23.2). Transport contributed 14.3% (76 Mt) of net national emissions, an increase of 3.3% of 1999 levels and 24.2% of 1990 levels. In 2000, road transport contributed 90.2% (69 Mt CO_2-e) of transport emissions or 12.9% of net national emissions (table 23.3). Cars contributed 62.4% (43 Mt CO_2-e) of transport emissions or 8% of the net national emissions. Trucks and light commercial vehicles contributed 35.3% (24 Mt CO_2-e) or 6.5% of the net national emissions.

Total emissions

Overall, Australia's emissions per urban passenger kilometre travelled have increased by 7.5% between 1990 and 1999 (1999 figures are the latest reliable figures). Emissions per non-urban passenger kilometre travelled have fallen by 9.7% in the same period, and emissions per tonne-kilometre of freight have decreased by 9.5% since 1991. The volumes of travel have increased in this time as well, leading to a net increase in emissions (AGO 2002).

Emissions by transport mode

Passenger cars contributed 56.3% (43 Mt CO_2-e) of transport emissions, an increase of 22.2% over 1990 levels (table 23.3). The number of vehicles on Australia's roads and number of kilometres travelled have increased, and on-road fuel efficiency has also increased. Liquid petroleum gas, a less polluting source of fuel, has increased its usage level by more than double since 1990.

Truck emissions increased by 33.9% between 1990 and 2000, to 15 Mt. The fuel efficiency of trucks fell by 4% over the same time period (AGO 2002). Light commercial vehicles emissions increased by 31.2% in this period despite an increase in fuel efficiency of 2%. Bus emissions increased by 17.9%.

23.2 CONTRIBUTIONS TO AUSTRALIA'S CO_2 EMISSIONS(a), Selected industries

	1990	1995	1999	2000
	Mt CO_2-e	Mt CO_2-e	Mt CO_2-e	Mt CO_2-e
Energy				
Stationary energy(b)	209	227	260	264
Transport	62	68	74	76
Fugitive emissions from fuels(c)	30	30	31	32
Agricultural	91	88	94	98
Waste and industrial processes	27	24	26	27
Forestry and other	–27	–25	–26	38
Total emissions(d)	**391**	**413**	**458**	**535**

(a) Carbon dioxide equivalents (CO_2-e) are used to standardise the impacts of a range of emissions (such as methane and nitrous oxide) based on their greenhouse effect relative to carbon dioxide. (b) Includes electricity generation. (c) Includes emissions released in the extraction, processing or transportation of fuel types. (d) Sums may not add to totals due to rounding.

Source: AGO 2000; AGO 2001; AGO 2002.

23.3 TRANSPORT EMISSIONS, By mode — 2000

	Mt CO_2-e	% of total transport emissions	% change 1999 to 2000	% change 1990 to 2000
Road transport				
Passenger cars	43	56	2.4	22.2
Other road transport	26	34	4.9	32.8
Domestic aviation	4	6	4.8	68.5
Railways(a)	2	2	—	–7.8
Domestic shipping	2	2	1.5	–33.0
Total emissions	**76**	**100**	**3.3**	**24.2**

(a) Rail figures do not include emissions from electrified rail; these emissions are included in electricity generation emissions.

Source: AGO 2002.

23.4 ESTIMATED GREENHOUSE GAS EMISSION LEVELS, By gas type(a) — 1999

Transport mode	Units	CO_2	CO	NO_x	CH_4	NVMOCS	SO_2	N_2O
Road	(b)Gg	62 355	2 356	340	20.8	405.6	41.0	12.4
Rail	Gg	1 560	5	35	0.1	1.6	2.6	0.1
Civil aviation	Gg	4 109	87	13	0.2	2.7	0.8	0.1
Water	Gg	1 438	127	19	2.4	21.8	14.2	—
Other	Gg	41	4	—	—	0.7	—	—
All transport	**Gg**	**69 503**	**2 579**	**407**	**23.5**	**432.3**	**58.5**	**12.6**
Proportion of total energy-related emissions of specific gas	%	21.5	70.3	27.3	1.8	50.4	8.7	79.0

(a) CO_2: carbon dioxide; CO: carbon monoxide; NO_x: nitrogen oxides; CH_4: methane; NVMOCs: non-methane volatile organic compounds; SO_2: sulphur dioxide; N_2O: nitrous oxide. (b) Gigagrams.

Source: BTRE 2002a.

Emissions from aircraft have increased by an average of 5.4% each year since 1990, due to an increase in domestic air passengers and freight. Coastal shipping emissions were 1.5 Mt in 2000 (2% of transport emissions).

Types of transport emissions

Most transport emissions are CO_2, with small amounts of nitrous oxide and methane (table 23.4). Nitrous oxide emissions have doubled in proportion to other gases, from 2.7% of transport emissions in 1990 to 5.4% in 2000. This has been attributed to the increase in vehicles with catalytic converters and other pollution prevention technology. Three-way catalytic converters reduce emissions, but produce 12% more methane and 154% more nitrous oxide per kilometre than cars with two-way converters or those without pollution control devices. Catalytic converters have been fitted to new cars since 1987, and aim to reduce the contribution of car emissions to air pollution (AGO 2002). For more detail on the environmental impact of emissions, see *Chapter 16, Greenhouse gas emissions*.

Impacts of road transport

Use of road transport

Of the Australian vehicle fleet, passenger vehicles constituted 9.7 million (80%) of the 12.2 million vehicles on Australian roads during the 12 months ended 31 October 2000. Light commercial vehicles were the second most populous vehicle type, with just under 1.7 million vehicles (14%). During this period, the total fuel consumed by Australian vehicles amounted to 24,926 million litres, passenger vehicles accounting for 16,190 million litres (65%). Total kilometres travelled in this time were 180,782 million. These measures all rose in the three years to 31 October 2000 and provide an indication of the growth of the road transport task in Australia (ABS 2001b).

Road transport's fuel efficiency

In 2000 the average rate of fuel consumption of passenger cars was the second lowest (at an average of 11.7 litres (L) per 100 kilometre (km) travelled) after motorcycles (6 L/100 km). The vehicle type with the highest average fuel use was articulated trucks, consuming 52.3 L/100 km). Energy efficiency, while increasing slightly, has been offset by increases in vehicle weights and power outputs. For example, engines have become more efficient, but are bigger and more powerful, leading to only slightly lower fuel use levels per car (ABS 2001b).

The average age of passenger vehicles, the largest component of the vehicle fleet, was 10.1 years at 31 March 2001. Some 44% of the passenger vehicle fleet was 13 years or older and 24% was 8 years or older. The rate of fuel consumption of these vehicles is important.

The Bureau of Transport and Regional Economics has recently published figures on both fuel consumption and engine performance of Australia's passenger vehicle fleet, from the mid 1970s. Trends indicate that both are decreasing, but only slightly, and less than could be expected with the current advance in efficiencies and technology.

Car manufacturers are responding to buyers' demands for bigger, more powerful cars, and as a result, fuel efficiencies and fuel consumption have decreased by slightly more than 10% (BTRE 2002a). Several manufacturers are now offering dedicated LPG fuel vehicles and hybrid petrol and electric vehicles with the aim of reducing the environmental impacts of motor vehicle use. A major initiative of the Australian Greenhouse Office is to encourage the purchase of fuel efficient vehicles by placing a fuel consumption sticker on new cars, showing the on-road fuel efficiencies. Some 24% of Australian households purchased a motor vehicle in the 12 months to March 2000. The environmental impact of the car was the least important factor in households' decision to buy a car (rated most important by only 3% of households), while the cost of the motor vehicle was the major factor (rated as such by 53% of households) (ABS 2000).

Minimising road transport travel demand and vehicle kilometres travelled

Reducing vehicle kilometres travelled (VKT) and managing the demand for transport are key areas for minimising the environmental impact of transport. Overall VKT has increased over time. Passenger vehicles contribute the bulk of VKT (Newton et al. 2001). Initiatives to minimise VKT include programs to reduce the demand for transport, maximise vehicle occupancy rates and maximise uses of public transport services which will reduce fuel use, emissions and congestion. Private vehicles are the most common form of transport to work or school, with 76% of households driving to work or school in 2000. In contrast, 6% walked or cycled, and 12% took public transport. Only 2% took public transport for environmental reasons (ABS 2000).

Road transport's impacts on biodiversity and wildlife

Although only limited research has been carried out, transport is thought to impact on biodiversity and wildlife in several ways. Road transport is responsible for a large number of deaths and injuries to animals each year, although the numbers are difficult to obtain. WIRES (NSW Wildlife Information & Rescue Service) estimates that 3,400 native animals are killed every day on Australian roads. Table 23.5 shows deaths or injuries to native wildlife in New South Wales in 1993–94. Other estimates of roadkill suggest that up to 5.5 million frogs and reptiles are killed on sealed Australian roads each year (Mackey et al. 1998).

Roads themselves impact upon biodiversity and wildlife. Roads are a barrier to movements by some native species, and can isolate species and alter the interactions of wildlife populations as a result. Roads enhance the dispersal and movement of weeds and feral predators. In the same way that species can travel unknowingly in ballast water, seeds and spores can travel on vehicles in mud deposits and colonise new areas, while feral animals (such as cats, dogs and foxes) use the roads as a corridor to move into areas previously unaffected by the feral species (Mackey et al. 1998). Road and track construction can also impact locally on the natural environment, as it can lead to changes in an area's water flows and increase sedimentation in local waterways. Off-road vehicles have an effect on local areas, through increased erosion levels, frightened wildlife, devegetation of adjacent areas and increased access to remote areas, thereby decreasing the wilderness values of areas (ABS 1997).

23.5 NATIVE FAUNA DEATHS OR INJURIES FROM ROAD VEHICLES, NSW — 1993–94

Species	Killed(a)	Injured/ treated(b)	Not requiring treatment(c)	Fate unknown(d)	Total
Birds(e)	1 215	522	13	138	1 888
Kangaroos	154	45	1	96	296
Wallabies	115	20	1	52	188
Koalas	11	4	—	2	17
Possums	247	124	4	35	410
Wombats	19	10	1	9	39
Echidnas	10	5	5	—	20
Reptiles	123	52	11	10	196
Other(f)	25	5	—	2	32
Total	**1 919**	**787**	**36**	**344**	**3 086**

(a) Animals that were found dead on arrival, died after being taken into care or were euthanased while in care. (b) Animals that were either released, taken into permanent care, reunited with parents or owner or were still in long-term rehabilitation. (c) Animals that were left and observed or animals which were relocated without being taken into care. (d) Animals that had disappeared before rescue or those that escaped while in care. (e) Includes wildfowl, water birds, owls, seabirds and other native birds. (f) Includes species such as bandicoots, bats, flying foxes and quolls.

Source: ABS 1997.

Road transport's impacts on urban stormwater

Urban sprawl in cities increases the amount of impervious areas in a catchment area. This leads to increased run-off into local waterways, as less water soaks into the ground. Increased run-off has been linked to the increase in pollution levels of local waterways. Vehicles contribute to this pollution through the buildup of deposits from emissions and from mechanical parts wearing out. Tyres and brake linings (from brake pads etc.) are a major source of heavy metals in urban environments, as are petrol and oil deposits. Cars deposit small amounts of these contaminants as they travel, and as more cars travel the deposits build up. When it rains, the deposits can be washed into the stormwater systems, eventually polluting waterways, estuaries and beaches, where the stormwater is released (ABS 1997).

Road transport's impacts on the urban environment

The quality and distribution of urban transport systems have a major bearing on the livability of urban environments. The private car maintains its place as the dominant form of transport for personal travel (ABS 2000). Cars have had a profound impact on the structure of urban areas, leading to the concept of car-centered urban sprawl. Dispersed cities put greater strain on infrastructure such as water supply and sewerage systems and lead to stalled traffic, excessive noise and polluted air (Brown 2001). Congestion is another product of urban dependence on the private vehicle. The costs of congestion are considerable, as fuel, time and other resources are wasted (Newton et al. 2001). Urban areas have become more congested as more automobiles are being driven and mobility has decreased.

Impacts of marine transport

Australia's coastal environment is threatened by our heavy dependence on international and coastal shipping to transport goods to, from and around the country.

Oil spills cause a significant impact on marine environments. Fortunately, Australia has not suffered a catastrophic oil spill as other countries have. Australia has, however, experienced several spills that have impacted upon the local environment. Some of the major spills are shown in table 23.6. These spills have been the result of various circumstances and have had significantly different impacts. Some spills have been a result of extreme weather forcing vessels, such as the *Korean Star*, to run aground and leak fuel and oil, while other ships have been damaged in ports, allowing the subsequent spill to be successfully contained to minimise the impacts. Several spills occurred in open water, and resulted in the loss of wildlife and severely damaged local environments, such as the spill from the *Arthur Phillip*, which killed or seriously affected 200 fairy penguins. Other spills have been the result of the transfer of cargoes, such as between the *Laura D'Amato* and the *Mobil Refinery*.

23.6 MAJOR OIL SPILLS IN AUSTRALIAN WATERS

Date	Vessel name	Location	Tonnes of oil spilled
20.05.1988	Korean Star	Cape Cuvier, WA	600
28.07.1988	Al Qurain	Portland, Vic.	184
21.05.1990	Arthur Phillip	Cape Otway, Vic.	Unknown
14.02.1991	Sanko Harvest	Esperance, WA	700
21.07.1991	Kirki	WA	17 280
30.08.1992	Era	Port Bonython, SA	300
10.07.1995	Iron Baron	Hebe Reef, Tas.	325
28.06.1999	Mobil Refinery	Port Stanvac, SA	230
03.08.1999	Laura D'Amato	Sydney Harbour, NSW	250

Source: AMSA 2002.

Ballast water, bilge water, sewage, wastes from vessel maintenance and anti-fouling paints cause some of the other environmental impacts associated with shipping. Ballast water, used to stabilise empty ships when travelling to pick up cargoes, presents the potential for major environmental impact. Ballast water is discharged when loading, and may contain invasive non-native organisms that can impact on local environments (Newton et al. 2001). Ballast water can introduce non-native and environmentally harmful organisms, diseases, toxins and parasites that affect humans and ecosystems. At least 55 species of fish and invertebrates and a number of seaweeds have been introduced through ballast water discharge (ABS 1997). Anti-fouling paints are used on vessels to stop organisms growing on hulls. The paints contain toxic chemicals that leach into the surrounding water, polluting harbours and waterways.

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24 Environmental views and behaviour[1]

Concerns about environmental problems

The attitudes of Australians influence decision-making on environmental issues. Australians appear to have become less concerned about environmental problems during the last decade. In 1992, three out of four Australians (75%) stated that they were concerned about the environment, but this level of concern fell to 62% in 2001. The decline in the level of concern is most pronounced among young Australians (aged 18–24), only 57% of whom expressed concern about the environment in 2001 compared to 79% in 1992. People in the 45–54 age group contained the largest proportion expressing concern about environmental problems (69% in 2001), while older people (65 years and over) contained the smallest proportion (51% in 2001) (graph 24.1).

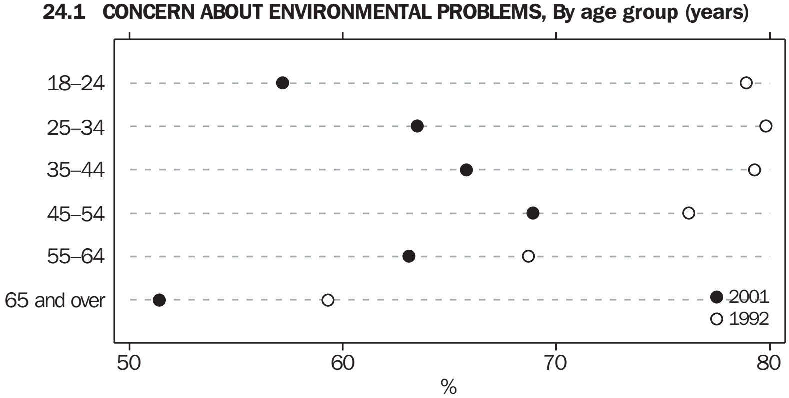
Registration of environmental concerns

Of those who stated concern about environmental problems, less than one in 10 (8%) registered their environmental concern by writing letters, telephoning, participating in a demonstration, signing a petition or making some other form of official expression. Of those who registered concern, 37% signed a petition, 33% wrote letters and 27% used the telephone. The least favoured method of registration was participation in a demonstration (6%) (graph 24.2).

Of those registering environmental concerns, younger people (aged 18–24) were the most likely to sign a petition (60%) or participate in a demonstration (10%) to register their concern, and were more than twice as likely to pursue these options than those aged 55 and over. People aged 45 and over were most likely to register their concern by writing letters.

Only 7% of Australians stated that they belonged to an environmental group. Younger people reported the highest membership in environmental groups (9%). Of those who were members of an environmental group, the majority (62%) belonged to non-specific environmental groups. Membership was highest for landcare or catchment management groups (36%), more than three times that of marine conservation groups (11%).

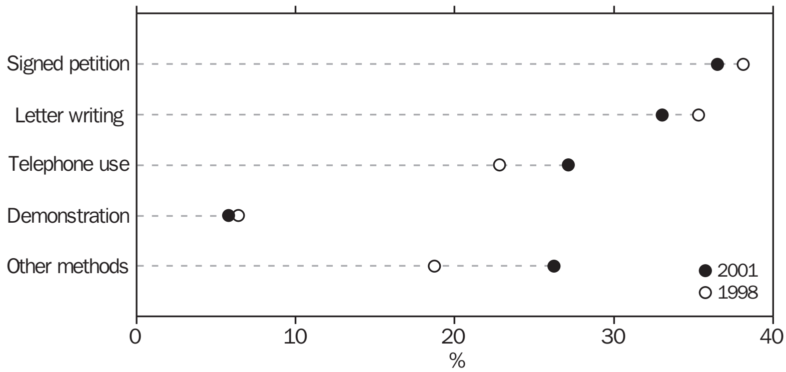
24.1 CONCERN ABOUT ENVIRONMENTAL PROBLEMS, By age group (years)



Source: ABS 2001.

1 From *Chapter 14, Environment* in *Year Book Australia 2003.*

24.2 METHOD OF REGISTRATION OF ENVIRONMENTAL CONCERN



Source: ABS 2001.

Donation of time or money to environmental protection

As concern about environmental issues has declined among Australians, so has the time and money donated by households to environmental protection. In 1992, more than 28% of Australians stated that they donated time or money to environmental protection, compared with only 20% in 2001. While people aged 35–44 ranked highest in terms of contribution at 23%, the same group registered the highest decline in contribution (13%) from 1992 (graph 24.3).

Time was the main factor limiting involvement in environmental actions. Nearly half (49%) of Australians claimed that they had 'no time' for such involvement. 'Age, health or inability' was the next most likely reason (10%), particularly for people aged 65 and over (46%). Only 5% of respondents stated 'no money' as the main reason for non-involvement.

Comparison of environmental views and practices across states and territories

Environmental views and practices differ across states and territories. People in the Australian Capital Territory reported the highest level of concern about environmental problems (71%), followed closely by South Australia and Western Australia (70% and 69% respectively). New South Wales and Tasmania reported the lowest levels of environmental concern in 2001 (59% and 60% respectively). Since 1992, Tasmania has consistently reported lower levels of environmental concern than other states and territories.

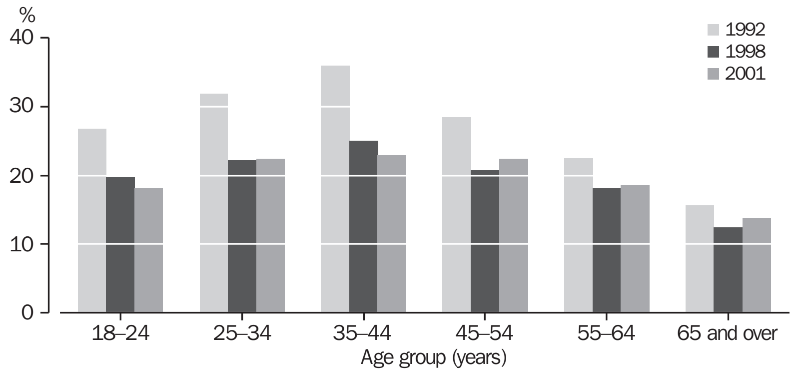
Registration of environmental concerns by Australians fell across all states and territories (except South Australia) between 1992 and 2001. Western Australians were the most likely to register their environmental concerns (12%) and people in the Australian Capital Territory were least likely to do so (7%) in 2001.

People in South Australia and Western Australian were the most likely to contribute time or money towards environmental protection; in both states, one in four provided such support in 2001.

Water supply, quality and conservation

Water is essential for all living organisms. Australia is considered one of the driest inhabited continents (Smith 1998). Relative to other continents, Australia is also characterised as having variable climatic conditions and high levels of evapotranspiration. These factors result in a low proportion of rainfall converted to streamflow (Pigram 1986), making freshwater a valuable resource. All Australians are affected by the provision and availability of good quality water.

24.3 DONATION OF TIME OR MONEY TO ENVIRONMENTAL PROTECTION



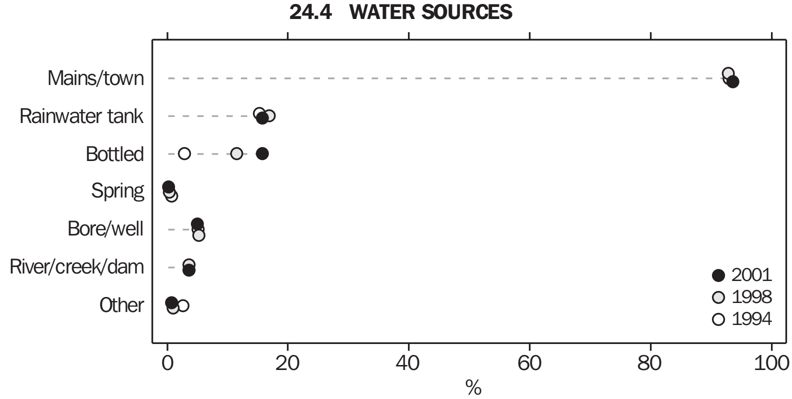
Source: ABS 2001.

Water supply

Mains or town water is the most common source of domestic water supply in Australia. Over nine in 10 (94%) Australian households received their domestic water supply from this source in 2001 (graph 24.4). Mains water was fully established in the Australian Capital Territory (100%). Tasmanians were the least likely to have mains water supply; in Tasmania 87% of the households were connected to it. Rainwater tanks and bottled water were the next most important sources of water (both 16%) after mains water supply. South Australians were the most likely to depend on these sources of water (on rainwater by 52%, and on bottled water by 27%); both shares were more than twice the national average dependency on those sources of water.

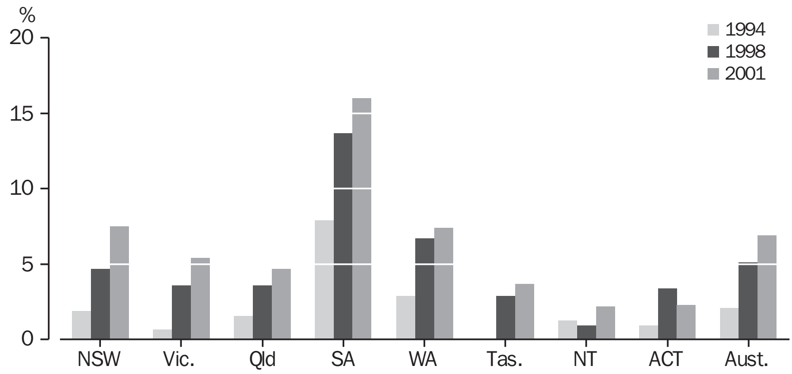
Bottled water has become an increasingly important source of drinking water across Australia since 1994 (7% dependency in 2001, compared with 2% in 1994). Except for the Australian Capital Territory, all states and territories showed a rising trend in the consumption of bottled water. Since 1994, South Australia consistently ranked highest for use of bottled water as a source of water (from 9% in 1994 to 24% in 2001). South Australians were the most likely to rely on bottled water as their main source of drinking water (16%), which was more than twice the national average. People in New South Wales (8%) and Western Australia (7%) reported the next highest degree of dependency (graph 24.5).

24.4 WATER SOURCES



Source: ABS 2001.

24.5 BOTTLED WATER AS MAIN SOURCE OF DRINKING WATER



Source: ABS 2001.

Water quality

Water quality can be affected by a number of factors including bacterial contamination and physical or chemical changes such as turbidity, colour and acidity. Treating water with chlorine can affect its taste. The national water quality guidelines, the *Australian Drinking Water Guidelines 1996*, are endorsed by the National Health and Medical Research Council and the Agriculture and Resource Management Council of Australia and New Zealand. These guidelines are not mandatory standards, but represent a framework for identifying acceptable water quality through community consultation (WSAA 2001).

In 2001, over a quarter (27%) of Australians were not satisfied with the quality of tap-water for drinking (graph 24.6). South Australians were the most dissatisfied (42%), to the extent that 10% of people indicated they did not drink any tap-water at all. This was four times the national average. Dissatisfaction with the quality of tap-water for drinking has declined in most states and territories, the exceptions being South Australia and Tasmania. People in the Northern Territory were the most satisfied with the quality of tap-water for drinking (90%).

Several problems affected the quality of mains tap-water for drinking. Half of those who expressed dissatisfaction with quality of drinking water (52%) nominated taste as the reason for their dissatisfaction (graph 24.7). About a third stated chlorine as a problem (32%). Other common complaints included: dirty water (16%); odour (16%); colour (15%) and microbial or algae contamination (14%). Since 1998, the proportion of Australians concerned about the different problems associated with water quality declined, except in relation to chlorine, which registered a small increase in concern (30% in 1998; 32% in 2001).

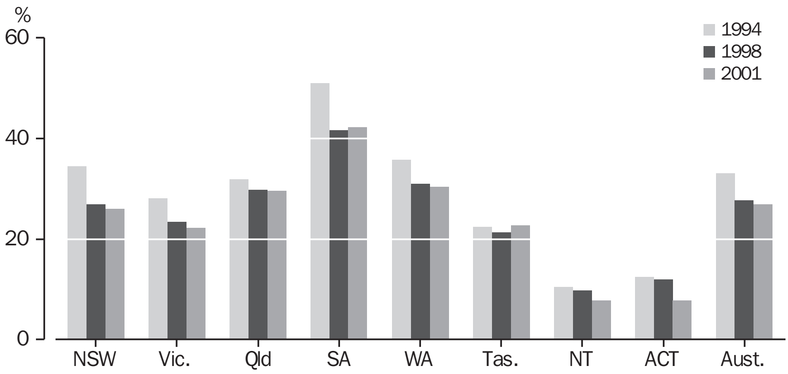
South Australian households registered the highest levels of dissatisfaction with taste (65%), followed by Western Australian households (58%). Northern Territorians were the most likely to complain that the tap-water was salty (5%). About 4% of South Australians also mentioned this problem. This corresponds with research by the Commonwealth Scientific and Industrial Research Organisation which found that salt concentrations in several Adelaide Hills catchments periodically exceeds Australian drinking water guidelines (Newton et al. 2001).

Water conservation

Australian households used 1.8 million megalitres of water in 1996–97, making households the second largest user of water after the agriculture sector (ABS 2000). Therefore, water conservation methods at home can make a significant contribution to reducing the total amount of water consumed.

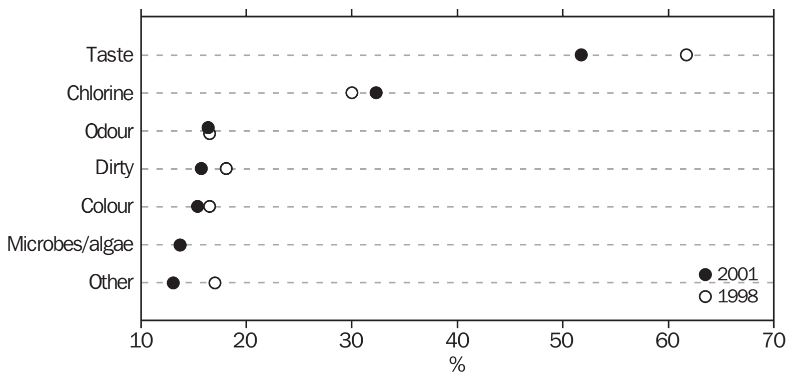
Household water conservation can be achieved through both the use of devices such as dual flush toilets and reduced flow shower heads and behavioural practices like having shorter showers.

24.6 DISSATISFACTION WITH TAP-WATER QUALITY FOR DRINKING



Source: ABS 2001.

24.7 QUALITY PROBLEMS WITH MAINS TAP-WATER FOR DRINKING



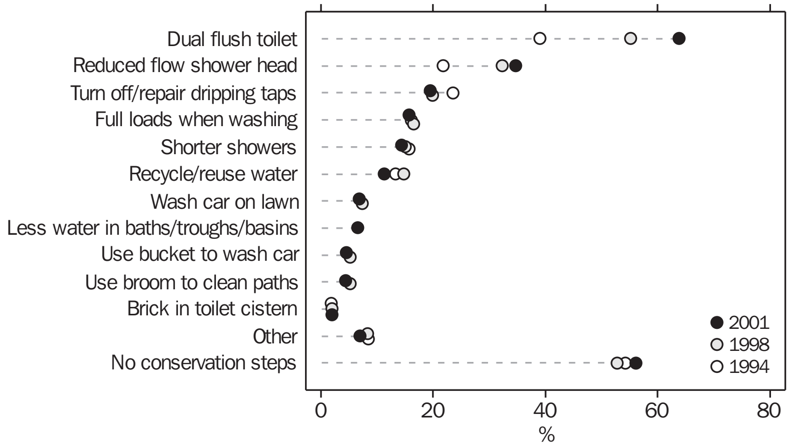
Source: ABS 2001.

In relation to water conserving devices, 64% of households had a dual flush toilet (up from 55% in 1998), and 35% of households had a reduced flow shower head (up from 32% in 1998) (graph 24.8). Just over a quarter of Australian households (27%) did not have either of these items.

Turning off or repairing dripping taps was still the most common behavioural practice reported by Australian households in 2001 (20%). The second most common practice was having full loads of washing (16%), followed by having shorter showers (14%). The overall commitment to saving water in the household by behaviour modification slipped slightly over the years, with 56% of households reporting that they did not adopt any behavioural practice to conserve water in 2001. This compares with 53% in 1998 and 54% in 1994.

Victorian households were the most likely to practise water conservation, with just over half (51%) of households reporting taking some steps. This is a significant increase on 1994 figures, when 40% of Victorians took specific water conservation steps. In contrast, several states including New South Wales, Queensland and Western Australia, and the Australian Capital Territory, showed a significant decline in households taking water conservation steps.

24.8 WATER CONSERVATION METHODS, Devices and behavioural practices



Source: ABS 2001.

Just over half (58%) of Australian households with a garden reported that they regularly conserve water in the garden, with a further 3% reporting that they sometimes use water-saving measures. Home gardeners in Western Australia were the most committed (68%) and those in New South Wales were the least likely to do so (50%).

The main method used by Australian home gardeners was to water either early in the morning or late in the evening when it was cooler (graph 24.9). The next two most common practices were to water less frequently but for longer periods (20%), and to use recycled water (18%). Around one in 10 households with a garden reported that they did not bother to water the garden at all but only relied on rainfall.

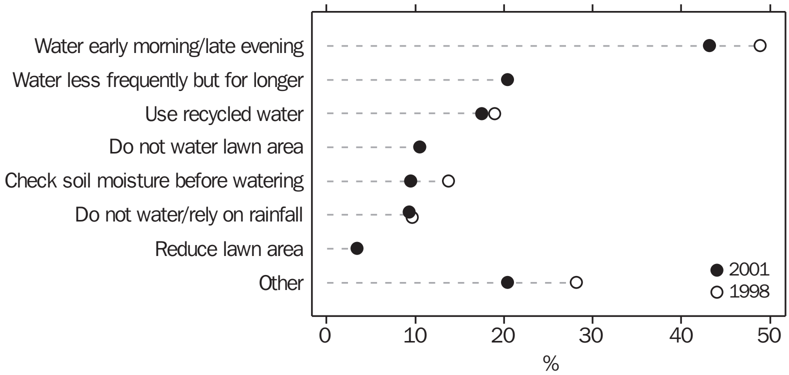
Over two-thirds (69%) of Australian households with a garden used mulch in 2001. Nearly three-quarters of those using mulch in the garden did it to conserve water (74%), while over a third mulched to reduce weeds (36%). Around 58% of households with gardens planted native trees or shrubs, with the highest proportion occurring in the Australian Capital Territory (66%). However, only around 18% of households planted natives for their water-conserving attributes.

Household waste management

Australia is among the top 10 solid waste generators within the Organisation for Economic Co-operation and Development (OECD) (OECD 1999). The primary pressure from waste generation is the need for disposal, and the consequent environmental impacts. The main form of waste disposal in Australia is landfill, which accounts for over 95% of solid waste disposal in some states and territories (Newton et al. 2001). The impacts of landfill disposal include: use of land that could otherwise be used for another purpose; potential leachates from toxic wastes; release of methane from the decomposition of organic wastes; and greenhouse gas emissions through the transportation of wastes to landfills, which are mostly on the fringes of cities (Newton et al. 2001).

Wastes are generally categorised as either urban solid wastes or hazardous wastes. Urban solid wastes are further classified into three types: municipal (domestic and council); commercial and industrial; and construction and demolition. Approximately 40% of all solid wastes are municipal, much of it from domestic households. The rate of household waste disposal in Australia is among the highest 10 in the OECD. Based on 1996–97 data, the per capita disposal of domestic waste in Australia was approximately 400 kilograms per year (OECD 1999). Waste from households typically includes garden wastes, paper, glass, plastic and food wastes.

24.9 WATER CONSERVATION METHODS IN THE GARDEN



Source: ABS 2001.

The guiding principles for current waste management strategies are represented by the waste minimisation hierarchy. This strategy is aimed at providing options to avoid generating waste in the first place, and extracting the maximum benefits from the waste. The hierarchy begins with reducing waste, following by reusing and recycling, then recovery of heat energy such as methane, and finally treatment and disposal. This strategy embraces a life-cycle approach whereby reusable and recyclable waste may be used as an alternative to traditional resource inputs. Therefore, not only is waste reduced but some of the pressures on natural resources are alleviated.

Reducing

Reducing waste means preventing waste generation in the first place. Householders can avoid generating waste by bulk buying, using refillable containers, composting food scraps, choosing products with minimal packaging, buying products that are built to last, and refusing disposable carry bags. Other methods of reducing waste are to use durable, long-lasting goods instead of disposable ones, in order to reduce the input of virgin materials by consuming less.

Reusing

Reusing involves using something more than once, either in its original form, or for a different purpose. Examples include using refillable containers, donating old clothes to other family members or charities, and buying secondhand or antique furniture. Reuse for a different purpose includes using paper, cardboard and packaging for children's art and craft activities, and reusing glass and plastic containers.

Recycling

Recycling infers processing of products or materials into similar products or using them as secondary raw materials for producing new products. Usually less energy is consumed, less virgin material is used (avoiding further environmental damage), and landfill space is saved.

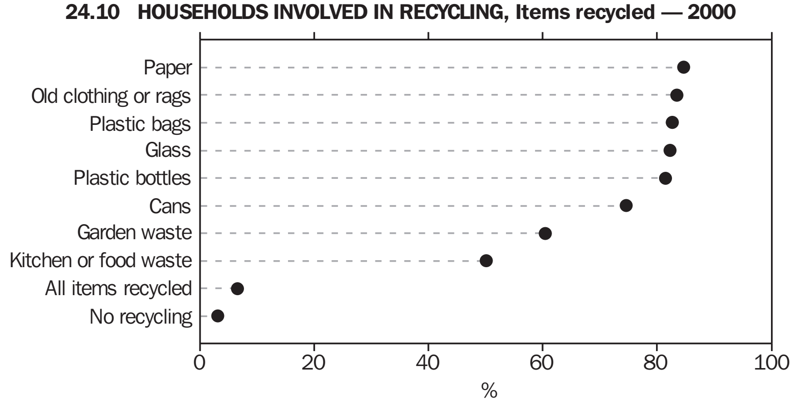
Household recycling increased in Australia during the 1990s: in 1992 around 85% of people recycled at least one item of their household waste; by 2000 the vast majority of Australians (97%) practised at least some recycling, with 7% doing so for all recyclable items. Paper, old clothing, plastic bags and glass were the items most commonly recycled (graph 24.10). The preferred method for household recycling of paper (by 87% of households), glass (by 88%), cans and plastic bottles (both by 89%) was a collection service from the dwelling. For plastic bags, reuse was the most popular option. Around two-thirds of Australian households composted or mulched their kitchen or food waste (67%) and garden waste (71%). Old clothes or rags were usually (73%) taken to a central collection point such as a charity depot.

As more Australians have become involved in recycling, the proportion of households not participating declined from 15% in 1992 to only 3% in 2000 (graph 24.11). Lack of recyclable materials was the main reason for households not recycling, and these households were most likely to be composed of people living alone.

Use of environmentally friendly products (EFPs)

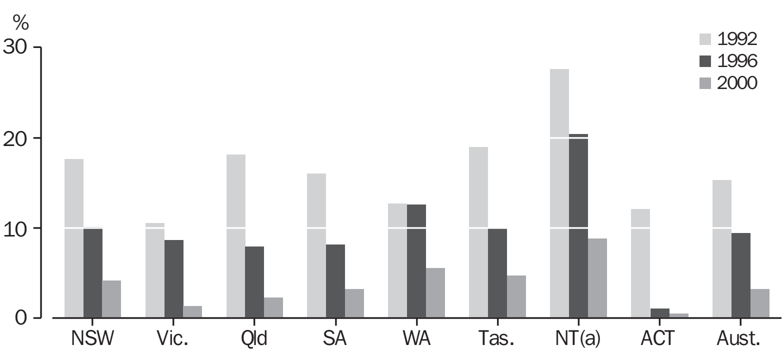
EFPs are important for reducing waste produced within households as they generally take less natural resources to produce and generate less waste than their counterparts. In 2001, the most widely used EFPs in Australian households were refillable containers, followed by recycled paper (table 24.12). More than half of all Australian households claimed they do not eat organically grown fruit and vegetables (56%) and nearly one in two households did not use unbleached paper (45%) or phosphate-free cleaning products (43%).

24.10 HOUSEHOLDS INVOLVED IN RECYCLING, Items recycled — 2000



Source: ABS 2001.

24.11 HOUSEHOLDS NOT RECYCLING ANY WASTE



(a) NT data refer mainly to urban areas.

Source: ABS 2001.

24.12 USE OF EFPs(a)

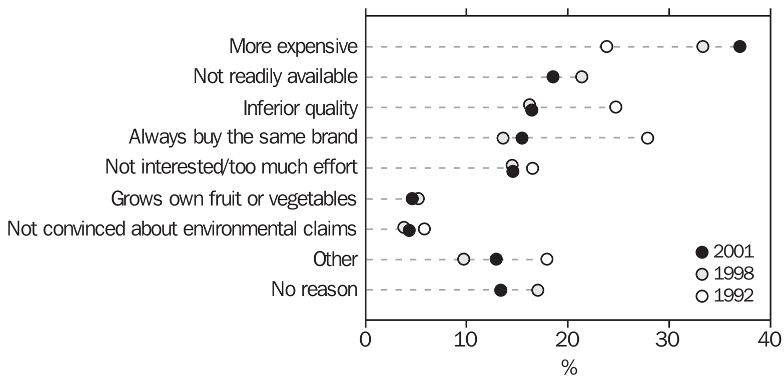
	1992	1998	2001
	%	%	%
Refillable containers	63.3	72.4	64.5
Phosphate-free cleaning products	37.7	42.5	39.5
Unbleached paper	63.4	52.2	51.3
Recycled paper	67.9	71.1	69.8
Organically grown fruit and vegetables	(b)	39.8	41.8

(a) For 1998 and 2001, includes households which sometimes use EFPs. (b) Respondents were not asked about organically grown fruit and vegetables in 1992.

Source: ABS 2001.

Cost was the single most important factor which prevented households from using EFPs (graph 24.13). Over a third of households (37%) which did not use them believed that these products were more expensive to buy. About 4% were not convinced of the environmental benefits.

24.13 REASONS EFPS NOT USED



Source: ABS 2001.

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25 Accounting for the environment in the national accounts[1]

Introduction

The economy has a complex relationship with the environment. The environment provides the raw materials and energy for the production of goods and services that support our lifestyles, but it also sustains damage through the activities of households and businesses. The national accounts are sometimes criticised for including the value of goods and services produced and the income generated through the use of environmental assets, but not reflecting the economic cost of depleting those assets or the damage that arises from economic activity. This anomaly is well recognised by national accountants, as are a number of other deficiencies relating to the use of national accounts as a comprehensive measure of the 'wellbeing' of society (e.g. the value of unpaid housework is excluded from gross domestic product (GDP)).

This chapter discusses how the environment is currently treated in the national accounts, and gives a broad overview of the work being done by the ABS to extend the core national accounts in what could be called a satellite account for the environment.

International standards

The national accounts are a macroeconomic data set revolving around the central economic concepts of production, income, expenditure and wealth. They also comprise a monetary system, and therefore rely substantially on being able to measure the money transactions taking place between the various economic agents in a market economy. The Australian system of national accounts (ASNA) is based on the latest international standard, *System of National Accounts 1993* (SNA93).

While the environment clearly provides services to the economy, these are often provided at no cost or are implicit in the value of goods and services rather than in explicit transactions. Environmental assets are often not controlled by economic agents because of their physical nature, or in some cases are so plentiful that they have a zero price. For this reason, the valuation of environmental flows and stocks is fraught with conceptual and practical difficulties. Nevertheless, international research has been proceeding over a number of years and substantial progress has been made in sorting out the issues and concepts, although there is still limited experience in practical measurement.

The United Nations Statistical Division published an interim handbook *Integrated Environmental and Economic Accounting* in 1993. Over the last few years it has been redeveloped and extended by an international expert working group consisting of national accountants and environmental accountants. The revised handbook, titled the *System of Integrated Environmental and Economic Accounting* (SEEA), is currently in final draft stage and has recently been endorsed by the United Nations Statistical Commission for publication. It will provide a detailed conceptual and classification framework for environmental accounting and should provide an impetus for the advancement of environmental accounting internationally. Some of the material in the handbook relates to a clarification of the measurement of environmental assets in the traditional system of national accounts, but much of it concerns material that could be developed in a satellite account separate to the traditional accounts. Satellite accounts provide the freedom to develop alternative concepts, classifications and measurement techniques which are different, but at the same time retain a connection back to the national accounts based on SNA93.

The environmental accounting work being done by the ABS is consistent with the recommendations in SEEA.

1 From *Chapter 29, National accounts* in *Year Book Australia 2003.*

Natural resources in the ASNA

Stocks

The national and sector balance sheets record the value of environmental assets that are defined as being within the scope of the system of national accounts — known as the asset boundary. For an asset to be included within the asset boundary of the national accounts it must have an identifiable owner, and the owner must be able to derive an economic benefit from the use of the asset. Assets included are those termed economic environmental assets, such as subsoil assets, land, forests, water, and fish stocks in open seas, that are under the control of an economic agent (often the government).

Environmental assets such as atmospheric and terrestrial ecosystems are outside the scope of economic assets as they do not have an identifiable owner who can derive an economic benefit from their use. This is not to suggest that these assets are of no value. On the contrary, many of them are essential to life itself. However, even if they fell within the definition of an economic asset, the valuation techniques available to measure such assets tend to be arbitrary and controversial.

The environmental assets on the Australian national and sector balance sheets are land, subsoil assets and native standing timber. Land valuations are available through administrative sources, and net present value (NPV) techniques (which take into account current production rates, prices, costs, and discount rates) are used to value both subsoil and native forest assets. Plantation standing timber could also be considered an environmental asset, and plantations are included in the balance sheet as inventories because timber growth is controlled. Water and fish stocks have not been included on the Australian national balance sheet due to a lack of available data.

The Australian national balance sheet recorded $3,459b worth of assets as at 30 June 2001, of which $1,160b (33%) were economic environmental assets (table 25.1).

While land accounts for 84% of the value of Australia's economic environmental assets, the value of rural land accounts for only 12% of the total value of land. Subsoil assets account for 15% and timber (native and plantation) accounts for 1% of Australia's economic environmental assets (based on table 25.2). No values are included for water or fish stocks, or other environmental assets outside the SNA 93 asset boundary.

The value of environmental assets in current prices grew strongly during the 1990s, increasing by 84% between 30 June 1993 and June 30 2001. Much of this growth was due to rising prices. Environmental assets grew in volume terms by 18% during the same period (based on table 25.3).

25.1 AUSTRALIA'S TOTAL ASSETS, Current prices — As at 30 June

	1993	1994	1995	1996	1997	1998	1999	2000	2001
	$b	$b	$b	$b	$b	$b	$b	$b	$b
Financial	145	169	185	193	230	300	316	396	440
Buildings and structures	934	973	1 024	1 067	1 107	1 159	1 236	1 318	1 399
Machinery and equipment	251	257	265	268	274	291	301	312	317
Other produced	96	101	107	104	106	111	118	129	138
Other non-produced	—	—	—	—	—	—	—	3	6
Environmental	631	676	721	736	816	882	966	1 062	1 160
Total assets	**2 057**	**2 176**	**2 301**	**2 368**	**2 533**	**2 742**	**2 937**	**3 221**	**3 459**

Source: ABS 2002.

25.2 AUSTRALIA'S ENVIRONMENTAL ASSETS, Current prices — As at 30 June

	1993	1994	1995	1996	1997	1998	1999	2000	2001
	$b	$b	$b	$b	$b	$b	$b	$b	$b
Rural land	60	65	68	86	91	101	105	110	115
Other land	498	532	557	557	619	669	730	797	861
Oil and gas	38	43	49	49	51	48	51	61	76
Other subsoil	28	28	38	35	46	55	69	83	97
Native standing timber	2	2	2	2	2	2	2	3	3
Plantation standing timber	5	6	6	6	7	8	8	8	8
Total assets	**631**	**676**	**721**	**736**	**816**	**882**	**966**	**1 062**	**1 160**

Source: ABS 2002.

25.3 AUSTRALIA'S ENVIRONMENTAL ASSETS, Chain volume measures(a) — As at 30 June

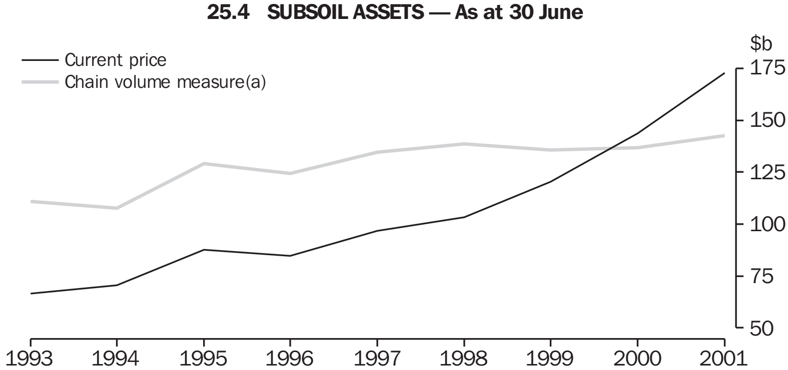
	1993	1994	1995	1996	1997	1998	1999	2000	2001
	$b	$b	$b	$b	$b	$b	$b	$b	$b
Land	781	805	824	805	824	839	860	886	908
Subsoil assets	110	108	129	124	135	139	136	137	143
Native standing timber	3	3	3	3	3	3	2	2	2
Plantation standing timber	6	7	7	7	7	8	8	8	8
Total assets	**900**	**922**	**963**	**939**	**969**	**988**	**1 006**	**1 034**	**1 061**

(a) Reference year for chain volume measures is 1999–2000.

Source: ABS 2002.

Chain volume estimates of subsoil assets increased by 29% between 30 June 1993 and 30 June 2001, compared with growth of over 160% in current prices (graph 25.4). The strong volume growth has been due to new discoveries exceeding extractions during this period. The current price growth has been driven by increasing prices in significant minerals such as iron ore, magnesite, crude oil, condensate, and LPG, and falling real discount rates. Minerals deposits cannot be extracted all at once, but are extracted over a long time period, and a discount rate is needed to calculate the NPV of future extractions.

25.4 SUBSOIL ASSETS — As at 30 June



(a) Reference year for chain volume measures is 1999–2000.

Source: ABS 2002.

The volume estimates of native standing timber fell by 8% over the same period, while the current price estimates were increasing (graph 25.5). Volume estimates have fallen due to logging of native forests and the protection of some forests, resulting in their removal from the economic production boundary of the national accounts.

While the area of land is unlikely to change very much during the normal course of events, volume change also includes changes in quality due to natural processes, soil conservation and other land improvement measures, land degradation due to human activity, and the rezoning of land so that it is available for higher value uses. The practical task of splitting value changes into their price and volume components is a difficult one. As an interim approach, the ABS has calculated the growth in volume of urban land at half the rate of growth in the volume of overlying construction. Zero volume growth is assumed for rural land. This assumes that land degradation, reclassification and land improvement net to zero for rural land.

Transactions — the national income, expenditure and production accounts

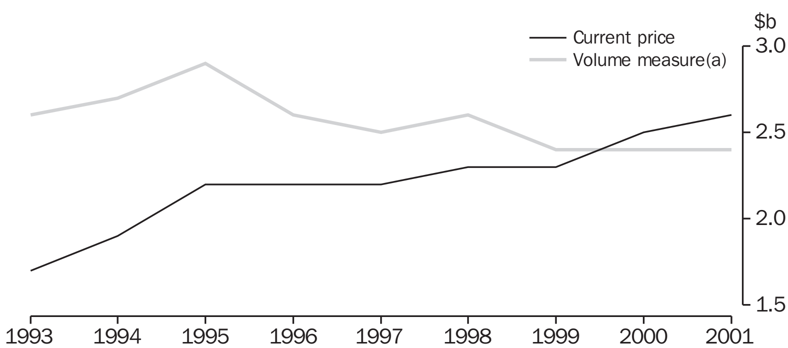
The transaction accounts of the ASNA measure production, incomes, consumption, capital and financial flows during the accounting period. GDP is the most readily identifiable statistic from the national accounts. Of most interest in the context of environmental accounting is the way environmental assets are used in the production process to produce goods and services for consumption, capital investment or export. However, the services provided by the environment are often either implicit in the values for other items or they are excluded as they are costed at zero price.

Where there are explicit rents for the use of natural assets, they are shown in the item 'rent on natural assets' in the sector income accounts. The general government sector received $2.6b in resource rents in 2000–01 (mainly from petroleum, mining and forestry royalties). Many environmental assets (e.g. land) are used by their owners for which there is no money transaction.

In terms of GDP, the value of the services provided by the environment are implicit in the value of the output of the products produced and the incomes derived from their sale. In 2000–01, the current price industry gross value added of the agriculture, forestry and fishing industry accounted for 3.5% of total gross value added, while the mining industry accounted for 5.2%. The value added also reflects the input of labour and produced capital, as well as natural capital.

The value of new additions to environmental assets, such as discoveries of subsoil assets or natural growth in native standing timber, is not included as income or GDP. However, the cost of mineral exploration is regarded as fixed capital formation, and is reflected in GDP as the creation of an asset.

25.5 NATIVE FOREST ASSETS — As at 30 June



(a) Reference year for volume measure is 1999–2000.

Source: ABS 2002.

As mentioned, no deduction is made from income for the depletion or degradation of the natural environment. Thus, '...a country could exhaust its mineral resources, cut down its forests, erode its soil, pollute its aquifers, and hunt its wildlife to extinction, but measured income would not be affected as these assets disappeared' (Repetto et al. 1989).

A satellite account for the environment

The national accounts have a wide range of potential uses for policy making and economic and social research, and thus it is unlikely that the core accounts will be able to meet all possible objectives. In recognition of this, satellite accounts allow for a more flexible approach by providing frameworks that are linked to the national accounts, but focusing on a certain aspect of social or economic life. Satellite accounts also allow for standard concepts to be varied to suit particular studies within the context of the national accounts.

An environmental satellite account could take a number of forms and have a number of layers of detail. The ABS work program has focused on compiling asset accounts and accounts which decompose the changes in the value of assets during a period. The latter accounts can be used for adjusting the national accounts for the depletion of and additions to specific environmental assets in a satellite account framework.

Measuring depletion

Depletion is defined in the SNA93 (12.29 and 12.30) as the:

> ...reduction in the value of deposits of subsoil assets as a result of the physical removal and using up of the assets, ... the depletion of water resources, and the depletion of natural forests, fish stocks in the open seas and other non-cultivated biological resources as a result of harvesting, forest clearance, or other use.

Depletion in an economic sense results because the value of the resource stock has been lowered through its use in a productive activity, and the use has reduced the asset's ability to produce an income stream in the future. In this sense depletion is analogous to depreciation of produced assets whereby the current value of the stock of fixed assets declines from normal use.

Physical depletion may not necessarily equate to economic depletion in cases where asset values are low or the resource life is long. While the physical dimension of depletion can be fairly readily observed in practice, its value cannot. This is because the mineral or other natural resource product is not what is being valued — rather it is the decline in the value of the mineral asset below the ground or of the standing timber in the forest. Generally, one has to resort to capital theory to undertake this valuation. In capital theory the value of depletion is a derivative of the amount of the resource extracted and the resource rent.

The resource rent is the value of the flow of capital services provided by a natural asset. It is calculated as the value of the output of the natural resource production (e.g. coal, oil) after the intermediate expenses, returns to labour (wages), returns to produced capital (profits accruing from the use of produced capital), and return to government (taxes) have been removed. Algebraically, the resource rent is represented as:

$$RR = (p - c) * Q$$

where RR = resource rent, p = unit price,
c = unit cost (includes wages, intermediate costs, normal return to produced capital, and taxes),
Q = quantity extracted.

The resource rent in each period is discounted to derive the NPV of the natural asset:

$$V_t = \sum_{t=1}^{n} \frac{RR}{(1+r)^n}$$

where V = NPV, r = discount rate, n = asset life.

Depletion can be shown to be equal to the resource rent in the year minus a return (income) on the natural resource asset.

$$d_t = V_{t-1} - V_t = RR_t - rV_t$$

where d = depletion.

Where the total stocks of an asset are unknown, discoveries of new stocks of subsoil assets or growth in biological assets may increase the stock of a resource so that the level of currently exploitable reserves from which the economic valuation is derived is rising rather than falling. How to account for additions is a vexed issue. In the national accounts, the value of mineral exploration is included as a separate produced asset and is therefore in income and GDP. It could be argued that this should be replaced with the actual value of discoveries.

The following sections focus on subsoil, land and forest assets respectively.

Subsoil assets

Subsoil assets are considered to be economic when they have a high geological assurance, extraction is expected to be profitable at the prevailing price and technology, and they are owned by an economic entity (usually the government). In the Australian balance sheets economic demonstrated resources include both proven and probable reserves.

Although SNA93 recommends that assets should be valued at their current market price, for many natural assets it is not possible to observe the market price directly as there is little trading of undeveloped stocks in the marketplace. The next best method is to value assets as the NPV of the future expected earnings, which is theoretically equivalent to the market value. This is the approach adopted in the national balance sheet and in deriving estimates of the value of depletion and additions to subsoil assets presented in table 25.6.

Year-to-year changes in the value of subsoil assets for Australia can be decomposed into revaluations, depletion and discoveries. Revaluations capture the change in prices of the existing stock.

The depletion in any one year is the change in the value of the asset between the beginning and end of the year arising purely from the extraction of minerals. As can be seen from graph 25.7, the depletion of crude oil accounts for a high proportion of the total depletion estimate. This is a reflection of crude oil's relative scarcity and high value.

A discovery occurs when previously unknown stocks of minerals are found and delineated. It is valued using the same NPV techniques described earlier. In the national accounts the value of a new discovery in itself is not considered as production or income because it is a gift of nature. However, the cost of mineral exploration is considered as production and included in income and GDP.

One approach that could be considered in a satellite account is to include the value of a discovery as production and income and to treat the exploration cost as intermediate input to the production of discoveries. As shown in graph 25.8, the value of discoveries shows an erratic pattern which, under such an approach, would flow through to income. A possible variation on the concept could be to record the value of discoveries as an accrual over the average period of exploration in order to smooth the income flow.

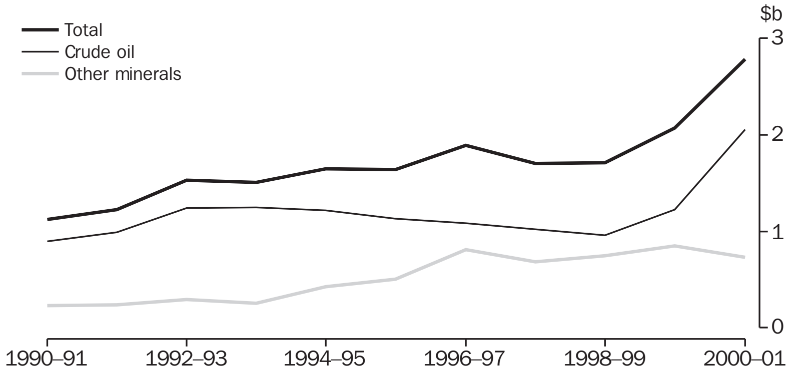
As long as the value of discoveries continues to outpace or equal the value of depletion the activity can be seen to be sustainable. This is illustrated in graph 25.9.

25.6 RECONCILIATION OF OPENING AND CLOSING VALUES FOR SUBSOIL ASSETS, Current prices

			Volume changes		
	Opening stock	Revaluation	Depletion	Discoveries	Closing stock
	$m	$m	$m	$m	$m
1990–91	52 020	4 653	–1 126	841	56 388
1991–92	56 388	–27	–1 228	634	55 768
1992–93	55 768	9 586	–1 531	2 737	66 559
1993–94	66 559	1 946	–1 509	3 470	70 466
1994–95	70 466	17 185	–1 650	1 542	87 543
1995–96	87 543	–2 846	–1 640	1 664	84 721
1996–97	84 721	13 332	–1 892	583	96 743
1997–98	96 743	6 558	–1 703	1 762	103 361
1998–99	103 361	15 716	–1 710	3 050	120 416
1999–2000	120 416	23 203	–2 073	2 383	143 929
2000–01	143 929	28 944	–2 785	2 785	172 873

Source: ABS 2002.

25.7 SUBSOIL DEPLETION

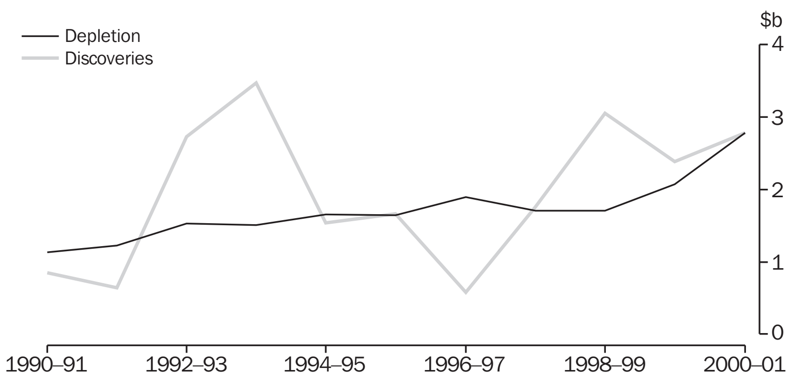


Source: ABS 2002.

25.8 SUBSOIL DISCOVERIES

Source: ABS 2002.

25.9 SUBSOIL DEPLETION AND DISCOVERIES



Source: ABS 2002.

Land/soil assets

Where land is used sustainably, it has an infinite life and therefore no adjustment for depletion is required — the whole value of the resource rent would rightly be considered as income. However, where land is being degraded due to economic activity, an adjustment to income for land degradation is applicable. As for subsoil assets discussed above, any economic costs should be offset against the benefits (income) derived from agricultural land use.

In the context of economic depletion used here, land degradation represents the year-to-year decline in the capital value of land resulting from economic activity (after deducting price rises due to inflation). Looked at another way it is equivalent to the year-to-year change in the NPV of the lost resource rent resulting from the declining productive capacity of the land. As such, it stops well short of a full measure of the cost of land degradation such as the cost to environmental systems and public infrastructure. The latter would, however, be captured in the national accounts estimates for consumption of fixed capital.

Changes in the value of agricultural land can be ascertained from data on market values or land rates data. However, data for land values are affected by a host of factors other than changes in productive capacity from the impact of land degradation, including inflation, technological advances and changes in land use due to rezoning, subdivision and 'lifestyle' considerations (Roberts 1997).

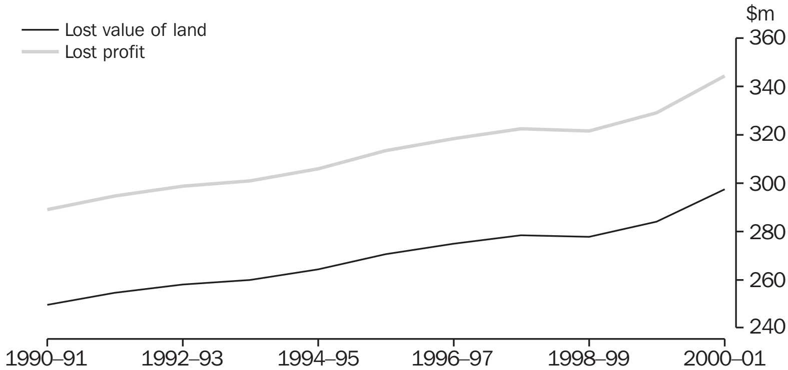
Two recent national studies used different approaches to measuring economic losses due to land degradation:

- Kemp and Connell (2001) used a farm survey to ascertain the extent of land degradation on farms. Combining data from the survey with land value data, regression techniques were used to estimate that the difference in the capital value of farms with and without degradation was approximately $14.2b in 1999. This represents the accumulated value of losses in land value due to degradation.
- The National Land and Water Resources Audit (2002) used models to estimate the 'yield gap', that is, the difference between profits with and without soil degradation. Lost profit at full equity due to salinity, sodicity and acidity was estimated as $2.6b in 1996–97.

To compare the results, either the former estimate has to be converted to a lost profit stream or the latter has to be capitalised. Profit at full equity is a measure of the net returns to land and water resources used for agriculture, and the managerial skill of land managers. Adjusting this concept to resource rent by removing the returns to the manager's labour and produced capital, and using a real discount rate of 5.8%, the capitalised value of the lost resource rent due to all past degradation is $16.4b in 1996–97. The results using this method are sensitive to the discount rate. The real discount rate has been derived as the long-term government bond rate adjusted by the consumer price index in 1996–97.

While the estimates mentioned above represent the accumulated value of losses in land value due to all past degradation since European settlement, it is the year-to-year increment in the value of degradation that should be deducted from farm income in each period (consistent with the treatment of depreciation of produced assets). There are a number of issues to consider, including whether to deduct degradation from income in the periods when the effect becomes evident, or in the periods in which it was caused (sometimes decades or even a century earlier). The latter would seem appropriate in economic accounting. For the purpose of the indicative estimates contained in this chapter, it has been assumed that degradation accumulated evenly over a period of 50 years. Using the $14.2b figure for lost land value, the annual increment (in 1999 dollar terms) is $284m per year. Using the alternative estimate of $16.4b, degradation is $329m per year (in 1997 dollar terms). The annual losses are adjusted using the chain price index for GDP to arrive at degradation in current prices. The higher value has been taken into the summary estimates provided in table 25.11. For estimates post-1999 it has been assumed that degradation will accrue at the same rate. No adjustments have been made to account for land improvements that might reduce the future loss of resource rent. The resulting series are shown in graph 25.10.

25.10 LAND DEGRADATION



Source: ABS 2002.

Forest assets

Forests are renewable biological resources. There are two types of forest: old-growth native forests (95% of the area of all Australian forests) and plantations. Broadleaved and coniferous plantation standing timber are treated as categories of produced assets in the national accounts, as the growth is under the direct control, responsibility and management of the owner. They are classified as inventories. Native forests are treated as non-produced assets as, although they may be owned and available for use, their growth is not the result of an economic process. As for other non-produced assets, the depletion of native forest assets due to harvesting is not charged against income in the national accounts.

The valuation of the depletion of renewable assets presents a different set of issues to non-renewable assets, as it may be possible to replace (over time) the part of the asset that is used in the current period. Where a forest is harvested sustainably, no depletion adjustment is required. SEEA suggests that either depletion and additions can be calculated separately, or that just the net depletion could be calculated. Where old-growth will not be replaced, only a depletion adjustment will apply. In some areas, however, old-growth forest will become second-growth forest. Where extractions (i.e. timber harvesting) still exceed growth, depletion should exceed additions. Once the transition period from old-growth forest to second-growth forest is complete, growth may exceed harvest. In this case yield can be considered economically sustainable.

In principle, the best approach would be to calculate both depletion and addition adjustments as this allows for the two impacts to be explicitly identified. Depletion is calculated as the change in the NPV of the forest arising from the harvesting of timber (similar to subsoil assets). The value of additions is the NPV of the growth in any one year. The compilation of this series requires data on the annual increase in forest cover.

It is also possible that forests will come into or out of scope of the balance sheet due to land-use management decisions or catastrophic events (e.g. bushfires) that affect the volumes of standing timber. Such changes should not be recorded as depletion because they are not regular economic events. Rather, they should be included as either positive or negative additions to assets in the balance sheet and recorded in the ‘other change in assets account’.

Estimates are not yet available for depletion of native forests. However, given that the value of native forests on the national balance sheet is $2.6b compared with $172.9b for subsoil assets, it is expected that depletion of the former will be relatively insignificant. This of course is taking an economic view only, and does not account for damage to intrinsic non-monetary values such as ecosystem services, biodiversity and aesthetic/recreational values.

Adjusting the national accounts

It was stated earlier in this chapter that there is an asymmetry in the national accounts between the treatment of produced assets such as buildings, and plant and natural (non-produced) assets. Depreciation of produced assets (termed consumption of fixed capital in the national accounts) is deducted to derive the various 'net' income measures in the national accounts such as net domestic product (NDP), net operating surplus (NOS), net national income and net saving. No such deduction is made for natural assets when they are used up or degraded as a result of economic activity. The net measures thus fall short of being sustainable concepts of income, although they are superior to the various 'gross' measures in the national accounts in this respect.

The experimental estimates derived for the value of depletions and discoveries of subsoil assets and the degradation of agricultural land are indicative of adjustments that could be made to the national accounts in the context of a satellite account, and are illustrated in table 25.11. Depletion adjustments unambiguously lower the net values. If the value of discoveries is included in income in place of the value of mineral exploration, the net effect of that adjustment can be positive or negative.

The net saving levels are changed by the same amount as for NOS, but the nation's net lending position is left unchanged.

Adjusting the national accounts for depletion and additions of subsoil assets also affects growth rates, which may increase or decrease. As table 25.12 shows, the adjustments have the biggest impact on both NDP and NOS in 1994–95, due to the low value of subsoil asset additions in that year compared to the previous one.

Energy and greenhouse gas emissions

A satellite account for energy and greenhouse gas emissions using the input-output framework was published by the ABS in *Energy and Greenhouse Gas Emissions Accounts, Australia* (cat. no. 4604.0) in 2001. It presented information on the supply, use and stock of primary energy resources, supply and use of secondary energy products, and greenhouse gas emissions associated with the use of these energy resources. Energy use and emissions of greenhouse gases were linked with economic data and tracked through the economy so that emissions were allocated to final end users of products, rather than to the producers of products.

Of the total net energy supply (13,397 petajoules), 66% was exported, 7% was consumed by households and 18% consumed by industry. Together household electricity use and motor vehicle use by households accounted for over 30% of Australia's energy-related greenhouse gas emissions.

Future work and further information

The work program on environmental satellite accounting is continuing. The ABS hopes to extend the depletion adjustment to include native forests. Other areas of work will be to highlight environmental protection expenditures and to look at extending the economic asset boundary to include the value of water and possibly fish. Work on the valuation of environmental damage (externalities associated with human and economic activity) is an undeveloped field of research and it is unlikely that the ABS will have the capacity to make advances in this area in the foreseeable future.

25.11 PRODUCTION AND CAPITAL INCOMES ADJUSTED FOR DEPLETION AND ADDITIONS, Current prices

	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99	1999–2000	2000–01
	$m	$m	$m	$m	$m	$m	$m	$m
plus								
Subsoil depletion	1 509	1 650	1 640	1 892	1 703	1 710	2 073	2 785
Land degradation	301	306	313	318	322	322	329	344
less								
Subsoil additions	3 470	1 542	1 664	583	1 762	3 050	2 383	2 785
plus								
Cost of mineral exploration	1 471	1 791	1 905	2 257	2 300	1 916	1 562	1 563
less								
COFC(a) on mineral exploration	1 109	1 147	1 199	1 248	1 316	1 364	1 448	1 517
equals								
Net depletion adjustment	**–1 298**	**1 058**	**995**	**2 636**	**1 247**	**–466**	**133**	**390**
GDP(b)	446 480	471 348	502 828	529 886	561 229	591 592	629 212	670 029
less								
Consumption of fixed capital	73 773	76 264	78 617	80 376	86 160	91 316	97 663	104 292
equals								
NDP(c)	*372 707*	*395 084*	*424 211*	*449 510*	*475 069*	*500 276*	*531 549*	*565 737*
less								
Net depletion adjustment	–1 298	1 058	995	2 636	1 247	–466	133	390
equals								
Depletion adjusted NDP(c)	**374 005**	**394 026**	**423 216**	**446 874**	**473 822**	**500 742**	**531 416**	**565 347**
GOS and GMI(d)	185 849	192 149	202 687	210 158	227 762	234 776	253 803	264 641
less								
Consumption of fixed capital	73 773	76 264	78 617	80 376	86 160	91 316	97 663	104 292
equals								
NOS(e)	*112 076*	*115 885*	*124 070*	*129 782*	*141 602*	*143 460*	*156 140*	*160 349*
less								
Net depletion adjustment	–1 298	1 058	995	2 636	1 247	–466	133	390
equals								
Depletion adjusted NOS(e)	**113 374**	**114 827**	**123 075**	**127 146**	**140 355**	**143 926**	**156 007**	**159 959**
Net saving	9 238	6 038	10 717	19 600	20 567	18 173	19 672	18 508
less								
Net depletion adjustment	–1 298	1 058	995	2 636	1 247	–466	133	390
Depletion adjusted saving	**10 536**	**4 980**	**9 722**	**16 964**	**19 320**	**18 639**	**19 539**	**18 118**

(a) Consumption of fixed capital. (b) Gross domestic product. (c) Net domestic product. (d) Gross operating surplus and gross mixed income. (e) Net operating surplus.

Source: ABS 2002.

25.12 PRODUCTION AND CAPITAL INCOMES ADJUSTED FOR DEPLETION AND ADDITIONS, Percentage changes

	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99	1999–2000	2000–01
	%	%	%	%	%	%	%	%
GDP(a)	4.9	5.6	6.7	5.4	5.9	5.4	6.4	6.5
NDP(b)	4.7	6.0	7.4	6.0	5.7	5.3	6.3	6.4
Depletion adjusted NDP(b)	4.9	5.4	7.4	5.6	6.0	5.7	6.1	6.4
Net change in NDP(b) growth	**0.2**	**–0.7**	**—**	**–0.4**	**0.3**	**0.4**	**–0.1**	**—**
GOS and GMI(c)	4.7	3.4	5.5	3.7	8.4	3.1	8.1	4.3
NOS(d)	4.0	3.4	7.1	4.6	9.1	1.3	8.8	2.7
Depletion adjusted NOS(d)	4.7	1.3	7.2	3.3	10.4	2.5	8.4	2.5
Net change in NOS(d) growth	**0.6**	**–2.1**	**0.1**	**–1.3**	**1.3**	**1.2**	**–0.4**	**–0.2**

(a) Gross domestic product. (b) Net domestic product. (c) Gross operating surplus and gross mixed income. (d) Net operating surplus.

Source: ABS 2002.

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ISBN 0 642 47899 6

Recommended retail price $41.00

Produced by the
Australian Bureau of Statistics