Australian Bureau of Statistics

AUSTRALIANS AND THE ENVIRONMENT

ABS Catalogue No. 4601.0

Australians and the Environment

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Cover design

The main image is a National Oceanic and Atmosphere Administration Advanced Very High Resolution Radiometer satellite image of Australia taken in September 1991. This image has been reproduced by permission of CSIRO Office of Space Science and Applications from their publication "Looking Back: the changing face of the Australian Continent, 1972–1992",

The photographs, from top to bottom, illustrate:
The natural preserved environment (Wetlands, Kakadu National Park, NT)
People's actions to improve the environment (Tree planting by school children, Rivett, ACT)
Industry and energy (North Rankin field platform on the North-West Shelf, WA)
Use of the natural resources (Fishing trawler, NSW south coast)
The urban environment and transport (Warringah expressway, North Sydney, NSW)
Impacts of natural events (Cyclone Winifred, Cairns, Qld, 1986)

Photographs courtesy of the Australian Information Service, Canberra, and the Disaster Awareness Program, Emergency Management Australia.

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INQUIRIES

- *for information about other ABS statistics and services,* please refer to the last page of this publication.

Preface

This is the second ABS compendium publication of environment statistics. The first, released in 1992, was titled *Australia's Environment, Issues and Facts*. The change in title for this edition reflects a changed approach in the statistics presented, which focus much more closely than in the first edition on the relationship between Australia's environment, its economy and society.

Australians and the Environment is intended to be a statistical source book for the general public interested in the environment. Some of the statistics are produced by the ABS, but the majority have been sourced from a wide range of other government organisations, as well as the private sector and academia. The publication is therefore intended to be a guide to the diversity of socio-economic data on the environment in Australia. We have attempted to present the most recently available data. However, the information presented generally represents the situation at about the end of 1995 in terms of data and the description of various response programmes.

Australians and the Environment has also allowed the ABS to explore, and contribute to, new organisational strategies and frameworks being developed in the field of environment statistics. Importantly, the research work undertaken in compiling this publication will also feed into ABS projects on the development of environmental accounts.

In addition to the identification of data sources for this publication, an important outcome of the work has been the identification of data gaps in some areas. These gaps are highlighted in the relevant sections, and are summarised in Part 1.

Australians and the Environment has also been designed to complement the 1996 State of Environment Report (SoE) for Australia. The SoE report produces an assessment of the condition — the state — of Australia's environment, and records actions taken by government, industry and society to address the environmental problems identified. *Australians and the Environment* is a statistical publication, presenting data which highlights the relationship between the environment, the economy and society.

Perhaps most importantly, the focus on the interactions between the environment, economy and society in *Australians and the Environment* follows the premise of sustainable development – that environment, economy and society are interdependent and that the information needed for decision making under policies of sustainable development must take account of this interdependency. It is hoped that the statistics presented in this publication contribute to decisions and debates relating to sustainable development.

The ABS welcomes feedback from users to this publication. Please send any comments to The Director, Environment and Energy Statistics Section, at the address below.

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June 1996

Acknowledgements

Many individuals and organisations provided data for inclusion in this publication. The use of their published and unpublished material is specifically acknowledged at their point of use and in the reference list for each section.

The ABS is also indebted to many people who willingly provided their time to referee the draft manuscript. They are: Russell Blamey, Don Rowland, Richard Green, Professor Val Brown, Brendan Mackay, Ken Johnson (Australian National University); Ian Creswell, Richard Thackway, Andrew Crawford, Jim Crennan (Australian Nature Conservation Agency); Bob Wark; Dr Mike Braysher, Dr Ian Lambert and staff, Phil Stewart (Bureau of Resource Sciences); Professor Henry Nix (Centre for Resource and Environmental Studies); Colin Chatres (CSIRO Division of Soils); Dr Peter Fairweather (CSIRO Division of Water Resources); Sal Emmanuel, Mark Hyman, Dr Geoff Thompson, Dr Paul Bainton, Barbara Butt and Waste Management section staff, Allan Haines and SoE Unit staff, Paul Pollard, Chris Fabricius (Department of Environment Sport and Territories); Peter May (Emergency Management Australia); Darren Cameron (Fisheries - Queensland DPI); Terry Brown (Griffith University); Patrick Michael Fleming (Hydrologist); Dr Martyn Denny (Mount King Ecological Surveys); Dr Steve Corbett (NSW Department of Health); Martin Hawes (Parks and Wildlife Service); Stephen Moore (University of New South Wales); Robert Dorrat, Dr John Langford (Water Services Association of Australia); Dr Neil Stacey, Dr J. Leigh (Worksafe Australia).

Symbols and usages

Symbols

The following abbreviations and symbols used in tables represent:

na	not available
nec	not elsewhere classified
nfd	not further defined
np	not available for publication, but included in totals where applicable
nya	not yet available
. .	not applicable
p	preliminary — subject to revision
*	should be used with caution, as number is subject to high sampling error
* *	suppressed due to unacceptably high sampling error

Measurement abbreviations

Distance		*Volume*		*Power*		*Weight*	
millimetre	mm	millilitre	ml	microwatt	μw	nanogram	ng
centimetre	cm	centilitre	cl	millawatt	mw	microgram	μg
decimetre	dm	decilitre	dl	watt	w	milligram	mg
metre	m	litre	l	kilowatt	kw	centigram	cg
kilometre	km	Cubic metre	m^3	megawatt	Mw	decigram	dg
			Ml	gigawatt	Gw	gram	g
		Gigalitre	Gl			kilogram	kg
						tonne	t
						kilotonne	kt
						megatonne	Mt

Time		*Area*		*Temperature*	
microsecon	μs	square metre	m^2	centigrade/celsius	C
second	s	hecatre	ha	kelvin	K
minute	min	square kilometre	km^2	degree	°
hour	h				

Energy		*Other*	
millijoule	mj	becquerel	Bq
joule	j	candela	cd
kilojoule	kj	carat	ct
megajoule	Mj	microsiemens	μS
gigajoule	Gj		
petajoule	Pj		

International system of units

Prefix	*Symbol*		
peta	P	10^{15}	1 000 000 000 000 000
tera	T	10^{12}	1 000 000 000 000
giga	G	10^{9}	1 000 000 000
mega	M	10^{6}	1 000 000
kilo	k	10^{3}	1 000
hecto	h	10^{2}	100
deca	D	10^{1}	10
		10^{0}	1
deci	d	10^{-1}	0.1
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	μ	10^{-6}	0.000 001
nano	n	10^{-9}	0.000 000 001
pico	p	10^{-12}	0.000 000 000 001

The prefixes in this table are used to simplify the standard units used in this publication. For example, rather than a table having a number of 0.000027 grams, this can be expressed as 27 milligrams or 27 mg.

Other abbreviations and symbols

percentage	%
per	/
smaller than	<
smaller than or equal to	<=
equal to	=
greater than or equal to	>=
greater than	>
thousand	'000
millions of dollars	$m
million	m
parts per million	ppm
parts per trillion	ppt
weight	wt

Selected chemical symbols

Ag	Silver	Cd	Cadium	I	Iodine	O	Oxygen	Se	Selenium
Al	Aluminium	Cl	Chlorine	Ir	Iridium	P	Phosphorus	Si	Silicon
As	Arsenic	Co	Cobalt	K	Potassium	Pb	Lead	Sn	Tin
Au	Gold	Cr	Chromium	Li	Lithium	Pd	Palladium	Ta	Tantalum
B	Boron	Cu	Copper	Mg	Magnesium	Pt	Platinum	Ti	Titanium
Be	Berylium	Fe	Iron	Mn	Manganese	Pu	Plutonium	Tl	Thallium
Bi	Bismuth	Fl	Fluorine	Mo	Molybdenum	Ra	Radium	U	Uranium
Br	Bromine	Ga	Gallium	N	Nitrogen	Rn	Radon	W	Tungsten
C	Carbon	H	Hydrogen	Na	Sodium	S	Sulfur	Zn	Zinc
Ca	Calcium	Hg	Mercury	Ni	Nickel	Sb	Antimony	Zr	Zirconium

Chemical notation — the symbol for a molecule (such as H_20) shows the symbols for the elements contained in it (O = oxygen, H = hydrogen), followed by a subscript numeral denoting the number of atoms of each element in the molecule where there is more than one. For example, the water molecule (H_20) contains two atoms of hydrogen and one of oxygen.

Other information

Total suspended particulates (TSP)	All particles from the smallest up to 50 μm in diameter: within this range are sub-categories of those:	less than 10μm	PM10
		less than 2.5μm	PM2.5
pH	Negative decimal alogarithm of hydrogen-ion concentration in moles per litre. pH is a measure of acidity or alkalinity of a solution. A pH of 7 is neutral, while a pH of less than 7 is acidic, and one of more than 7 is alkaline. pH is a logorithmic scale; hence a pH of 4 is 10 times as acidic as a pH of 5.		

Part 1— Introduction

Why a framework is used

A conceptual framework supports the collection, compilation, organisation and presentation of statistics and information. The framework defines the scope of the subject to be examined, the major elements involved and the nature of their interactions. The framework will also reflect the perceptions and the decision-making needs of the individuals and institutions designing it. In some sense, the framework becomes a model of the way the relevant pieces of the world operate, taking something that is complex and imposing on it a degree of order and simplicity.

Conceptual frameworks can be as simple or as elaborate as needed for the task at hand. From the point of view of a statistical office, conceptual frameworks provide a tool to guide the selection and organisation of appropriate statistics that serve the decision-making needs of its user community. These frameworks need to be well defined and detailed if they are to be useful to the statistician in identifying appropriate data series, establishing new collections and compiling the information.

Comprehensive conceptual frameworks play an important part in the development of environmental reports, because it is from the framework that the report's table of contents is derived. The framework guides the identification of the statistics that are desirable to portray a subject, condition or process. They also offer the user a means to identify gaps in the existing statistical base, and they provide a way of judging the value of alternative measures to be used when more appropriate statistics do not exist. As well as assisting the researcher in the preparation of the report, a clear, concise framework offers a guide to the user. It can help the user to understand how particular statistical presentations fit into the overall picture.

Frameworks that use categories of environmental media (air, water, soil) as top levels in the classification are one example of an approach that proceeds from an ecological perspective. State of Environment reports to date have been compiled in this way.

Relationship to State of the Environment Reporting

Australians and the Environment and the 1996 National State of the Environment Report will be released at about the same time. What are the differences between the two books?

Australians and the Environment is the second ABS compendium publication of environment statistics. The focus is on the interactions between the environment, the economy and society. The book uses ABS sources and a large range of other data sources. In this way it can act as a directory to other information and also identifies data gaps. The ABS publication does not make any judgements about the quality of the environment nor the appropriateness or quality of society's response to environmental issues.

State of Environment reporting can act as a *report card* on the condition of the environment and natural resource stocks. The role of the first SoE report is described as to identify the key environmental issues at the national level, using the best available data sets. The SoE report provides a first step in the environmental indicator development process because it has led to an initial identification/characterisation of the 'first generation' of national environmental indicators.

Australians and the Environment uses a framework different from that for the SoE report. The PEP framework (described in the next section) focuses on the relationship between the environment and the economy and between the environment and society.

In keeping with many industrialised countries, Australia has adopted the Organisation for Economic Cooperation and Development's pressure–state–response model for its reporting system. The PSR model is based on the concept of causality: human activities exert pressures on the environment and change its state, or condition. Society responds to this changed state by developing and implementing policies, which complete the cycle and influence those human activities that exert pressure on the environment. Human inactivity – a failure to respond – can also exert pressure on the environment, altering its state.

As noted in the preface, the approach taken in *Australians and the Environment* has been to complement Australia's 1996 *State of*

Environment Report. Material which is presented in considerable detail in the SoE report is presented in an overview form only in *Australians and the Environment*. While the environment remains the focus of *Australians and the Environment*, Australia's society and its economy are viewed in terms of their relationship to the environment.

The framework for this publication

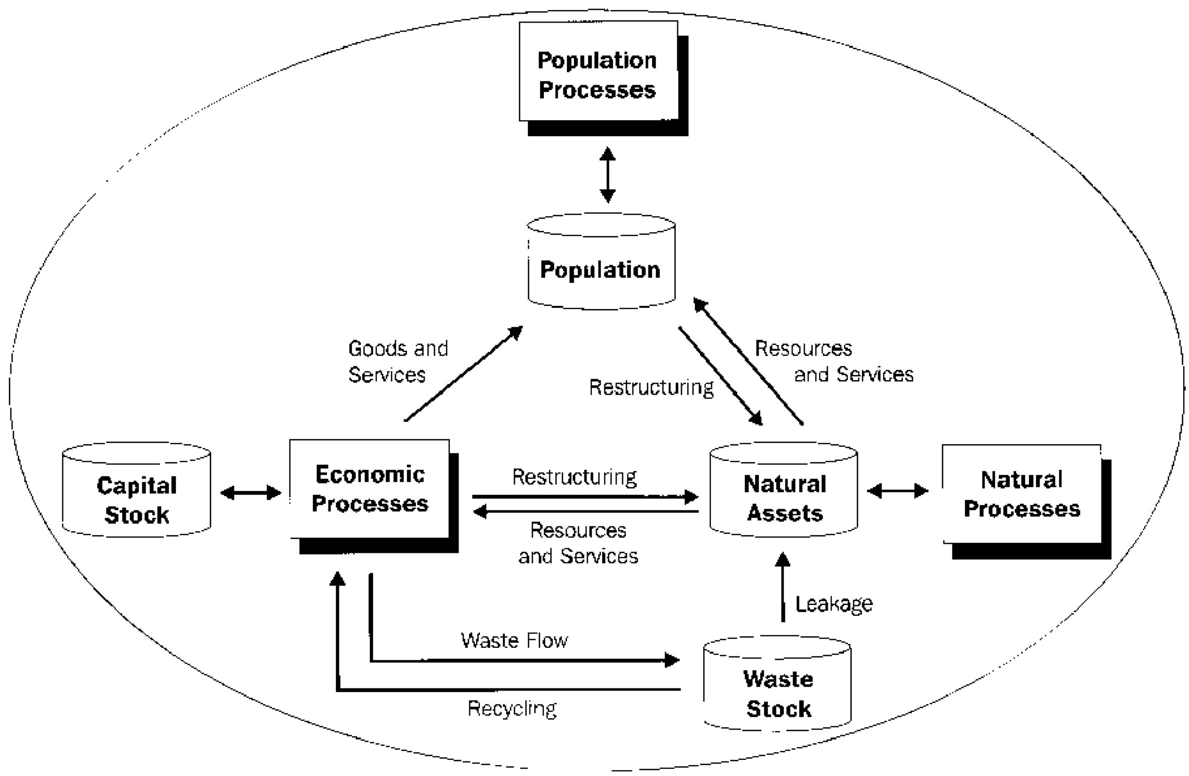
The first edition of the ABS environment statistics compendium employed the UN Framework for the Development of Environment Statistics. The main advantage of this framework for that publication was a clear, straightforward approach. It presented the environment in terms of the standard compartments the average person usually identifies when thinking about the environment — air, water, land and living things. At the same time, the systematic structuring of data by activities, the effects of those activities on the state of the environment, and human responses to those effects, proved to be an effective way of exploring the Australian environmental statistics base for the first time. The resulting document was not only a collection of information about the environment, but a tool to be used in critically assessing the adequacy of that base in terms of completeness, scope and level of detail.

For a statistical agency focusing on the relationships between the environment, economy and society, it emerged that such an approach was weak in linking socio-economic activity to its environmental impact. Feedback on the first ABS environment compendium and developments in the field of environment statistics, have led the ABS to adopt the Population Environment Process (PEP) framework, developed by Statistics Canada, for this edition of the publication.

PEP is "*a conceptual representation of how modern society interacts with the natural environment*" (Statistics Canada, 1994, pp. 32). The PEP framework in Figure 1 shows how the economy and the population interact with the stock of natural assets and natural processes. The framework indicates that resources and services flow from the environment to the population and the economy. Conversely the population and the economy 'restructure', or impact upon, the environment, resulting in changes to natural assets and natural processes.

Waste is represented as a separate output of the economic system, as it does not necessarily have a direct environmental impact. The PEP

The Population–Environment–Process Model



Source: Statistics Canada, 1994

framework shows that some of the waste stock may be recycled by the economy, while some of it may 'leak' into the stock of natural assets.

The set of relationships in the PEP framework — 'flows' from the environment to the economy and the population, and 'restructuring' of the environment by the population and the economy — are presented systematically in Parts 2, 3 and 4. Each part looks at flows or relationships that proceed in one direction only. This means that the benefits which flow from the environment to the economy and society are presented in Part 2, while statistics relating to 're-structuring' — the impact of the economy and society on the environment — are presented in Parts 3 and 4. This structure means that material on the same topic can be located in several different sections of the publication, depending on whether it relates to the impact of people or the economy on the environment, or is in some way an impact of the environment on people and the economy. For example, statistics on water quality and water use appear in Part 2, which looks at the flow of resources and benefits from the environment to people and the economy. Statistics on water pollution and changes to water systems are presented in Part 4, which looks at the economy and its impact on the environment. A clear understanding of the structure of the publication, reference to the table of contents, and use of the comprehensive index, will assist readers to quickly locate information on any particular topic.

Content and structure of this publication

The publication has been structured to focus on resource issues, with a major section in Part 2 presenting statistics on resource use and consumption. Rather than examining the environment — economy — society relationship by looking at issues from an economic perspective (i.e. the impact of different, specific industries on the environment), *Australians and the Environment* has chosen to provide a clearer focus on resource issues in the design of the table of contents. Information is available about the impacts of major economic sectors on the environment, although economic sectors do not appear as headings in the table of contents. For example, information on the impact of transport on the environment is found in sections which present statistics on emissions of pollutants to the air (Section 12.1.2), land restructuring (Section 12.2.1) and energy (Section 6.8). The index at the end of the publication will also assist readers locate information on these topics.

In terms of the PEP framework, Part 2 — From the Environment to People and the Economy — presents statistics which provide an overview of the stock of natural assets and natural processes. It then presents statistics on the 'flows' from the natural environment to both the economy and the population. These 'flows' are represented in statistics indicating the benefits to the economy (jobs and economic wealth) and to the population (recreation benefits and human health benefits). Statistics also indicate the pressure or impact the natural environment exerts on both the population (human health concerns and natural events and disasters) and the economy (impact of natural events and processes on the economy). The part concludes by presenting statistics on issues of resource use and consumption, and protection of biodiversity.

Part 3 — People and their Impact on the Environment — first presents statistics on population size and dynamics. These statistics provide the basis for the rest of the part to explore the 'restructuring' of natural assets and processes by the population. The statistics reflect pressures from people on the environment, through their consumption patterns, waste generation, introduction of non-native species and recreation activities. The part concludes by presenting statistics on some actions people take to reduce the pressure they exert on the environment.

Part 4 — The Economy and its Impact on the Environment — parallels the 'stocks' and 're-structuring' statistics presented in Part 3. This part starts with an overview of the economy, and then presents statistics on the pressures from economic activity on the environment (generation of wastes, and changes to landscapes and water systems). Statistics are also presented on efforts to reduce the pressures of economic activity on the environment, through environmental legislation, environmental expenditures, and other environmental actions such as recycling and waste minimisation.

Data quality and availability

The presentation of environment statistics using the PEP framework highlighted a number of areas with data problems. Some of these data quality and availability issues are well known in the user community. Others came to light through use of the PEP framework. Some sections of this publication were restricted by data which was localised and specific in nature, other sections were constrained by methodological and collection issues which made comparability of data across Australia or over time difficult, and other sections were constrained by a lack of current data. For example:

- most data on soil conditions and nutrients were restricted to localised studies only (see Sections 1.3 and 6.7);
- data on contaminants in biota were mostly restricted to localised, specific problems and circumstances (see Section 1.4);
- data on the impact of the environment on human health were mostly limited to specific studies (see Section 2.1);
- nationally consistent data, and agreed methodologies, for calculating the impact of consumption patterns on the environment - the 'ecological footprint' (see Section 9.1);
- availability of national data on the impacts of tourism and recreational activities on the environment (see Section 9.4);
- the currency of Australia-wide data on solid wastes (see Section 12.1.3); and
- data on solid wastes tended to be available in terms of the type of waste, rather than the sector generating the waste (see Section 12.1.3).

The sections in Parts 2, 3 and 4 discuss the data problems in some detail.

The research period for this project has spanned a considerable period of time. In this publication we have attempted to present the most recently available information. This means that we have attempted to present data series up to the 1994-95 financial year, where it is available. Also the description of various government response programs and legislation generally reflects the situation at about the end of 1995.

References

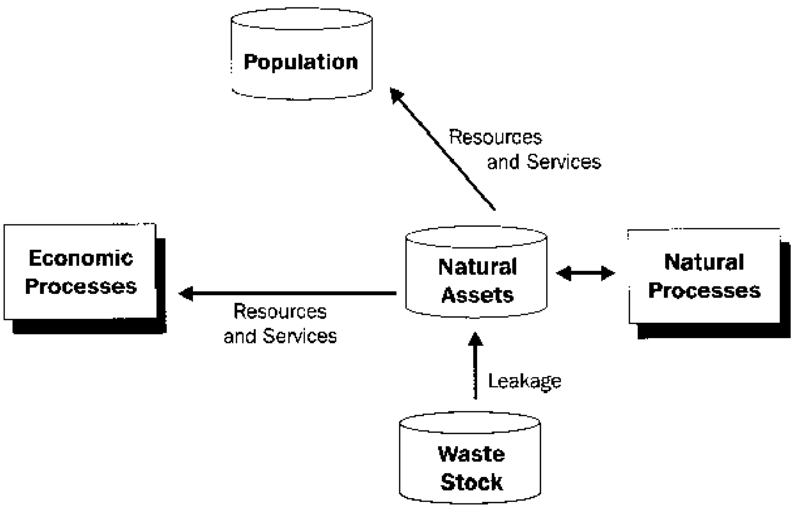
Australian Bureau of Statistics (ABS) 1992, *Australia's Environment Issues and Facts* (4140.0), AGPS, Canberra.

Australia – State of Environment Report 1996, CSIRO Publishing, Melbourne.

Statistics Canada, 1994, *Human Activity and the Environment*.

Part 2 — From the Environment to People and the Economy

Components of the Population Environment Process (PEP) Framework covered by Part 2



As indicated in the above diagram, Part 2 presents statistics from the perspective of the 'Natural Assets' and 'Natural Processes' components of the PEP framework, and the 'flows' to the population and economy.

After an overview of statistics on Australia's water quality, atmospheric conditions, soils and landscapes, and its flora and fauna — including statistics on contaminants in biota (Chapter 1), Part 2 examines the flow of resources and services from 'Natural Assets' to the 'Population'. Within this flow, statistics indicate the nature of environmental pressures on individuals (Chapter 2) and environmental benefits to individuals (Chapter 3).

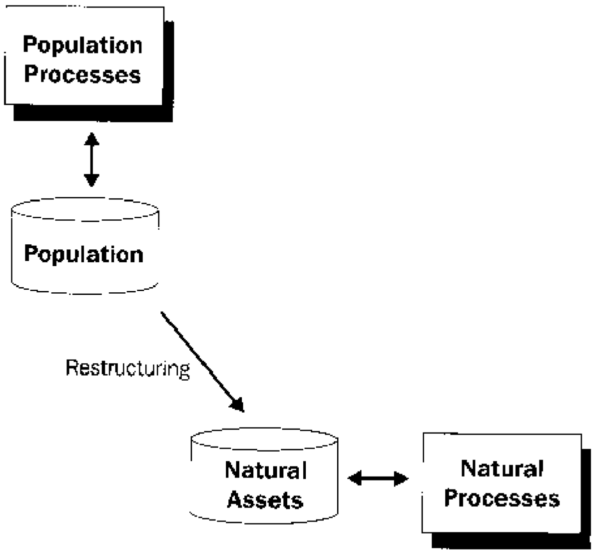
Part 2 then examines the flow of resources and services from 'Natural Assets' (the natural environment) to 'Economic Processes' (the economy). The impacts of natural events and processes on the economy are presented in Chapter 4, and environmental benefits to the economy are presented in Chapter 5.

Chapter 6 discusses the use of a range of resources through human activities in relation to the available stocks. Resources covered in this chapter include forests, fish and other aquatic resources, wildlife, agricultural plants and animals, water, minerals and metals, soils and soil nutrients and energy.

Part 2 concludes by presenting statistics on measures taken to preserve biodiversity, both in terms of preserving biota and preserving habitats, lands and waters (Chapter 7).

Part 3 — People and their Impact on the Environment

Components of the Population Environment Process (PEP) Framework covered by Part 3



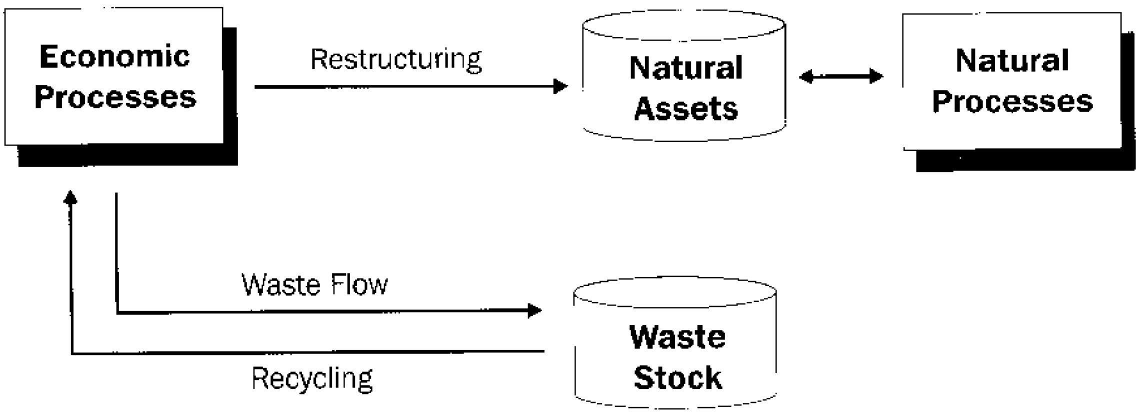
As indicated in the above diagram, Part 3 presents statistics from the perspective of the 'Population' and 'Population Processes' components of the PEP framework. This part therefore presents statistics on the population and its 'restructuring' of 'Natural Assets' by the population.

After an overview of statistics on Australia's population conditions, change, distribution, and density, (Section 8.1) and the components of population change and population projections (Section 8.2), Part 3 examines the 'restructuring' of the environment by the population, in terms of the pressures individuals exert on the environment. Chapter 9 presents statistics on consumption patterns of the population, waste generation, the introduction of non-native species into the natural environment, and pressures on the environment from recreational activities undertaken by the population.

Chapter 10 concludes the coverage by presenting statistics on the efforts of individuals and households to reduce these various pressures of the population on the environment.

Part 4 — The Economy and its Impact on the Environment

Components of the Population Environment Process (PEP) Framework covered by Part 4



As indicated in the above diagram, Part 4 presents statistics from the perspective of the 'Economic Processes' component of the PEP framework. This chapter provides statistics on the economy and its 'restructuring' of 'Natural Assets' by 'Economic Processes'. In addition to the direct 'restructuring' of 'Natural Assets', Part 4 also picks up the 'flow' of wastes from the economy to 'Waste Stock', and the flow of some materials (in the form of recycling, for example) back to 'Economic Processes'. The leakage of some of the 'Waste Stock' to 'Natural Assets' indicated in the PEP framework is covered in Section 1.4.2 (Contaminants in Biota).

After an overview of statistics on Australia's economy, (Section 11.1) and international trade (Section 11.2), Part 4 presents statistics on the restructuring of the environment by the economy, in terms of the pressures economic activity exerts on the environment. Chapter 12 presents statistics on the generation of a range of wastes (emissions to water, air, solid waste disposal and disposal of special wastes) and on other ways in which the economy restructures both land and water systems, for example by the building of dams and transport infrastructure.

Part 4 concludes by presenting statistics on the ways in which the economy attempts to reduce the impact - or the level of restructuring - on the environment. These activities cover environmental legislation (Section 13.1), expenditures to reduce pollution (Section 13.2) and other environmental actions, such as recycling, waste minimisation etc (Section 13.3).

Chapter 1 — Life Support Conditions

This chapter presents an overview of the 'Natural Assets' and 'Natural Processes' components of the PEP model. The aim of the chapter is to present statistics which serve as an introduction to many of the issues which arise out of, or depend on the basic life support conditions of

- Water quality (Section 1.1);
- Atmospheric conditions (Section 1.2);
- Soils and landscapes (Section 1.3); and
- Flora and fauna (Section 1.4).

More statistics on these topics are presented later in Part 2 in terms of resource consumption and use, and in Parts 3 and 4, where the impacts on these basic life support conditions by people and the economy are explored.

The material in this chapter is covered in much more detail in the 1996 State of Environment Report for Australia and is presented here as an overview only. Consequently there are many references to that report in Chapter 1.

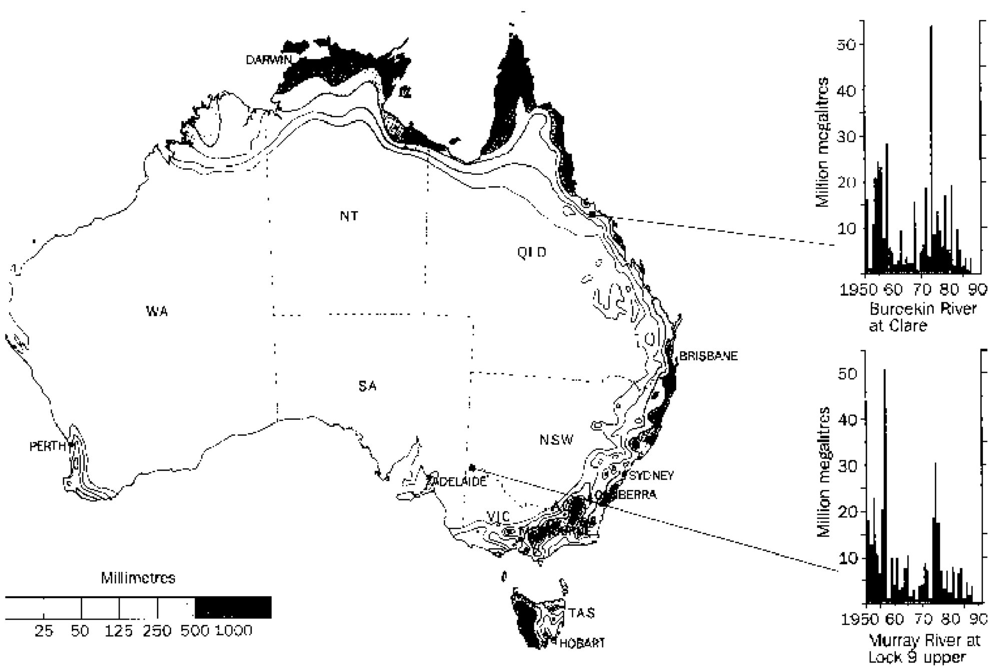
1.1 Water stocks and quality

Despite Australia's relatively high available water resources per capita (see Section 6.5), it is known as the dry continent, with most of its land mass classed as arid or semi-arid. The median rainfall for 80% of the country is less than 600 millimetres, and less than 300 millimetres for 50% (see Section 1.2).

When compared with the other continents, Australia has the lowest percentage runoff (12%), i.e. rainfall that is yielded as stream flow and groundwater. Antarctica has less mean annual precipitation but greater discharge to the surrounding oceans. Australia's high rates of evaporation, relatively low rainfall and the low relief of the continent all contribute to the smaller runoff and inherent aridity (see Figure 1.1.1). The above, combined with the highly variable rainfall patterns for around two thirds of Australia, render water a precious resource.

The quantity and quality of Australia's inland, coastal and marine waters have received increasing attention over the past decade from all sectors of Australian society. The aforementioned factors, contributing to the low runoff and the high variability of rainfall and stream flows, highlight the need for efficient and effective resource management. Until recently the

1.1.1 Median annual run-off



Source: AUSLIG 1992, p. 65.

emphasis in that management has been on quantity rather than quality, and perhaps the sparseness of nationally comparable water quality data (SoE 1996, pp. 7-5) can be partly attributed to this.

This section gives an overview of the natural resource and its quality in terms of major concerns. The Drainage Division will be used as the standard geographical boundary as it describes the major water catchment areas and is consistent with the current national approaches to water management and research.

Major concerns regarding water quality

Turbidity is a condition where the amount of Suspended Particulate Matter (SPM) in water (usually clay and fine silt) renders the water cloudy or murky and reduces light absorption needed for benthic life (that which lives in or on the bed of a body of water). When the SPM settles to sediment it can smother sessile organisms (stalkless organisms attached to the bottom) and affect filter feeders. Raised levels of turbidity impair the water purification process for human drinking water.

Eutrophication is a condition where an enrichment in mineral and organic matter in a lake or body of water reduces its oxygen content and light absorption to a point where it cannot sustain animal life.

Salinity — Salts in the landscape come from rainfall and the weathering of rocks and frequently accumulate in groundwater, particularly in arid and semi-arid regions. If the natural hydrological cycle is disturbed by, for example, clearing of deep rooted vegetation or the introduction of irrigation, highly saline groundwaters can be raised or displaced. The leads to salinisation of landscapes and greatly increased salt loads in rivers and streams (Fleming, P.M., 1996, pers. comm.).

Toxicity is the level of toxic substances (either to the ecosystem, stock or humans) to be found in water. This condition can be either organic (the presence of E. coli bacteria indicating faecal coliforms, or the heptatoxins and neurotoxins produced by Blue-green algae and organic compounds such as organochlorine insecticides), or inorganic (radiological and chemical — e.g. lead, cyanide and mercury).

Nutrient loading occurs continually in streams, rivers, lakes and estuaries. As water follows its drainage course it takes with it various impurities, either in solution or in particle form. Phosphorus and nitrogen are two naturally occurring agents; while necessary for plant growth, an overabundance of them under the right conditions can promote the growth of Blue-green algae (Cyanobacteria). Because most Australian soils are lacking in both elements, these agents have been extensively used in fertilisers (see Section 6.4) in Australia's agricultural areas. Agricultural runoff, coupled with the byproducts of human waste management (see Section 12.1.1) and the low flow rates of rivers, has led to high levels of these nutrients in waterways (for further information see Figures 1.1.6 and 1.1.7).

Surface inland waters

Climate, topography, geological history and land use all affect the quality and quantity of Australia's inland surface waters. As can be seen from the map in Figure 1.1.2, Australia's rivers are for the most part short and coastal, or ephemeral. There are 245 river basins in Australia's 12 Drainage Divisions. The eastern Murray-Darling river system is the only large waterway system to the sea, draining about one seventh of the land mass of the continent. The Murray and Darling rivers are among the longest in the world, extending for 2,500 and 2,740 kilometres respectively.

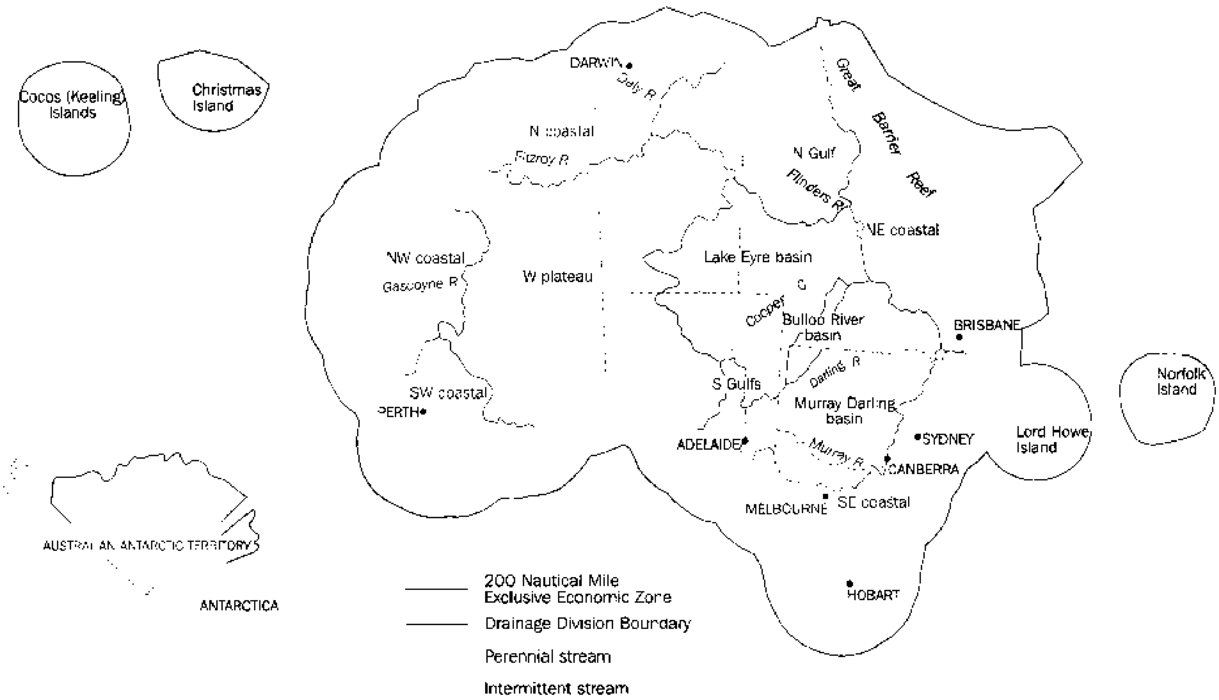
The Murray-Darling catchment is called the bread basket and heartland of Australia. It accounts for between 30% and 40% of the nation's production from resource-based industries. Half Australia's sheep and crops, one-quarter of the dairy and beef cattle and three-quarters of the irrigated field crops are in the more than one million square kilometres of the basin (Murray Darling Basin Commission (MDBC), Managing Australia's Heartland).

See Section 6.5 for further details on Australia's reliance on this resource.

The runoff associated with each Drainage Division which is translated into the rivers and streams is shown in Table 1.1.3.

The differences between the annual runoff and the annual outflow can be attributed to evaporation and, to a lesser extent, to the recharge of groundwater aquifers. Drainage Divisions 10, 11 and 12 all have an annual average evaporative rate of more than 2,800 millimetres while the median annual rainfall is below 600 millimetres. The major waterways of the area are ephemeral (only running in the wet season) and drain inland to Lake Eyre.

1.1.2 Australia's lakes and rivers, drainage divisions and Exclusive Economic Zone



Source: Australian Water Resources Council 1987; Zann 1995.

Inland surface water quality

The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) developed Australian water quality guidelines for fresh and marine waters in 1992 and these are being revised again. Drinking Water Guidelines to replace the 1987 set for drinking water quality issued by the National Health and Medical Research Council and the Australian Water Resources Council are expected to be released about the middle of 1996. Other guidelines focus on part of the water cycle or on a particular activity within the water cycle (e.g. urban stormwater, sewerage systems, rural land uses) and specific industries such as wineries and tanneries.

The guidelines in Table 1.1.4 are from Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC 1992). The guidelines are not reproduced in their entirety, but a summary of the guidelines for raw water for drinking are included in this table. The water quality guidelines extend from the quantitative parameters (a small portion is given in the table) to qualitative concerns such as water colour and even water weed and debris content of a waterway with respect to suitability for human recreation. A category called amenity takes water supply hardness (Calcium Carbonate or $CaCO_3$), water odour and discolouration into account. Further information is provided in the cited document.

Salt limits (using micro-siemens per centimetre as the unit for electrical conductivity in fresh

1.1.3 Surface water resources by drainage divisions

	Area	Mean annual runoff	Mean annual outflow
Drainage Division	*km²*	*Gl*	*Gl*
North-East Coast	451 000	83 900	83 900
South-East Coast	274 000	41 900	41 900
Tasmania	68 200	52 900	52 900
Murray-Darling	1 060 000	24 300	12 200
South Australian Gulf	82 300	877	767
South-West Coast	315 000	6 670	6 600
Indian Ocean	519 000	3 960	3 840
Timor Sea	547 000	80 700	80 700
Gulf of Carpentaria	641 000	92 500	92 500
Lake Eyre	1 170 000	6 310	0
Bulloo-Bancannia	101 000	1 090	0
Western Plateau	2 450 000	1 580	0
Total	**7 680 000**	**397 000**	**375 000**

Source: Australian Water Resources Council 1987, p. 40.

water bodies) are listed in Table 1.1.5 for particular uses.

ANZECC suggests in the above cited guidelines that a limit of 1,500 μS/cm should be a guide for surface fresh water salinity.

ANZECC encourages the local determination of site-specific limits for nutrients (phosphorus—P and nitrogen—N) related to Blue-green algae blooms. Total P between 5 and 50 micrograms per litre (μg/l) and total N of 100 to 500 μg/l are quoted by ANZECC to be indicative of an algal problem. The sites of recent major algal blooms in the Murray-Darling Basin are shown in Figure 1.1.6.

Data for the Murray-Darling Basin have been collected on a comparable and consistent basis over a long period. The following charts depict average turbidity (in NTU), nutrients (as phosphorus—P, and nitrogen—N) , and salt (in μS/cm) levels at various points along the Murray

1.1.4 Selected quality guidelines for raw waters for drinking purposes subjected to course screening

Parameter	*Acceptable limits*
Biological parameters	
Total coliforms	<10 coliform organisms per 100ml. No coliform organisms in any 2 consecutive 100ml samples. No coliform organisms in 95% of 100ml tests each year.
Faecal coliforms	No faecal coliforms in any 100ml sample.
Algae	Up to 5,000 cells/ml may be tolerated. Levels of 1,000–2,000 cells/ml of cyanobacteria may result in problems.
Toxic parameters	
Arsenic	0.05mg/l.
Lead	0.05mg/l.
Nitrate — N	10mg/l.
Nitrite — N	1mg/l.
Pesticides:	
DDT	3mg/l.
Endosulfan	0.04mg/.l
Radiological:	
Gross alpha activity	0.1 Bq/l.
Gross beta activity (a)	0.1 Bq/l.
Aesthetic parameters	
Physical Turbidity	Site-specific determinant.
Chemical	
Aluminium	0.2mg/l.
Iron	0.3mg/l.
pH	6.5–8.5mg/l.

(a) Excluding activity of ^{40}K.
Source: ANZECC 1992, pp. 4-3 – 4-4.

1.1.5 Salinity limits for specific uses

µS/cm	*Suitable purpose*
0–800	Human consumption.
0–1 500	Peas, apricots and grape production.
800–2 300	Irrigation of most mildly salt tolerant crops (pears, apples and tomatoes).
2 300–5 500	Fodder crops, olives, figs, spinach etc.
>4 000	Shell cracking occurs in poultry.
<6 000	Consumption by pigs and poultry.
6 000–10 000	Only beef cattle and adult sheep.
>50 000	Sea water.

Source: ANZECC 1992, pp. 5-8 – 5-11 ; Salt Action Victoria.

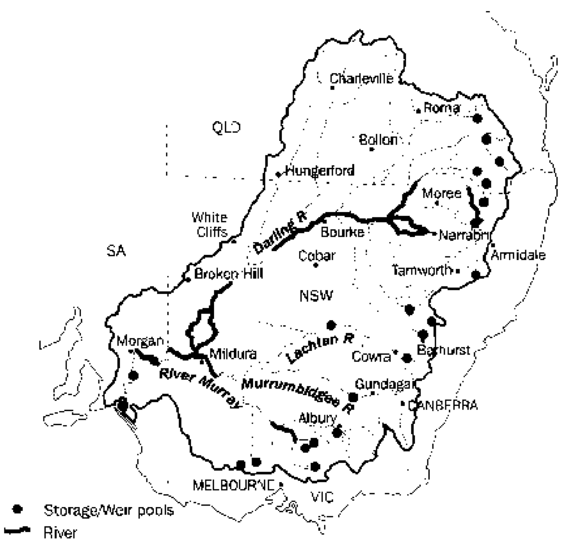
River taken over the past twenty years at five yearly intervals.

As can be seen in Figure 1.1.7, as the water moves downriver the readings increase.

Of particular concern to the Murray-Darling Basin Commission have been the increases in salt and nutrient loads for the basin. The 1988 State of the Environment Report for Victoria produced the map of Victorian waterway areas and their estimated salt levels in Figure 1.1.8. The NSW State of the Environment Report (EPA NSW 1993 p. 39) considers salinity a serious threat to the State's waterways, with the Namoi and Lachlan rivers (tributaries to the Murray-Darling) showing the highest concentrations.

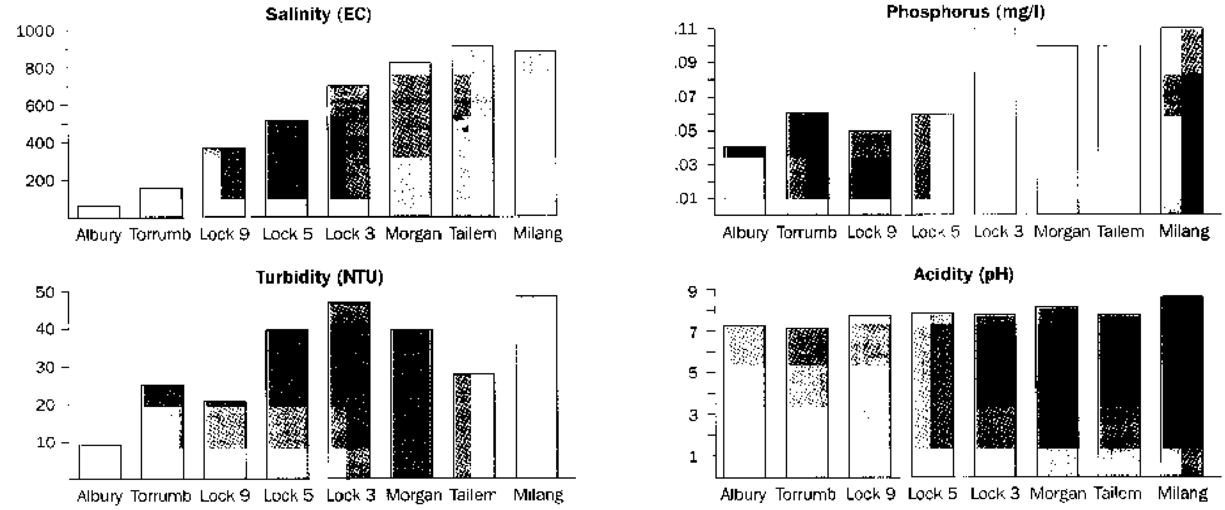
While salt levels in waterways are damaging to crops, livestock, the ecosystem and metal fixtures, nutrient levels of phosphorus and nitrogen, when present in about a 16 to 1 ratio, promote algal growth in water given warm, light

1.1.6 Murray Darling Basin algal blooms



Source: Murray-Darling Basin Commission 1994, p. 3.

1.1.7 Average levels of salinity, turbidity, phosphorus and acidity in the River Murray for the past 20 years

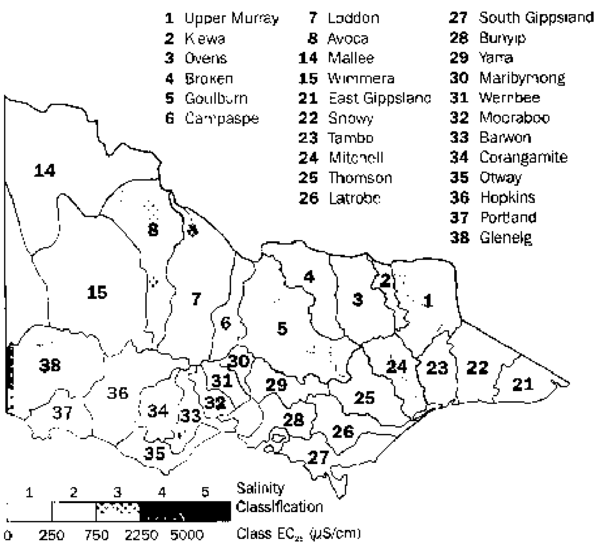


Source: Murray-Darling Basin Commission, 1995 unpub.

conditions and calm waters. Cyanophyta, or Blue-green algae, is considered a nuisance growth at best. When blooming it covers the water surface with an emerald green, foul smelling slime which not only results in eutrophication of the water body, but certain Cyanophyta (microcystitis, Nodularia) produce heptotoxins (affecting the liver), and Anabaena produces neuro (nerve) toxins. Swimming in and ingesting Blue-green algae have also resulted in gastric problems and dermatitis (ANZECC 1992, pp. 3–5). The Environmental Protection Agency of NSW acknowledged that Blue-green algae blooms were occurring with regularity in NSW water storages and rivers. The 1,000 kilometres long Darling River bloom in November 1991 was perhaps the most notorious (EPA NSW 1993, p. 40). Median Total Phosphorus contents above the suggested levels that may indicate algal problems were observed at sites on the Border River, in the Namoi and Macquarie Basins and in the Darling River at Bourke (Department of Land and Water Conservation 1995a p. 29).

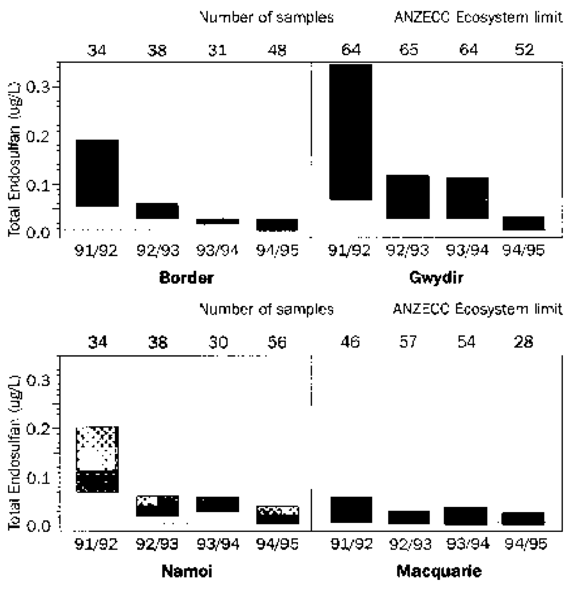
Pesticide residues are another area of concern for the north-west rivers of NSW. Endosulfan, as an example, is used extensively for insect control in the growing of cotton and oilseed crops. Figure

1.1.8 Salinity of surface water, Victoria, 1985



Source: Office of the Commissioner of the Environment 1988, p. 214.

1.1.9 Total Endosulfan by basin irrigated cotton areas 1991–92 to 1994–95



Each box represents the middle half of the data collected for the November to March period allowing a consistent way of comparing results. The largest and smallest quarters of data have not been displayed. The mid line represents the median (or 50th percentile) value.

Source: Dept of Land & Water Conservation 1995b, pp. 39–40.

1.1.10 Major groundwater resources of Drainage Divisions

Drainage Division	*Area of Aquifers (a)* km²	*Fresh* Gl	*Marginal* Gl	*Brackish* Gl	*Saline* Gl	*Total* Gl
N-E Coast	114 250	1 260	464	185	94	2 000
S-E Coast	71 660	760	699	353	50	1 860
Tasmania	7 240	47	69	8	0	124
Murray-Darling	908 500	782	594	435	349	2 160
SA Gulf	2 500	0	74	10	1	85
S-W Coast	328 000	466	415	260	78	1 220
Indian Ocean	487 400	22	241	174	71	508
Timor Sea	328 900	617	1 980	161	57	2 820
Gulf of Carpentaria	340 250	721	1 180	16	11	1 930
Lake Eyre	834 030	81	382	125	31	619
Bulloo-Bancannia	90 100	28	27	41	4	100
Western Plains	1 706 700	44	746	64	90	944
Total	**5 219 530**	**4 828**	**6 871**	**1 832**	**836**	**14 370**

(a) Includes surficial, sedimentary and fractured aquifers.

Source: Australian Water Resources Council (AWRC) 1987, p. 62.

1.1.9 describes the 50th percentile value in micrograms/l (μ/l) of samples taken between November and March for four years in four north-western NSW rivers.

Levels of endosulfan in 1994, though lower than in 1991, were still at or above the ANZECC ecosystem limit shown on the chart at 0.01 mg/litre. Compared with the readings for 1991, the lower readings for 1992 through 1994 may be partly due to better management practices (Department of Land and Water Conservation 1995b pp. 39–40).

The inland surface water systems of other States and Territories exhibit the same tendencies as those discussed here (salinity, nutrient loading, turbidity and pesticide/herbicide residues), in particular the already mentioned south-west region of Western Australia. The Adelaide foothills experience a high salinity problem as does the agricultural region of Queensland.

The combination of drought and the diversion of the Murray River, in order to satisfy agricultural, hydroelectric and water supply needs (see Section 6.5) has dramatically reduced the Murray's flow rate and its outflow to the sea. This, combined with changes to the river ecosystem through human inputs and land use change (e.g. flood plain to farmland), has had serious impacts on the Murray's water quality. When the flow rate of a river is reduced it decreases the river's ability to flush impurities, leading to an increase in their concentrations. Over time, if impurity input levels were to remain the same but the flow rate to decrease, the water quality would become lower. A reduced flow rate also yields conditions favourable to Blue-green algae blooms, lowered oxygen levels and eutrophication. The median annual outflows of the Murray-Darling Basin have gone from 2,880 Gl/year in 1988 to 2,540 Gl/year in 1994 — a drop of 12% (MDBC 1995, p. 16).

Groundwaters

Of the total volume of water in the world, 97.3% is sea water and only 2.7% is fresh. Of the fresh water not frozen at the poles, 95% is groundwater (Water Resources Commission, NSW 1984, p. 7).

Groundwater underlies about 60% of Australia, or 5,226,440 km². About 80% of Australia is dependent on groundwater supplies, and of that, 20% relies on groundwater as the dominant source (ABS 1992, 4140.0, p. 161). In a normal year groundwater provides 30% of Perth's public water supply and 65% of all the water used (Government of Western Australia, p. 79). In addition about six hundred small communities in Australia depend mainly on groundwater for their domestic water supply (AWRC 1992, p. 3). Groundwater is a vital resource to Australia. The nature of the resource is summarised in Table 1.1.10 by Drainage Division.

It is important to understand how groundwater forms and the time scales involved in order to appreciate its vulnerability to leaching from impurities.

Groundwater occurs when rain that does not run off to streams meets soil moisture needs and moves into the spaces between the rocks. If there is no soil cover, rain may move directly to these spaces. From there the water moves down with gravity. Groundwater may not rejoin the hydrological cycle for tens of thousands of years, or it may rise into lakes, rivers or wetlands and be transported to the sea.

There are three broad categories of water bearing formations, or aquifers:

- unconsolidated sediments consisting mostly of clays, silt sand and gravel, which provide a shallow aquifer;
- porous rocks in large basins such as the Great Artesian Basin; and
- fractured rocks the water content of which is dependent on a number of natural factors such as climate, vegetative cover and type of rock (ABS 1992, 4140.0, p. 161).

Groundwater quality

Groundwater does not flow freely as do rivers and streams. It may take a day or a year to move one or two metres with gravity, depending on the type of aquifer and the recharge rate. Therefore it is unable to flush impurities quickly. This makes groundwater extremely susceptible to surface impurities and pollutants which may leach into the recharge waters. If the aquifer occurs near the coast, sea water could encroach if the aquifer is overused or not recharging at a sufficient rate.

Groundwater in New South Wales has dissolved mineral salt content (see Table 1.1.11), but has been found to be relatively pathogen free and of generally good quality. When aquifers occur in unconsolidated sediment the water is effectively filtered of sediment and bacteria as it passes through to the basin. When in fractured or consolidated rock, filtration does not occur as effectively. Chemicals in solution are not removable through filtration in the groundwater system.

Nearly 65% of all the water used in the Perth area for industrial, domestic and agricultural purposes is groundwater. Problems have been found with nutrients from agriculture, nitrate and micro-organisms from septic, and a broad range of pollutants from industrial and waste sites contaminating a few areas of the Swan Coastal Plain. There are 1112 sites in the Perth Basin with contaminated groundwater.

The south-west of Western Australia is highly susceptible to salinity problems (see Figure 1.1.12) and, when compared to the examples of groundwater analysis in NSW (Table 1.1.11), it may be more severe.

Coastal and estuarine waters

Australian seas extend through three Southern Hemisphere basins — the Pacific, Indian and Southern Oceans. All the temperature zones are represented — Tropical, Sub-tropical, Temperate, Sub-polar and Polar. Australian waters are dominated by tropical water masses of low nutrient value. Runoff from the Australian continent is naturally low in nutrients due to the age and leached condition of the land mass. Without nutrients biological productivity is low.

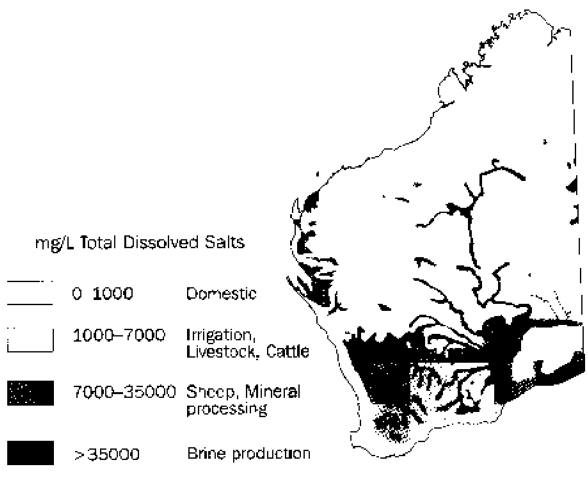
The 200 mile Exclusive Economic Zone (EEZ), including the Antarctic Territory, is estimated to cover over 11 million km^2, though it has not been accurately assessed since its recent proclamation in August of 1994 (Zann 1995, p. 101).

1.1.11 Examples of groundwater analyses

Source	Location	Depth m	Salinity (a) μS/cm	pH	CaCo$_3$(b) mg/l
Well	Hunter Valley	10	9 540	8	4 645
Well	Hunter Valley	11	2 740	7	630
Well	Hunter Valley	8	5 305	7	1 568
Well	Macquarie R., Dubbo	37	na	7	125
Well	near Orange	18	430	7	147
Artesian Bore	Glenroy	774	1 181	9	5
Bore	Mulgoa	234	na	5	73
Bore	near Young	53	1 950	7	576
Bore	near Tallebung	106	4 514	6	1 143
Bore	near Mudgee	59	645	7	293
Bore	Sydney Basin	43	na	7	2 573

(a) Electroconductivity in microsiemens/cm at 25°C.
(b) Calcium carbonate is a compound that makes water hard.
Source: Water Resources Commission, NSW, p.15.

1.1.12 West Australian groundwater risks from salinity



Source: Government of Western Australia 1992, p. 83.

1.1.13 Occurrence of water quality classes in Australian estuaries

State	Excellent No.	Fair No.	Poor No.	Insufficient data No.	Total No.
NSW	0	5	9	67	81
Vic.	5	2	2	26	35
Qld	149	6	1	151	307
SA	0	0	0	15	15
WA	121	4	2	18	145
Tas.	16	1	1	45	63
NT	133	0	0	3	137
Aust.	**424**	**18**	**15**	**326**	**783**

Source: Saenger 1995, p. 56.

The total coastline of the mainland and the 12,000 surrounding islands is about 70,000 kilometres long — one of the longest coastlines in the world. Inherent to the coast are Australia's 783 estuaries. Most of the available nutrients in Australian coastal waters are flushed from rivers and creeks into the estuaries where they remain for some time until they mix with sea waters. As a result of this the biological productivity of estuarine waters is high when compared with that of off-shore waters.

Included in Australia's marine environment are the coral reef areas of north-east Queensland (the Great Barrier Reef), and those of Western Australia. The temperate reefs of the Tasman and Southern Australia are also of high conservation value as the world's "outstanding region for richness of benthic algae" (Zann 1995, p. 13). Both the coral and temperate reefs are rich in distinctive flora and fauna.

Coastal and estuarine water quality

As with the fresh waters of Australia, the estuaries and coastal waters suffer from elevated nutrient and sediment loads, eutrophication and heavy metal, organochlorine and hydrocarbon pollution. The quality of Australia's marine environment reflects our use of the land and rivers, and the estuaries are the outflows for the above concerns (Zann 1995, p. 55).

Saenger states in his conclusions that "more research is needed on detailed individual catchment characteristics and water quality.." (Saengar 1995, p. 58).

The occurrence of water quality classes in Australian estuaries is shown in Table 1.1.13. It is of interest to note that in New South Wales no estuaries were considered of excellent quality and that in South Australia there were insufficient data to determine the quality of any. Estuaries in the Northern Territory, far north Queensland and northern Western Australia are relatively undisturbed and, as such, reflect a high water quality. The paucity of estuarine water quality data can be seen by the 326 estuaries of undetermined water quality as a result of insufficient data.

1.1.14 Nutrient concentrations at which observable increases in plant growth have occurred in various waterbodies

Waterbody/ area	Total nitrogen µg/l	Total phosphorous µg/l
Hawkesbury Nepean	650	55
Peel/Harvey	150	25
Lake Burley Griffin	90 (a)	60
Lake Macquarie	600	60
Murray River	550	40
Kosciusko National Park	360	40

(a) Only oxidised forms of nitrogen measured.

Note: These are approximate thresholds only. These waterbodies show a gradation of effects with time and location and hence it is not possible to be sure where and when eutrophication is apparent.

Source: Brodie 1995, p. 10.

Elevated sediment and nutrient levels from rural erosion, sewage and urban runoff are changing estuaries and shores by smothering sea life, encouraging Blue-green algae blooms and "red tides" of dinoflagellate organisms, and causing eutrophication in estuaries and bays. The toxic algae also affect shellfish, fish and seagrass beds while rendering the water foul smelling and unfit for recreational purposes. Loadings of estuarine waters with phosphorus and nitrogen have been linked to coastal algal blooms which have in turn been linked with coastal eutrophication (see Tables 1.1.14 and 1.1.15).

The nutrient loadings are supplemented by sediment, or Suspended Particulate Matter (SPM), that then settles. The problem has become a concern in the Great Barrier Reef lagoon where eutrophication and declining corals on the inner reefs are thought to be the result of sedimentation (Zann 1995, p. 56). The sediment load deposited by north Queensland rivers into the lagoon has more than doubled since European colonization (Brodie 1995, 16).

It is estimated that 16,000 tonnes of oil and petrol runoff and scheduled discharge from ships enter Australian marine waters. Though major infrequent oil spills and tanker accidents cause

1.1.15 Australian coastal areas showing eutrophication

Locality	*Effects*
Swan River Estuary	Phytoplankton blooms.
Peel-Harvey Estuary	Phytoplankton and macroalgal blooms.
Cockburn Sound	Seagrass loss.
Wilson Inlet	Minor enhanced seagrass growth.
Albany Harbour	Seagrass loss.
Port Lincoln	Seagrass loss.
Gulf St. Vincent	Major seagrass loss, toxic algae.
Port Phillip Bay	Macrophyte growth, toxic algae.
Western Port	Major seagrass loss.
Gippsland Lakes	Phytoplankton blooms.
Derwent Estuary	Phytoplankton blooms, toxic algae.
Huon Estuary	Phytopankton blooms.
Lake Illawarra	Seagrass loss and macrophyte growth.
Botany Bay	Seagrass loss.
Avoca Lagoon	Phytoplankton blooms.
Harbord Lagoon	Phytoplankton blooms.
Tuggerah Lakes	Seagrass loss and macrophyte growth.
Lake Macquarie	Phytoplankton blooms.
Clarence Estuary	Seagrass loss.
Tweed Estuary	Minor seagrass loss.
Moreton Bay	Phytoplankton blooms.
Great Barrier Reef Lagoon	Macrophyte growth and coral in decline.

Source: Brodie 1995, p. 15.

1.1.16 Occurrence of petroleum hydrocarbons in Australian waters and sediments

Location	*Concentration* *µg/l*
Waters	
Great Barrier Reef	0.29 petroleum.
Port Phillip Bay (Vic.)	0.2 –22.6 petroleum. 0.25–0.7 total hydrocarbon.
Western Port (Vic.)	<0.1–7.1 petroleum.
Yarra River (Vic.)	0.05–0.41 PAHs (a).
Parramata River (NSW)	0.17–0.41 PAHs.
Brisbane River (Qld)	0.10–0.28 PAHs.
Sediments	
Great Barrier Reef	0.2–0.8 dry wt hydrocarbons.
Brisbane River (Qld)	3.9–16.1 dry wt PAHs.
Parramatta River (NSW)	0.1–13.6% grease.
Mallacoota (Vic.)	0.80–0.11 PAHs.
Western Port (Vic.)	2.3–5 271 dry wt hydrocarbons.
Corio Bay (Vic.)	0.49–3.0 PAHs.
Corio/Geelong/Port Phillip Bay (Vic.)	6–1 516 petroleum hydrocarbons.
Yarra Estuary (Vic.)	0.12–10.9 PAHs.
Rowley Shelf (WA)	0.015–0.05 dry wt alkanes.
Background	variable (<1).

(a) Polycyclic Aromatic Hydrocarbons.
Source: Zann 1995, p. 58.

greater furore, the runoff from land is greater and causes chronic damage (Zann 1995, p. 58).

Table 1.1.16 clearly indicates the high incidence of hydrocarbons in estuaries and rivers near or at major urban centres.

Heavy metal concentrations in marine sediments and waters from urban runoff, industrial effluent, mining operations and atmospheric fallout have the potential to be toxic to fauna above certain levels. As can be seen from Table 1.1.17 the concentration levels in water fall below ANZECC guidelines in all the data shown except for Port Pirie, which has a lead smelter. On the other hand the accumulated levels in the sediment observations exceed ANZECC limits in many cases. The worst occurrences that concurred with water reading sites are shown here.

Elevated pH in estuarine waters is a concern of a recent study in the CSIRO's Coastal Zone Program. The rises in sea level which occurred prior to 6,000 years ago left behind iron pyrite rich sediments which are potential acid sulphate soils. These soils in turn, when oxidised, can result in runoff containing toxic levels of iron and aluminium resulting in large fish kills along the coast. Acid groundwater results in lower agricultural productivity and eats away concrete constructions (CSIRO 1994, p. 13).

Drinking water quality

Maintaining closed catchment areas, by restricting the land uses within the water harvest area for urban water supplies, served to keep the quality of water good. Now with more demands being placed on available land, some previously closed catchments have become open to urban, recreational, agricultural and forest development, resulting in a poorer raw water quality.

The quality of Australia's city tap water is of a high standard when compared with the rest of the world. Against the Australian Drinking Water Guidelines (see NHMRC 1994), metropolitan supplies comply with bacterial guidelines in 98% of instances, supplies in non-metropolitan areas in 83% of instances and supplies in remote areas in 40% (SoE 1996, pp. 7-36). The closed catchment and full water treatment (coagulation, filtration and chlorination) systems for metropolitan areas yield high water quality. Rural and remote areas are not as good due to variability in source water quality and lack of

1.1.17 Heavy metal concentrations in selected estuaries and sediments in south-eastern Australia (a)

	Cu	*Pb*	*Cd*	*Zn*	*Hg*	*As*	*Co*	*Ni*
	µg/l	*µg/l*	*µg/l*	*µg/l*	*µg/l*	*µg/l*	*µg/l*	*µg/l*
ANZECC Guideline	5	5	2	50	0.1	50	na	15
Estuaries								
Mid Port Phillip Bay, Vic.	0.60	<0.80	<0.05	<2	<0.002	3	na	na
Corio Bay, Vic.	1.10	<0.80	0.20	<2	<0.002	3	na	na
Port Hacking, NSW	0.50	0.40	0.20	na	na	na	na	na
N. Lake Macquarie, NSW	1.50	1.60	1.90	5.2	na	na	na	na
S. Lake Macquarie, NSW	1.20	0.10	0.20	1.0	na	na	na	na
Port Augusta, SA	0.45	0.54	0.37	<10	na	na	na	na
Port Pirie, SA (offshore)	0.25	5.10	0.32	47.0	na	na	na	na
Derwent River, Tas.	1.20	0.23	0.05	3.4	0.034	<6	0.03	0.27
Estuarine and marine sediments								
Corio Bay mid	4–35	14–100	0.2–9	14–166				
Port Phillip Bay (offshore)	8	22	2.0	40				
Port Phillip Bay Werribee	<5–75	<20–140	<5	9–300				
N. Lake Macquarie (b)	170	1 200	160	2 400				
S. Lake Macquarie (b)	20	68	4	150				
Port Kembla Harbour (c)	113	113	2	380				

(a) See Symbols and usages p. vi.
(b) 5 cm depth.
(c) 10 cm depth.
Source: Zann 1995, p. 60.

appropriate monitoring and treatment (SoE 1996, pp. 7–37).

Water storage reservoirs may develop the quality problems of thermal stratification, turbidity, salinity and Blue-green algae. Thermal stratification occurs during warmer months when the waters at the top heat but the bottom remains cold and becomes anoxic (oxygen deficient). This condition also initiates chemical reactions which release nutrients, gases and metals from sediment. The other problems mentioned here are referred to earlier in this section.

An article in the September 1995 issue of Choice Magazine mentioned two bacteria that are not treated with the chlorination process, Cryptosporidium and Giardia. These can cause often serious intestinal complaints.

Other points brought out in the article are the inherent problems with the treatment process. Chlorine can react with other substances to produce potentially carcinogenic s by-products such as trihalomethanes. The benefits of chlorination are currently regarded as outweighing the potential but unconfirmed risks. The use of aluminium compounds to clarify water in some supplies was noted. It is possible that small amounts of aluminium in drinking water may dissolve and be absorbed by the brain. This is thought by some to be linked with Alzheimer's disease. Once again, the need for conclusive research is indicated (Choice Magazine, 1995).

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1.2 Atmospheric conditions

Introduction

This section presents statistical information on atmospheric conditions and air quality. It introduces information on why these are such important environmental issues, and some basic concepts on the structure and function of the earth's atmosphere. The first part of the section then presents an overview of Australia' s climate and weather patterns. The last three parts give an overview of air quality issues, changes under the enhanced greenhouse effect and depletion of stratospheric ozone. Chapter 5 of the State of the Environment Report for Australia contains more detailed information on the atmosphere and atmospheric conditions, including indoor air quality.

The state of the atmosphere is a major environmental concern, as illustrated in Table 1.2.1, which is based on the results of a household survey conducted by the ABS into environmental issues in June 1994.

The Earth's atmosphere is a gaseous mixture surrounding its surface. It not only gives us the weather, it also prevents the Earth having an average temperature around freezing point by helping to distribute heat more evenly around the globe. It can be separated into various distinct layers or regions. Closest to the Earth are the troposphere, which goes to a height of about 15km, and the stratosphere, from 15km to 60km. Beyond these are the mesosphere and the thermosphere, which blend into airless space at a height greater than 100km. The concentration of the atmosphere decreases exponentially with increasing altitude above the Earth's surface because of the effect of gravity, which keeps most of the air molecules close to earth (see Figure 1.2.2).

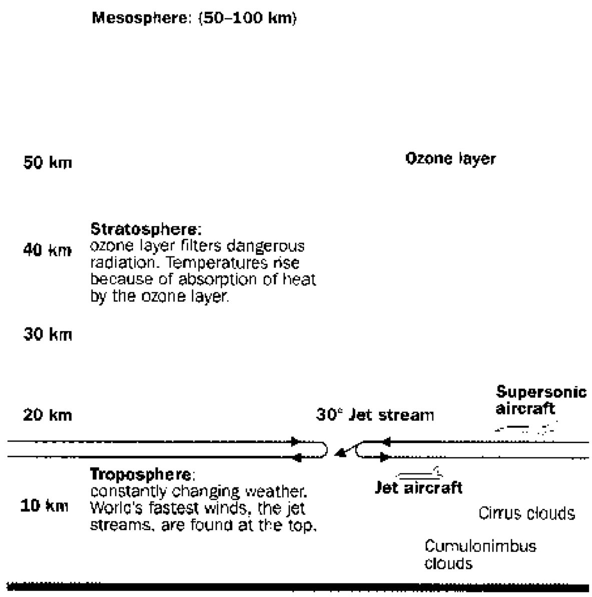
The chemical composition of the atmosphere is dominated by nitrogen (78%) which is a relatively inert gas, oxygen (21%) which is highly reactive and is a necessary element for many chemical reactions and metabolic processes, and argon (<1%) which is essentially inert. All other components are minor by volume. However, the levels of some of these gases, such as carbon dioxide, methane, nitrous oxide and tropospheric ozone, are steadily increasing in concentration, from both the result of human activity and natural sources. Human activity is also responsible for the introduction to the atmosphere and steady increase in concentrations of lead and chlorofluorocarbons.

1.2.1 Concern about atmospheric pollution and degradation, 1994

Environmental problem	*% of population*
Air pollution	34.1
Ozone layer	17.1
Greenhouse effect	8.8

Source: ABS 1995 (4602.0).

1.2.2 Composition of earth's atmosphere



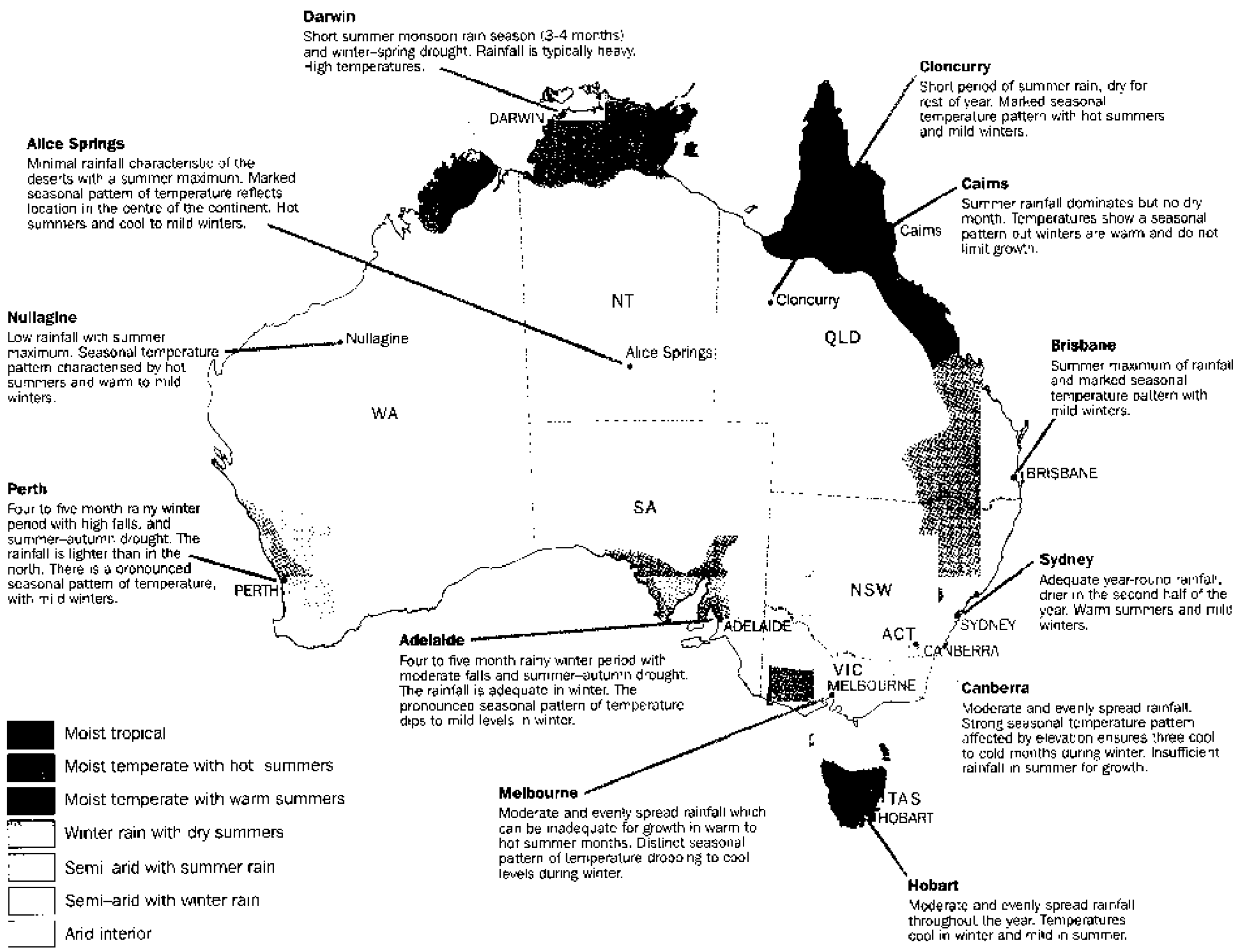
Source: AUSLIG 1992, p. 14.

An overview of Australia's climate

The climate of a place has a major influence on the characteristics of ecological systems, human lifestyles and the nature of economic systems. The extremes of temperature, precipitation, sunshine, frosts and wind speeds define the bounds within which natural systems, and to some extent human systems, must operate.

Australian ecosystems are diverse, and this diversity is a reflection of the great variation in these natural conditions around the continent. The characteristics of vegetation, flora and fauna regimes, and even soils of an area, are shaped by the ranges of temperature, amounts of precipitation and other factors of climate. The desert ecosystems of Western Australia, for example, bear the influence of minimal rainfall and high daytime temperatures, while Tasmanian rainforests show the influence of generous rainfalls and more moderate temperatures. The wide variations in the Australian climate are shown in Figure 1.2.3. Summer and winter rainfall and temperature are shown in Figure 1.2.4.

1.2.3 Climate classification, Australia



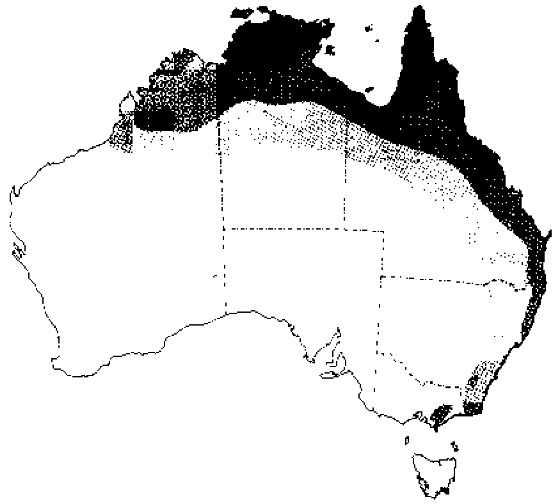
Source: AUSLIG 1992, pp. 70–71.

The climate of eastern and northern Australia is influenced by the Southern Oscillation (SO), a seesawing of atmospheric pressure between the northern Australian/Indonesian region and the central Pacific Ocean. Over eastern and northern Australia this oscillation is the second most important cause of climatic variation after the annual seasonal cycle. The Southern Oscillation Index is a measure of the difference in sea level atmospheric pressure between Tahiti in the central Pacific and Darwin in northern Australia. At one extreme of the oscillation the pressure is abnormally high at Darwin and abnormally low at Tahiti. Severe and widespread drought over eastern and northern Australia generally accompanies this extreme.

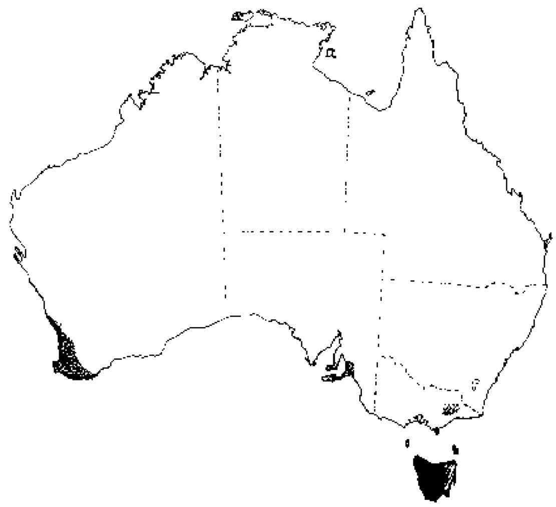
The above extreme is generally preceded immediately or followed by the opposite extreme, where pressures at Darwin are abnormally low and those at Tahiti are abnormally high. In this case, rainfall is generally above average over eastern and northern Australia. The SO is linked to sea surface temperatures in the Pacific Ocean. Dry extreme SO years are accompanied by above normal sea surface temperatures in the central and/or eastern equatorial Pacific and vice versa. Dry extreme years are called El Nino years (see Figure 1.2.5), and wet extreme years are called La Nina years.

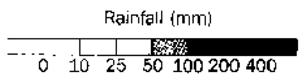
1.2.4 Variations in summer and winter rainfall and temperature

January Rainfall



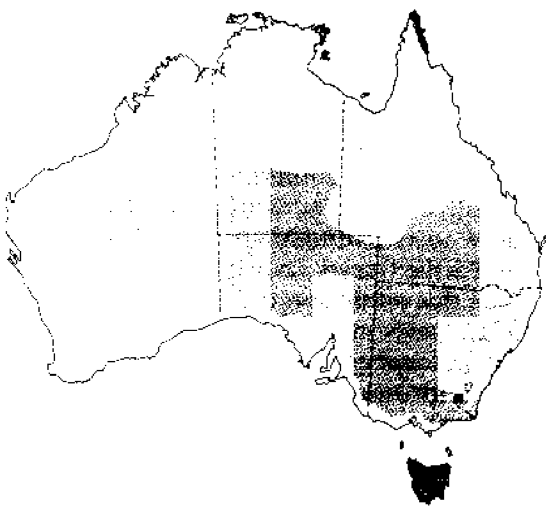
July Rainfall

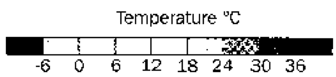




January Maximum Temperatures

July Minimum Temperatures

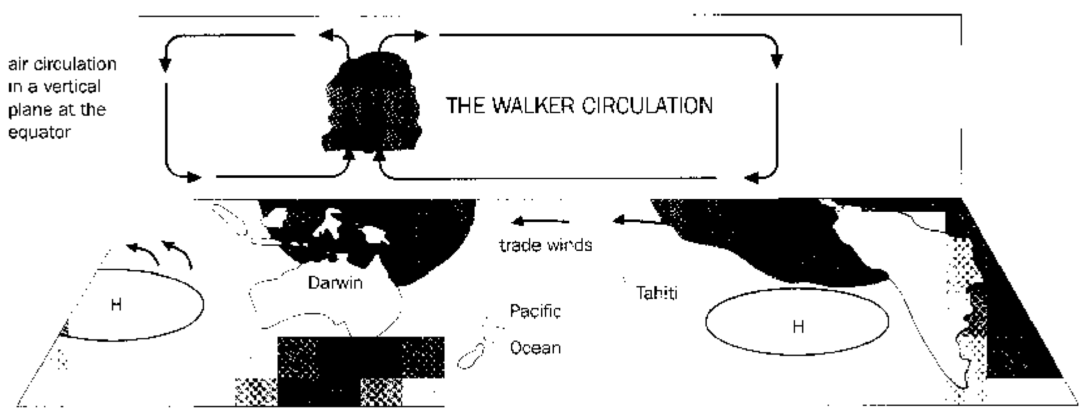




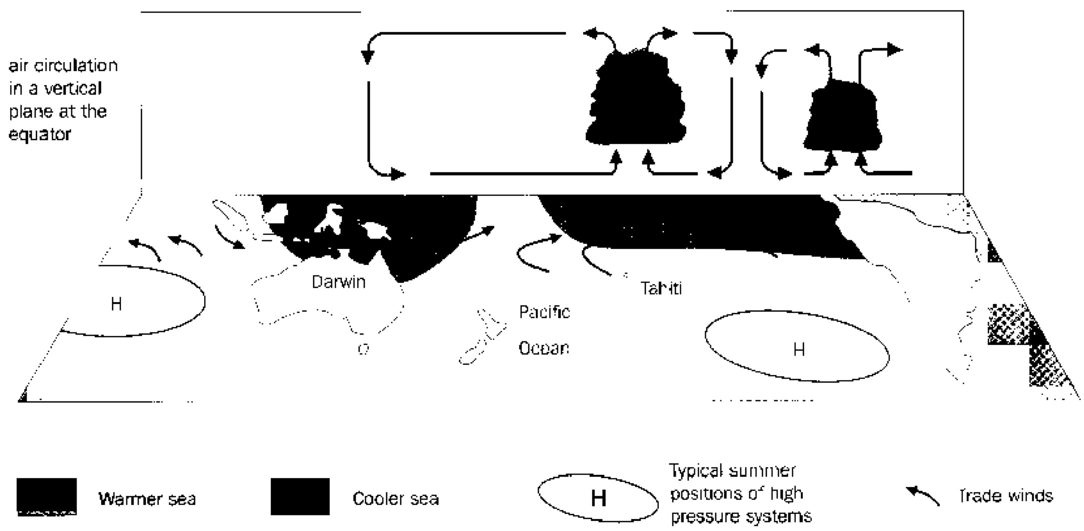
Source: AUSLIG 1992, pp. 68–69.

1.2.5 Typical and El Nino circulation patterns

Typical Walker circulation pattern



Walker circulation during El Niño



Note: The Walker Circulation is the east-west air circulation, with air ascending over the warm western Pacific and descending over the colder waters off the west coast of South America.

Source: Commonwealth of Australia, 1994, p.14.

Air quality

In Australia, individual State and Territory authorities have the main responsibility for monitoring air quality. Regular monitoring is limited to:

- the major metropolitan areas around most capital cities;
- some regional and industrial areas (such as the Latrobe and Hunter Valleys); and
- some areas around individual large sources of emissions.

The 1996 State of Environment Report for Australia has noted that ambient air quality over much of Australia cannot be adequately assessed because of a lack of data. Currently data are available only covering about 5% of the total land area and about 70% of the total population (SoE 1996, pp. 5-19).

1.2.6 Some major air pollutants and emissions

Carbon monoxide	Mainly produced from fossil fuel combustion sources. The car is the main contributor of this pollutant.
Sulfur dioxide	Emitted from sources such as coal burning, oil combustion and some industrial processes.
Oxides of nitrogen	Produced from processes in air, oil and water such as lightning and soil biological processes. Can also be produced from sources such as fossil fuel combustion, biomass burning, cultivated soils and intensive use of fertilisers. Nitrogen oxide also contributes to the greenhouse effect and depletion of stratospheric ozone.
Lead	One of the most significant pollutants, owing to its toxic nature, particularly its effects on young children. Sources include petrol engines, lead smelters, refineries, combustion of recycled sump oil and battery manufacture.
Air toxics	Includes pollutants known to cause or suspected of causing long term health effects in humans. Many air toxics are either volatile organic compounds or metallic compounds that could affect health following long-term exposure at very low concentrations.
Particulate matter (particles)	Particles of various sizes suspended in the air can reduce its clarity. These particles may include sea salt, sulphate from sea salt and SO_2 emissions, carbon from combustion processes, silica from soil and pollen.
Ozone	Tropospheric ozone is a secondary air pollutant, formed in the process of photochemical reactions among other chemicals.
Fluoride	Recognised as one of the traditional pollutants because of its effects on vegetation and livestock. Has a limited effect on the human body. Major sources are industrial processes, such as aluminium smelting, phosphate fertiliser production and brick and glass making.
Greenhouse gases	A number of trace gases which have a significant effect on the radiative energy balance of the earth's atmosphere. Includes carbon dioxide (CO_2), methane (CH_4) nitrous oxide and chlorofluorocarbons and their substitutes.

Source: ABS cat. 4140.0 pp 72–99; SoE 1996, pp. 5-21 — 5-23.

The State of Environment Report for Australia records that, for the 95% of Australia which is not covered by routine monitoring, it is believed that the major concerns relate to:

- sulphur dioxide from industrial sources;
- heavy metals (including lead) from ore processing;
- particulates from forestry and agricultural activities such as controlled burning, bushfires and the erosion and transport of fine topsoil by strong winds;
- pesticides from aerial spraying; and
- emissions caused by heavy traffic on some rural roads (SoE 1996, pp. 5-20).

Table 1.2.6 presents an overview of some of these major air pollutants.

Table 1.2.7 shows guidelines of the Australian and New Zealand Environment and Conservation Council (ANZECC) and the National Health and Medical Research Council (NHMRC) which could be used a basis for national comparison and measurement. With the exception of fluoride (where the guideline was established to protect vegetation) all the guidelines were designed to protect human health (SoE 1996, pp. 5-20).

Table 1.2.8 provides a summary of Australian urban and regional air quality and notes where breaches of the relevant guidelines have occurred. Chapter 5 of the State of Environment Report provides a series of charts showing the incidence of some of the major air pollutants for some capital cities of Australia.

1.2.7 Ambient air quality guidelines recommended by ANZECC and NHMRC

Pollutant	*Averaging time*	*Concentration*
Ozone	1 hour	0.12 ppm
Nitrogen dioxide	1 hour	0.16 ppm
Sulphur dioxide	10 minutes	0.5 ppm
	1 hour	0.25 ppm
	1 year	0.02 ppm
Total suspended particulate matter	1 year	90μ g/m³
Carbon monoxide	8 hours	9 ppm
Lead	3 months running average	1.5 μg/m³
Fluoride		
General land use	12 hours	3.7 μg/m³
	1 day	2.9 μg/m³
	7 days	1.7 μg/m³
	30 days	0.84 μg/m³
	90 days	0.5 μg/m³
Special land use	12 hours	1.8 μg/m³
	1 day	1.5 μg/m³
	7 days	0.8 μg/m³
	30 days	0.4 μg/m³
	90 days	0.25 μg/m³
Sulphates	1 year	15 μg/m³

Source: SoE 1996, pp. 5–20.

1.2.8 Urban and regional air quality

Pollutant	*Areas of most significance*	*Measured levels*	*Trends*	*Other comments*
Ozone	Primarily Melbourne and Sydney.	Occasional breaches of guidelines.	Signs of improvement may be result of meteorological variability.	Potentially growing problem in Brisbane & Perth as populations increase rapidly.
Nitrogen dioxide	With heavy traffic.	Occasional breaches in large cities.	No clear trends.	
Sulphur dioxide	Near metal ore processing.	Substantial breaches of guidelines near some sites.	Some improvements due to better controls for specific plants.	Potential for pressure for new sources in future.
Carbon monoxide	Areas with heavy traffic, wood fires.	Some breaches.	Slight improvement in most cities.	Measured levels sensitive to monitor siting.
Total suspended particulates (TSP or PM10) (a)	Areas with heavy traffic, mining & industrial areas, biomass burning (including wood fires).	Some breaches.	General improvements.	TSP not as well related to health effects as PM10 or PM2.5 (a).
Lead	Lead point sources and motor vehicles.	Some substantial breaches.	Steady improvement in urban areas.	Motor vehicles declining in importance as lead emissions decrease.
Fluoride	Aluminium smelters and ceramics works.	Breaches, often in buffer zones.	General gradual improvements.	Vegetation protection.

(a) Particles are monitored and reported in size-related categories. Total suspended particulates (TSP) include all particles from the smallest up to 50µm in diameter: within this range are sub-categories of those less than 10µm in diameter, known as PM10 and those smaller than 2.5µ known as PM2.5

Source: SoE 1996, pp. 5-30.

Climate change

The 1996 State of Environment Report for Australia records that "human activity has led, and is still leading, to increased atmospheric concentrations of greenhouse gases (carbon dioxide, methane and nitrous oxide and ozone) as well as to the presence of new greenhouse gases such as CFCs. Most of these gases, once released into the atmosphere, persist for tens to hundreds of years, with an associated long-term impact on the background atmospheric levels. Using an understanding of the processes that govern the climate system, and applying this knowledge in computer climate models, scientists consider that the presence of additional greenhouse gases will affect the radiation balance of the atmosphere and lead to a warming at the earth's surface. This is now generally referred to as the enhanced greenhouse effect.

Since the 1990 Intergovernmental Panel on Climate Change (IPCC) First Assessment Report, considerable progress has been made to distinguish between natural and anthropogenic influences on climate. In its Second Assessment Report (IPCC 1995) the IPCC concludes that despite uncertainties in key factors, the balance of evidence suggests that there is a discernible human influence on global climate.

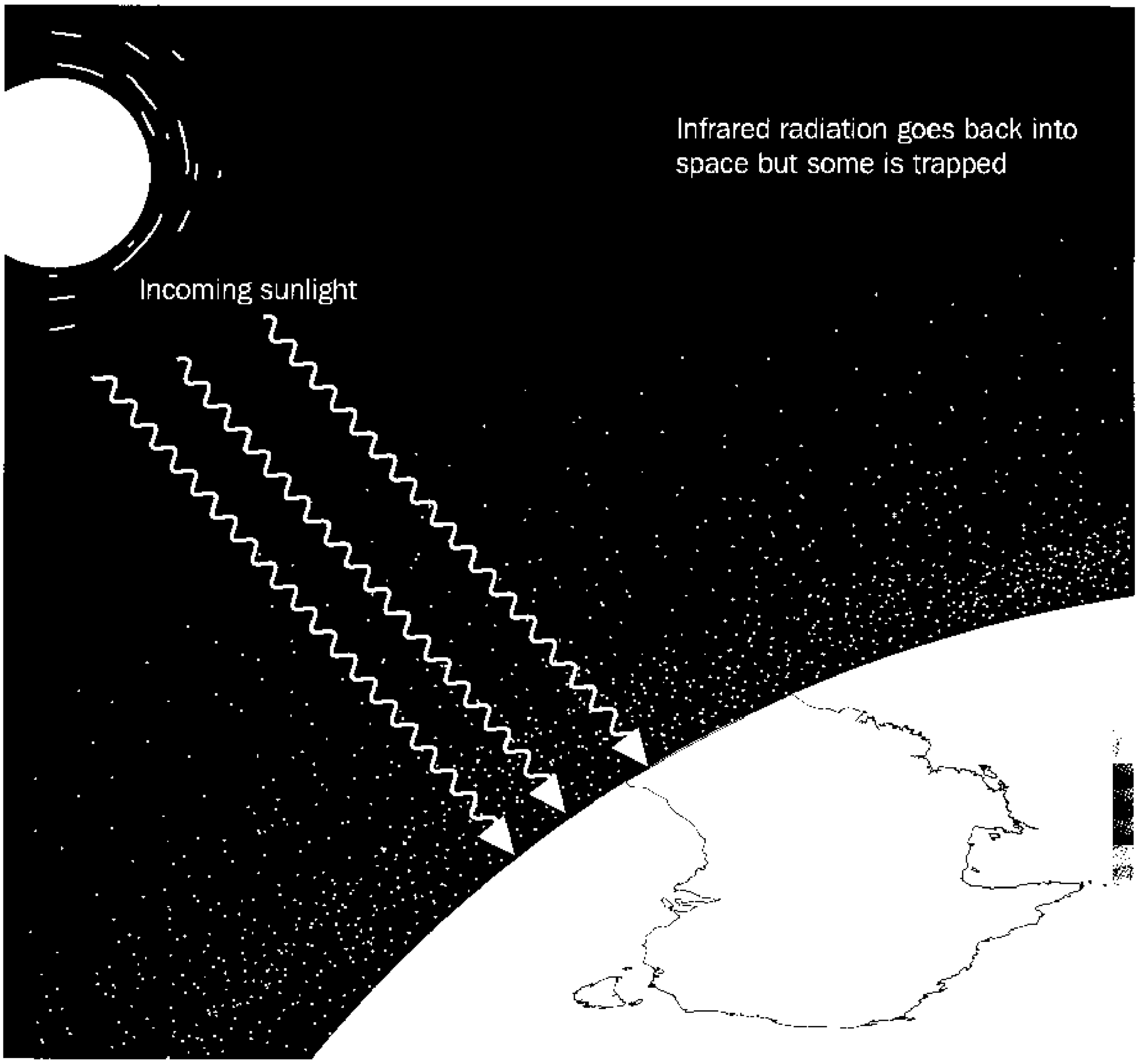
The IPCC projects an increase in global mean surface temperature relative to 1990 of about 2°C by 2100 and a corresponding increase in sea level of about 50cm.

The actual impact on global climate is likely to be complex and involve changes in atmospheric and oceanic circulations, accompanied by possible changes in sea level, diurnal temperatures, rainfall and other climatic variables. While climate model simulations already offer predictions of the global impact of the enhanced greenhouse effect, only broad indications of potential change on a regional scale are currently available (SoE 1996, p 5-13).

The greenhouse effect and the enhanced greenhouse effect

Short wave solar radiation passes relatively unhindered through the earth's atmosphere to the surface of the planet. The surface absorbs this incoming radiation and is warmed. The warmed surface, in turn, re-emits longer wavelength (infra-red) radiation back into the atmosphere. However, the atmosphere is less transparent to infra-red radiation than it is to short wave radiation (see Figure 1.2.9). Trace quantities of atmospheric gases absorb some of the outgoing infra-red radiation, re-radiating it back to the Earth's surface. In this way, they act like the glass in a greenhouse. By preventing a small portion of the infra-red radiation from escaping to space, these 'greenhouse gases' keep surface and lower atmosphere temperatures much warmer than would be the case in their absence. An equilibrium situation is reached whereby as much energy is lost to space as is gained from the sun, otherwise the Earth would become steadily hotter. Consequently, without the greenhouse effect, which helps to moderate the effect of

1.2.9 The greenhouse effect



Source: DEST 1995.

temperature on Earth, life in its present forms would not be possible. However, with the addition of greenhouse gases through human activities, theoretically more infra-red energy will accumulate in the lower atmosphere and, consequently, there will be an accumulation of heat at the surface and in the lower atmosphere. The greenhouse gases which contribute to this effect include: water vapour (H_2O); carbon dioxide (CO_2); methane (CH_4); various nitrogen oxides (NO_X), including nitrous oxide (N_2O), nitric oxide (NO) and nitrogen dioxide (NO_2); tropospheric ozone (O_3); and chlorofluorocarbons (CFCs). Other gases, notably carbon monoxide (CO), and various non-methanic organic compounds, also play an indirect role in the greenhouse effect by influencing the levels of other greenhouse gases.

Although carbon dioxide is the most abundant greenhouse gas, it is not as effective a radiation trap as others on a molecule for molecule basis. It and water vapour do not absorb much of the energy that the earth re-radiates on a molecule-for-molecule basis. Chlorofluorocarbons have such low concentrations in the atmosphere (about 0.7 parts per million) that they make a lower total contribution to the greenhouse effect than some other gases. Table 1.2.10 shows the contributions of the molecules of various gases to the greenhouse effect when both the relative abundance and infra-red energy absorption potential of the molecules are taken into account. There is some evidence to suggest that much of the extra carbon in the atmosphere is absorbed by sea water and plants, thereby reducing the effect of increased atmospheric carbon dioxide levels on global temperatures. Although the ocean and plant photosynthesis are thought to be

1.2.10 Gas molecule contribution to the anthropogenic greenhouse effect

Gas	*% contribution*
Nitrous oxides	5 – 10
Methane	10 – 15
Chlorofluorocarbons	15 – 25
Carbon dioxide	over 50

Source: Australian Academy of Science 1994, p. 189.

major sinks for carbon, there still appears to be a 'missing sink', that is, not all the carbon absorption processes which occur within the system seem to have been identified. Without detailed knowledge of the types and relative contributions of the various carbon sinks, it is unclear exactly how an increase in anthropogenic carbon will lead to changes in global temperatures.

The Australian report under the UN Framework for Climate Change in 1994 presented scenarios for changes in temperature and rainfall. The low bound of the scenarios assumes the lowest IPCC carbon dioxide emissions, a climate sensitivity of 1.5° C for an equivalent doubling of carbon dioxide, and a weak regional response. The equivalent high bound to the scenarios assumes the greatest IPCC emissions, a climate sensitivity of 4.5°C for an equivalent doubling of carbon dioxide, and a strong regional response, as determined from global climate models. Scenarios for temperature change are presented in Table 1.2.11. Scenarios for rainfall change and changes in temperature extremes are included in Figures 1.2.12 and 1.2.13.

As part of its obligations under the United Nations Framework Convention on Climate Change, Australia is required to compile an inventory of its greenhouse gas emissions and sinks. Australia's greenhouse emissions, and the activities responsible for those emissions, are discussed in detail in Section 12.1.2.

Stratospheric ozone conditions

Stratospheric ozone conditions are of critical importance to human activity. Ozone is important both in shielding the earth from ultra-violet radiation from the sun and in influencing the temperature conditions on earth. Recent monitoring efforts by atmospheric scientists, however, show that the ozone layer is thinning in some places.

1.2.11 Scenarios of temperature increase

	2030	*2070*
Region	*°C*	*°C*
Northern coast (north of about 25° S)	0.0–1.5	0–4
Southern Coast (south of about 25°S)	0.5–2.0	1–5
Inland	0.5–2.5	1–5

Source: Commonwealth of Australia 1994. p. 20.

Ozone is a naturally occurring gas that is found in trace quantities throughout the atmosphere. It is most abundant, however, in a relatively thin layer between 20 and 50km above sea level. This is the so-called stratospheric ozone layer. This ozone layer is critical to life on earth primarily because ozone molecules can absorb ultra-violet radiation. As such, the ozone layer helps to shield the surface of the Earth from extreme intensities of ultra-violet radiation. Ultra-violet radiation in large enough doses causes a change in the structure of DNA (deoxyribonucleic acid), which is the protein building block of life.

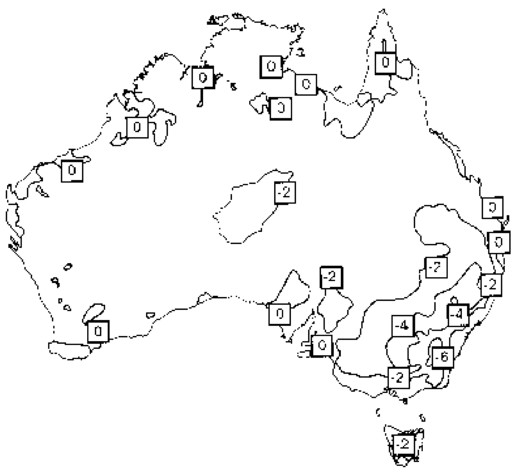
Over the last decade or so, the steady influx of pollutant gases such as CFCs into the stratosphere has hastened the depletion rate of ozone. CFCs are artificially manufactured compounds. They are used as components of the compressed gas that is pumped around refrigerators and air conditioners, in the manufacture of plastics and foam products, and in aerosols. They are also a safe compound to use because they are non-toxic, non-flammable and do not react readily with any other molecule. The inert nature of CFCs exacerbates their ozone-depleting capacity. Even though they meet very many other gas compounds on their slow journey through to the upper atmosphere, very few CFC molecules are broken down until they reach the stratosphere, where the action of intense ultra-violet radiation breaks most of the CFC molecules apart. This reaction liberates chlorine radicals (charged chlorine atoms) which, through a series of continuous chemical reactions, break down ozone.

Figure 1.2.14 shows the decrease in ozone concentration over Antarctica from 1979–1993. It is important to note that ozone decline does not just occur over the poles. All regions apart from the tropics have shown a decline in stratospheric ozone over the last decade, although not as severe as that over the poles (SoE 1996, p.5–12).

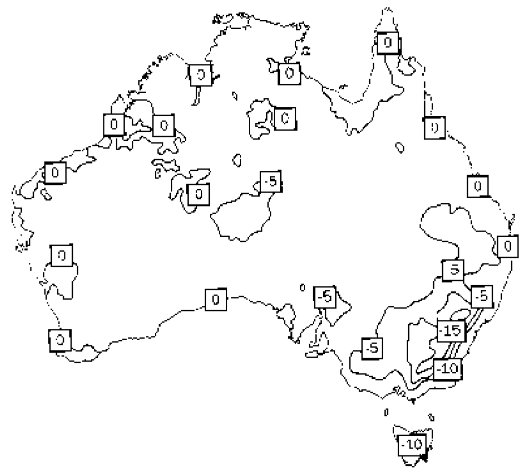
Figure 1.2.15 illustrates the effect of ozone depletion over the Antarctic during the spring of 1994. Antarctic ozone depletion does not commence until the early spring. It reaches a peak in mid-October. After that time, temperatures rise and reduce the number of polar stratospheric clouds that are formed, and ozone depletion levels off.

1.2.12 Predicted change in number of days with extreme temperatures under various assumptions, 2030

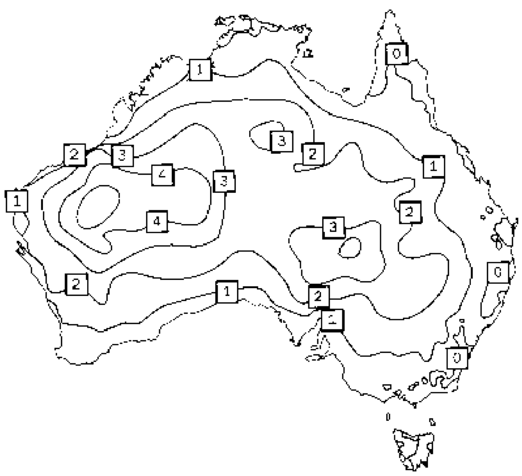
Winter nights below freezing.
Low change scenario



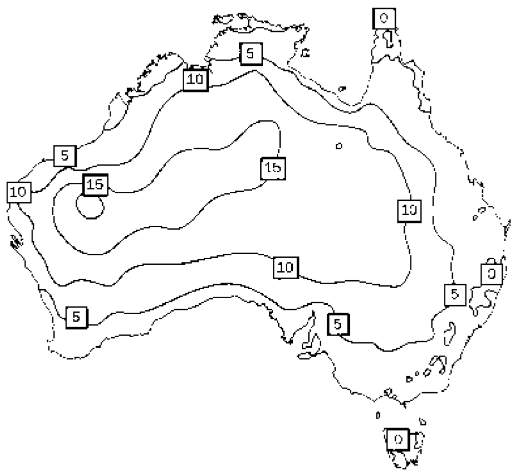
Winter nights below freezing.
High change scenario



Summer days above 40°C
Low change scenario

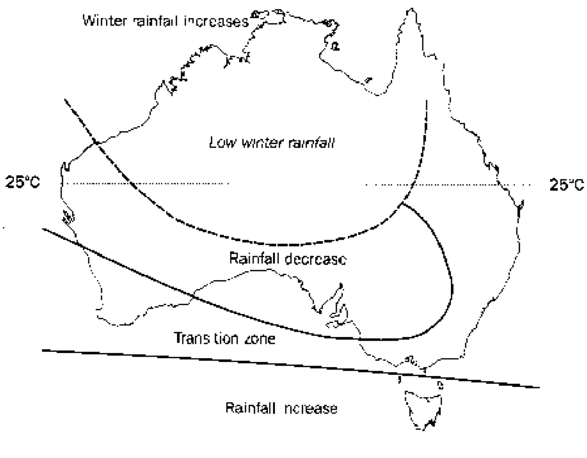


Summer days above 40°C
High change scenario



Source: Commonwealth of Australia 1994, p. 23.

1.2.13 Predicted change in winter rainfall

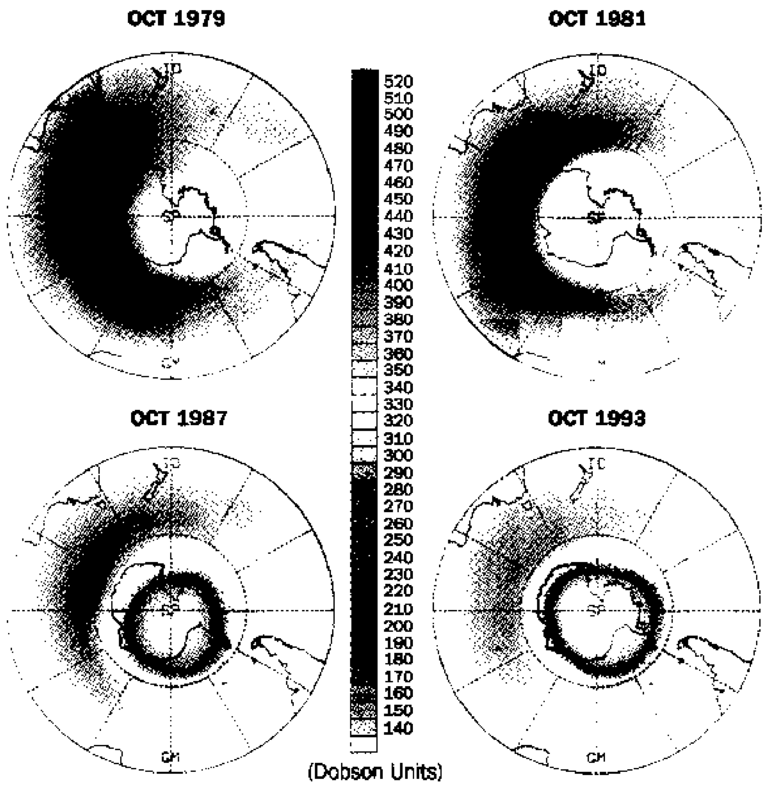


Source: Commonwealth of Australia 1994, p. 23.

There are other gas compounds which destroy ozone. These include halons, methyl chloroform, carbon tetrachloride, methyl bromide and hydrochlorofluorocarbons (HCFCs). All of these compounds have the same properties as CFCs and are used in one or more of the following: air conditioning, refrigerants, foams, aerosols, solvents and fire extinguishers. However, none of these compounds destroy ozone at a rate as high as the rate of CFCs. In fact, HCFCs are being phased in as temporary replacements for CFCs for just this reason. Despite this, HCFCs still release some chlorine into the atmosphere.

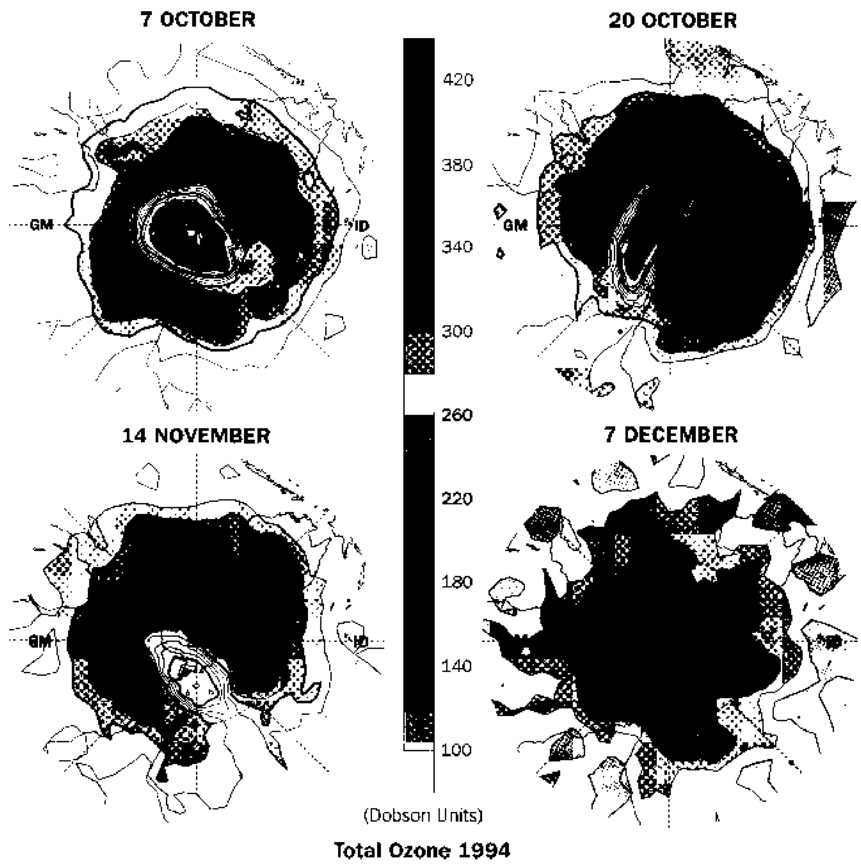
In general, a fall of 1% in atmospheric ozone has been calculated to be equivalent to an increase of between 1–2% in UV radiation at ground level. In humans, exposure to UV can cause sunburn, eye

1.2.14 Decrease in ozone concentration over Antarctica from October 1979 to October 1993



Source: AUSLIG, 1995, p. 99.

1.2.15 Ozone levels over Antarctica, October–December 1994



Source: Australian Meteorological Magazine, June 1996.

damage, skin cancer and damage to the immune system in susceptible individuals. Fair-skinned people are most at risk. Many other organisms, including plants, are also at risk from increased UV radiation. Too much ultra-violet radiation reduces plant growth, the sensitivity varying between species. Whereas humans can avoid exposure, it is more difficult for flora and fauna to do so, although some species can protect themselves by producing UV absorbing pigments in greater quantities following exposure (SoE 1996, pp. 5–12).

Other factors may also contribute to fluctuations in ozone depletion, such as lingering volcanic debris that has been forced into the stratosphere from large volcanic eruptions. The ozone layer in the tropics was about 10% thinner than normal in January 1992. This was considered to be a direct result of the eruption of Mt Pinatubo, Philippines, in 1991. (Australian Academy of Science 1994, p. 218).

At the beginning of this decade, concentrations of CFCs were rising at the rate of 4–10% a year, depending on the type. The monitoring station at Cape Grim, Tasmania, has recorded a steady increase in the amount of total atmospheric chlorine (SoE 1996, pp. 5-10). However, the rate of increase has decreased markedly (although the absolute concentration has not) since 1989, due to the Montreal Protocol of the Vienna Convention for the Protection of the Ozone Layer, which restricts and then phases out the use of CFCs.

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1.3 Soils and landscapes

Introduction

This section introduces the location, landforms and soils of the Australian continent. It looks at the soil-forming factors, i.e. the interrelationships between rock, climate, water, topography, organisms and time (the weathering factors). By also examining some of the naturally occurring degradation problems it highlights the continent's age and long exposure to weathering, which have resulted in Australian soils being considered infertile, shallow, stony and salt prone.

The Australian continent

The Australian continent is a land mass covering 7,682,300 square kilometres (see Table 1.3.1). It lies between the latitudes of 10°41'S (Cape York) and 43°39'S (South-East Cape, Tasmania) and longitude 113°09'E (Steep Point) and 153°39'E (Cape Byron). The mainland's most southerly point is South Point (Wilson's Promontory) at 39°08'S. The latitudinal distance between Cape York and South Point is about 3,180 kilometres, while the latitudinal distance between Cape York and South-East Cape, Tasmania is 3,680 kilometres. The longitudinal distance between Steep Point and Cape Byron is about 4,000 kilometres (ABS 1995, 1301.0).

The Australian landscape

Australia has a very distinctive physical geography (see Figure 1.3.2). It is the smallest, lowest and flattest continent. For example the average elevation of the continent is only about 330 metres, the highest point being Mt Kosciusko at about 2,230 metres and the uplands rarely exceeding 1200 metres (Camm et al. 1987; ABS 1995, 1301.0). The continent can be basically divided into three parts — the Western Plateau, the Central Lowlands and the Eastern Highlands (ABS 1995, 1301.0).

The Western Plateau consists of very old rocks (some over 3,000 million years old), and much of it has existed as a landmass for over 500 million years. Several parts have individual 'plateau' names (for example, Kimberley, Hammersley, Arnhem Land, Yilgarn). The Nullarbor Plain is virtually an uplifted sea floor, a limestone plain about 25 million years old (ABS 1995, 1301.0).

The Central Lowlands stretch from the Gulf of Carpentaria through the Great Artesian Basin to the Murray-Darling Plains. Much of the centre of Australia is flat, but there are numerous ranges (for example Macdonnels, Musgrave) and some individual mountains of which Uluru (Ayers Rock) is the best known. One of the best examples of the length of time Australian landscapes have been subjected to weathering is Uluru. The remarkable thing is not how Uluru got there, but that so much has been eroded from all around (ABS 1995, 1301.0).

In South Australia fault movements formed a series of 'ranges' (Mt Lofty, Flinders Ranges) and 'hills' (Adelaide Hills). The low lands are either occupied by sea (Spencer Gulf) or plains (lower Murray Plains) (ABS 1995, 1301.0).

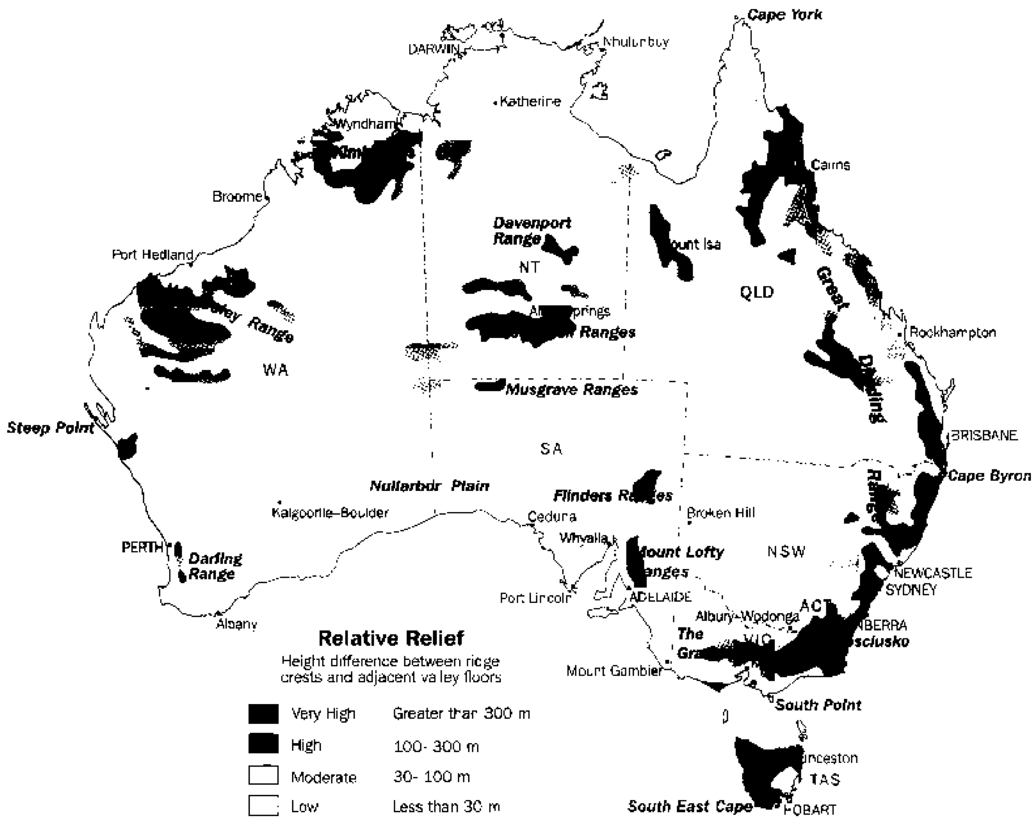
The Eastern Highlands rise gently from central Australia towards a series of high plateaus, and even the highest part around Mt Kosciusko is part of a plateau. There are a few younger faults and folds, such as the Lake George Fault near Canberra and the Lapstone Monocline near Sydney. Some plateaus in the Eastern Highlands

1.3.1 Area, tropical and temperate zones and length of coast line of Australia

	Estimated area		*Proportion of total area*		
	Total	*Proportion of total area*	*Tropical zone*	*Temperate zone*	*Length of coastline*
State/Territory	*km^2*	*%*	*%*	*%*	*km*
New South Wales	801 600	10.4	0	100	1 900
Victoria	227 600	3.0	0	100	1 800
Queensland	1 727 200	22.5	54	46	7 400
South Australia	984 000	12.8	0	100	3 700
Western Australia	2 525 500	32.9	37	63	12 500
Tasmania	67 800	0.9	0	100	3 200
Northern Territory	1 346 200	17.5	81	19	6 200
Australian Capital Territory	2 400	0.0	0	100	35(a)
Australia	**7 682 300**	**100**	**39**	**61**	**36 735**

(a) Jervis Bay Territory.
Source: Bureau of Meteorology cited in ABS 1995 (1301.0).

1.3.2 Australian topography and landforms



Source : AUSLIG 1992.

are dissected by erosion into rugged hills, and the eastern edges of plateaus tend to form high escarpments. Many of these are united to form a Great Escarpment that runs from northern Queensland to the Victorian border. For most of its length the Great Divide runs across remarkably flat country dotted with lakes and airstrips. In eastern Victoria, however, the old plateau has been eroded into separate High Plains (Dargo High Plain) — see Figure 1.3.2 (ABS 1995, 1301.0).

Rock and soil

Rocks, also referred to as stone, can be described as a mixture of one or more minerals, while minerals, which are made up of elements (such as gold and silver), are defined as "naturally occurring inorganic solids which possess a definite internal structure and a specific chemical composition" (Tarbuck and Lutgens 1987). There is some debate as to whether organic compounds (e.g. coal and petroleum) should also be classified as minerals (Tarbuck and Lutgens 1987). This publication deals with organic compounds separately (see Sections 6.6 and 6.8). Minerals are covered more fully in Section 6.6.

Human activity on the land is often governed by the type of rock evident. For example, the successful construction of towns and cities, and the building of roads and railways, often depend on what rock is found in the area. Rocks also provide clues to mineral bearing areas for the mining industry, and influence the type of soil formation which affects agricultural activities (Camm et al. 1987). The majority of the Earth's land surface is covered by a layer of rock and mineral pieces (known as regolith). This disintegrated and decomposed rock and mineral debris provide about one half of the total volume of a good quality surface soil (Tarbuck & Lutgens 1987).

1.3.3 The process of weathering, transportation and sedimentation

Parent rock

↓ Weathering

Weathered materials

IN SITU MATERIALS Common on hill crests and upper slopes		
	By gravity →	COLLUVIAL MATERIALS Common on footslopes and drainage depressions Mass movement Soil creep
	By water →	ALLUVIAL MATERIALS Common on alluvial plains, may be narrow (slopes & tablelands) or very broad (plains).
	By wind →	AEOLIAN MATERIALS e.g. sand, loess (silt) or parna (clay) Common in arid environments and in sand dunes of littoral environments
	By ice →	GLACIAL MATERIALS e.g. till, glacial drift, moraine

Source: ed. Charman & Murphy 1991.

Soil-forming factors

Soil is created through the interaction between:

- parent rock;
- climate;
- topography; and
- living organisms (e.g. animal, vegetation and human).

Parent rock, the original material from which soil is formed, can be from the weathering of bedrock or from materials transported and deposited. The parent material largely provides the mineral component of soil. Figure 1.3.3 indicates how the weathered materials are transported and deposited via gravity, water, wind and ice (Murphy 1991).

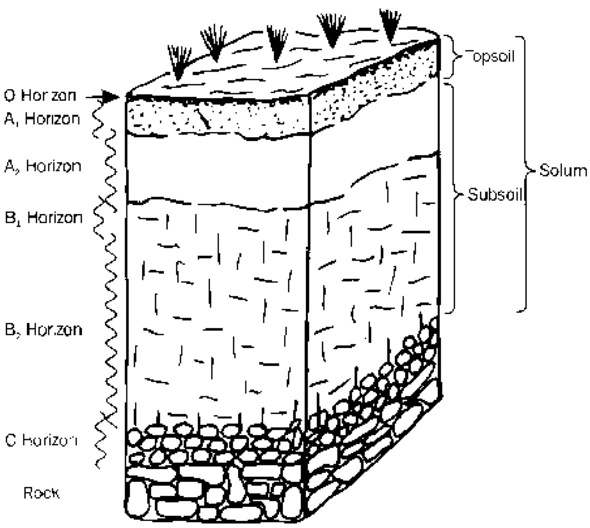
Climate strongly influences the soil forming process in both physical and chemical ways, e.g. the ratio of precipitation to evaporation and the amount of water available to transport materials (see Figure 1.3.3). Many of the soils in Australia, reflect the arid nature of the continent. However large areas of soil, especially in the arid interior, still reflect the environmental conditions prevalent many millions of years ago. Further information on water is contained in Sections 1.1 and 6.5.

Topography influences the distribution of water that is available for weathering, new mineral formation, leaching and translocation. Well drained soils mainly occur upslope, and there is generally an accumulation of water, weathering products and transported material in depressions or on lower slopes (Murphy 1991).

Biotic factors provide the materials and processes which make up the organic fraction of the soil. Dead or dying vegetation and animals provide organic material. This begins as undecomposed debris on the soil surface.

Soil is influenced by the amount of time in which soil-forming processes have been occurring. In the case of Australia this is many millions of years. Radiocarbon dating, undertaken by Dr Pat Walker of the CSIRO Division of Soils, suggests that the formation of 1mm of soil from alluvium in south-eastern Australia typically takes 20 to 30 years. The major soil replacement mechanism is through the spreading of silt by flooding (Ecos 66, 1990/91; Charman & Roper 1991; SoE 1996).

1.3.4 A soil horizon



Source: ed. Charman & Murphy.

Soil horizon

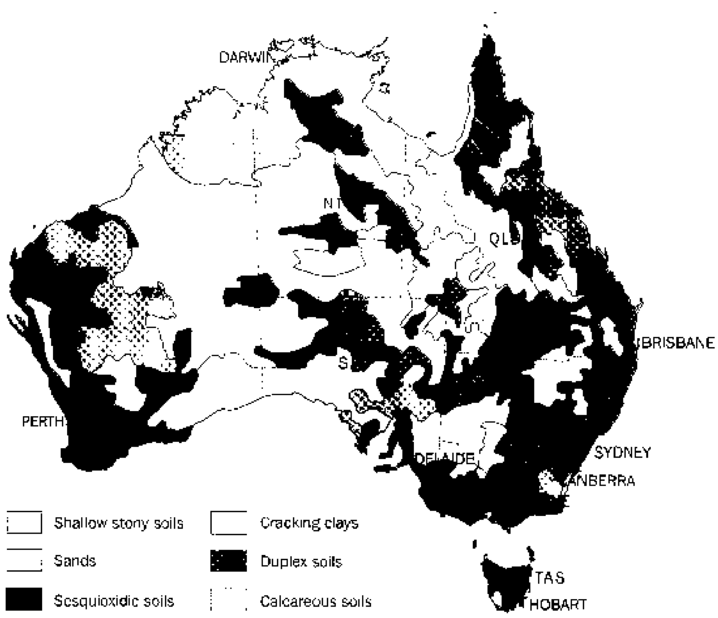
Soil typically comprises several layers, often referred to as horizons, which run more or less parallel to the earth's surface (see Figure 1.3.4).

The 0 horizon is composed of plant materials in varying stages of decomposition. The A horizon is the top layer of mineral soil. A1 is often the most useful part of the soil for plant growth and revegetation as the maximum biological activity occurs here, relative to other horizons. The A2 horizon (not always present in soils) is often paler in colour, poorer in structure and lower in organic matter. This is the zone which is known for its maximum leaching, weathering and clay translocation. The B horizons are usually finer in texture and often a less suitable medium for plant growth. The C horizon is recognised by its lack of soil formation activity and development (Murphy 1991).

Soils generally form very slowly and, because of this, measurement is a complex task. Estimates produced by Edwards (1988) and Sargeant (1990) found that, in Australia, on the northern and western slopes of the Main Divide 0.003 mm per year was created, while on the humid coastal areas of Victoria 0.02 mm per year occurred (McTainsh 1993). Data from the United States, however, suggest that some of its soils are formed at a rate of up to 0.08 mm per year (Schumm & Harvey 1979 cited in McTainsh 1993). Soil creation at a rate of 0.003 mm per year would result in 0.04 tonnes of soil per hectare per year (SoE Victoria 1991).

Australia, in the main, has only a thin covering of soil and, due to the great age of the continent, many surfaces have been exposed to extensive weathering. Weathering has resulted in the leaching out of nutrients from the soil, leaving it less productive. Where the soil is prone to wind and water erosion a nutrient decline is likely to occur (SoE 1996). This is because many of the nutrients are concentrated in the upper few centimetres of the soil, especially in arid areas (see Figure 1.3.4) (House of Representatives

1.3.5 Types and distribution of soils



Source: CSIRO Soils Division 1995.

Standing Committee for Long Term Strategies 1994).

Over one third of the continent is made up of unconsolidated sands, saline and sodic soils (see Figure 1.3.5). These soils are hard setting, and low in nutrients and organic matter. Many are cracking clay soils. The soils change abruptly in texture with depth, the clay content often increasing sharply just below the surface (Murphy 1991). (see Table 1.3.6). It is suggested that only 10% of Australia has reasonably productive soils, and some of these lie in unfavourable areas for agriculture. Where soils are deep and the rainfall good, tree growth is often poor because of nutrient deficiencies. The State of the Environment Report (1996) states that the area of arable land in Australia is 467,000 km^2 (about 6% of the land surface) (SoE 1996; Tarbuck & Lutgens 1987).

Soil types

In contrast with the northern hemisphere continents, Australia has a distinctive soil pattern. For example, there is an absence of many soils derived from volcanic ash or large areas of fertile humic soils derived from loess deposits (prairie soils or Mollisols) (Chartres & Isbell, 1995).

Because of the type of parent material, climate and geomorphic history, Australian soils can be broadly grouped into six informal classes. These are deep shallow stony soils, deep sands, cracking soils, calcareous soils, massive sesquioxidic soils and texture-contrast soils (also referred to as duplex soils). See Figure 1.3.5 and Table 1.3.6) (Chartres & Isbell 1995).

As Chartres & Isbell (1995) indicate it is important to realise that the classification of soils into six types is a "simplification of the Australian soil pattern". There are a number of soils not covered, due to the fact that they occupy only a small percentage of the continent, but are of agronomic importance and include high-iron soils such as Ferrosols (also referred to as Krasnozems) and Dermosols. These soils are used for small crops and are usually stable in structure. Alluvial soils, which are found on stream levees and flood plains, are also used widely for small

1.3.6 Six major Australian soil classes

Major class	*New classification*	*Description*	*Location*	*Usage*
Shallow stony soils	Tenosols, Rudosols	Range from sands to sandy clay loams, with gravel or stone throughout profile, usually shallow in depth.	Steep slopes in arid regions, or on ridge crests in humid zones.	Usually restricted to sparse rangeland grazing and minor forestry.
Deep sands	Tenosols, Rudosols, Podosol.	Sandy, usually siliceous except for some near coastal calcareous beach ridges. These soils occupy about 30% of the continent and are low in fertility.	Dunes, sand plains in arid and semi arid regions.	Used extensively for cereal cropping in WA, some horticulture and forestry plantations. Large areas unused.
Cracking clays	Vertosols	Uniform clay with profiles which may be very deep, up to five metres or more. Soils crack widely when dry. Soil fertility varies widely.	Found in eastern half of continent in semi-arid to sub-humid zones.	Used extensively for cereals, grain legumes, cotton, rice and sugar-cane. Some grazing.
Calcareous soils	Calcarosols	Range from sandy to loamy surface, becoming more clayey with depth. Calcareous materials disseminated through the fine earth. Can be low in fertility but high in alkalinity, salinity at depth and possible boron toxicity.	Widespread in southern Australia on undulating plains, low dunes and some stony rises.	Once covered with dense mallee vegetation but now widely used for winter cereals, lesser grains and legume crops.
Massive Sesquioxidic soils	Kandosols, Tenosols	Range from sand to sandy clay loam. Most soils exceed one metre in depth. Soils are usually low in nitrogen and phosphorus. Many are hardsetting and experience crusting problems.	Estimated to occupy 20% of continent. Range from monsoon tropics of Cape York Peninsula and Northern Territory to arid regions of the centre of the continent.	Main use is sparse grazing of native pasture with parts of NSW growing wheat.
Texture-contrast soils/Duplex	Chromosols, Sodosols, Kurosols	Essential feature is the marked increase in texture between loamy surface soils to clayey subsoils. This group is extremely diverse. Surface soils range from about 5 to 50cm (sometimes thicker). These soils range from strongly acid to highly alkaline and salinity and sodicity in the sub soil can range from nil to very high. Surface soils often low in organic matter and poorly structured. Prone to structural degradation, crusting and hardsetting.	Estimated to occupy almost 20% of continent. Occur on wide variety of land forms and throughout a wide range of climatic zones from subhumid tropical to arid.	Widely used for agriculture in temperate areas, especially wheat and improved grazing.

Source: Chartres & Isbell 1995.

crops and dairy pastures because of their usually high fertility status (Chartres & Isbell 1995).

Soil nutrients

The composition of the soil and its nutrients play a part in dictating the types of plants capable of growing and their rate of growth and reproduction.

McLaughlin, Fillery and Till (1992) suggest "it is generally recognised that it is the amount of phosphorus, more than any other nutrient, which governs the fertility of Australian soils" (McLaughlin, Fillery & Till 1992, citing Norrish & Rosser 1983). Unlike Australia's native vegetation, which has adapted to the low levels of phosphorus, agricultural plants require large quantities of some nutrients, especially nitrogen and phosphorus.

Other Australian soils lack sulphur, potassium, molybdenum, copper, zinc, boron and manganese (see Table 1.3.7). Conversely in acidic soils toxicity problems occur mainly due to an excess of aluminium or manganese. In Western Australia, South Australia and Victoria boron also causes toxicity (SoE 1996; Office of the Commissioner for the Environment 1991).

The State of the Environment Report (1996) states that little information exists on nutrient increase or decline. The data available mainly relate to the productive ability of the soils, for example, of the agricultural lands in Queensland and northern New South Wales. Where nutrient depletion is occurring this can be traced to "inadequate fertilisation (manufactured fertilisers or biologically fixed nitrogen), excessive cultivation (to mine nutrients in organic matter), or the loss of natural soil fertility through erosion due to poor grazing management, inappropriate cultivation or poor water management" (ed. Gifford & Barson, 1992). Further details on nutrients can be found in Sections 6.4 and 6.7.

Conversely, overuse of nitrogen fertilisers is causing acidity problems on some arable land (29 million ha, mainly agricultural land, are reported as being significantly acidified) (see Sections 6.4 and 6.7 for further details). Acidity also occurs naturally due to the weathering process, and can benefit plants in soils which are calcareous or alkaline sodic such as in areas in southern Australia (SoE 1996). Increased nutrient input also leads to unwanted stimulation of biological activity, for example the erosion or leaching of phosphates into inland waters stimulating algal growth (McLaughlin, Fillery & Till 1992), see Section 1.1.

Human activities have had a large impact on changes in nutrients. In the intensively farmed areas, losses and inputs of phosphates and nitrogen "have increased by orders of magnitude over natural fluxes" (McLaughlin, Fillery & Till 1992).

1.3.7 Selected nutrient problems in Australia

Nutrient	Plant requirement	Description
Nitrogen	A major component of protein in plants and animals. Required in large quantities.	Although soils can contain enough nitrogen for plants, it is often in a form useless for them. The most nitrogen rich soils are krasnozems. Even prior to European Settlement, it is suggested, nitrogen reserves in Australian soils were low by world standards.
Phosphorus	A key element in virtually every process which takes place in plants. Essential for reproduction and photosynthesis.	Soil organic matter can account for up to 80% of total phosphorus in the soil. Phosphorus is low in most Australian soils except those developed from the younger basalts or basalt-derived alluvium.
Sulphur	A part of many compounds which give flavour and smell to plants. It also forms part of protein molecule.	Most of the soil's supply of sulphur lies in its organic matter, but sulphur can be derived from minerals such as pyrites (iron sulphide). Dying plants and animals return sulphur to soil.
Potassium	Is used to regulate the balance of salts in the sap; helps regulate stem growth and assists in protecting the plant against disease. Required in large quantities.	Potassium is not derived mainly from the soil's organic content but is a common constituent of many minerals. Almost all potassium bearing soil minerals are aluminium silicates.
Molybdenum	Absence can retard plant growth. Used by the plant during its nitrogen fixation process.	Metamorphic rocks tend to be richer in trace elements Usually concentrated by plants in the surface soil, thus easily eroded. Deficiencies in this and other chemicals can result in soils' resistance to acidification being reduced. Molybdenum deficiency is one of the most widespread problems in Australian soils.
Copper and Zinc	Absence can retard plant growth.	Metamorphic rocks tend to be richer in trace elements Usually concentrated by plants in the surface soil ,thus easily eroded. Excess copper, along with other chemicals such as zinc, can cause toxicities and this is sometimes used for weed eradication. Zinc and copper toxicity occurs in red earths such as those in Captain's Flat in NSW and duplex soils such as those at Leadville NSW.

Source: Office of the Commissioner for the Environment 1991; Corbett 1969; Buchanan 1989.

Non-productive losses of nutrients are difficult to estimate, especially gaseous losses (including through fire) and losses due to leaching. Nutrient losses through soil erosion are extremely difficult to quantify because the scale on which erosion occurs varies with soil type, climate and land management techniques (McLaughlin, Fillery & Till 1992).

The State of the Environment Report (1996) suggests that, for Australia as a whole, the nutrient balance is positive for all the important elements. It indicates, however, that on a local level some areas will have a net depletion and others a net accumulation. Again information on a national level is sparse but further details are provided in Sections 6.4 and 6.7.

Naturally occurring changes to the soils

Erosion and soil degradation processes have been occurring in Australia for many millions of years. These processes are, however, being made worse by human land use and practices (further discussed in this publication). Research into naturally occurring versus human induced degradation and erosion is unfortunately scarce. A study in the United Kingdom by Morgan and Davidson (1986), has found that on natural lands "soil erosion rates 'averaged' about 0.05–2mm/year". Under cultivation this increases to about 5–10mm/year, with bare soil recording more than 25mm/year (cited in Aplin et al. 1995).

Soil resources in Australia, when compared with those of much of Europe and North America, are relatively fragile and susceptible to erosion, structure and nutrient decline, salinisation, sodification and acidification.

Water erosion is the most widespread form of land degradation in Australia. The process involves soil removal by rainfall or running water (ABS 1992, 4140.0). An example is the sand on Australian shores. This sediment may be from many miles inland, but some of it has been eroded, transported and deposited by the continent's waterways (Rose 1993). Climatic changes, such as hot dry seasons followed by very wet cooler seasons, also intensify this situation. Water erosion patterns similar to those experienced in Australia are to be found in countries bordering the Mediterranean Sea, which suffer similar hot summers and wet winters (Leeper & Uren 1993).

Calculating annual rates of soil loss is a complex problem as erosion varies due to the differences between soils, terrains and climatic conditions. For example, a study has shown that a mean annual loss from a forested area ranged from zero to 0.1 millimetres depth per year, however, following a bush fire and prior to regrowth, figures of 1 to 3.5 mm per year were recorded. Any event which reduces the protective groundcover thus increases the risk of soil loss. Research has found that rates of soil loss by water erosion in Australia generally increase from south to north and from inland to coastal regions, but this study noted that land use and management practices have a major effect on soil loss (Edwards, 1991 cited in ed. Charman & Murphy 1991; Rose 1993; ed. Charman & Murphy 1991; SoE 1996).

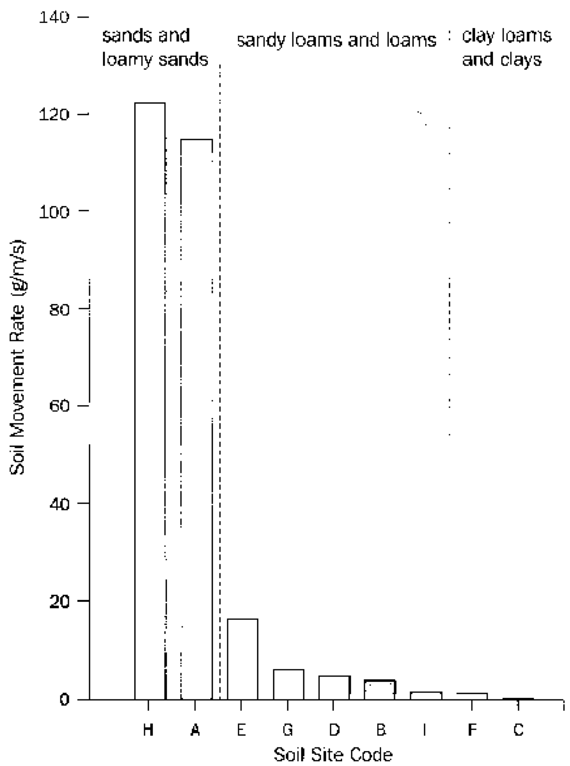
Estimates from the United States suggest that it loses 5 billion tonnes of top soil per year (80 % of which is caused through water erosion) (Aplin et al. 1995). In Australia the worst water erosion is found on the inland slopes of the Great Dividing Range in New South Wales and Victoria. These are areas subjected to hot dry seasons alternating with a wet season (with a total rainfall of >500 mm) (Leeper and Uren 1993). Figures for New South Wales, which comprises 80 million hectares, suggest that 28 million hectares have been affected by water erosion (Aplin et al. 1995).

Wind erosion is the process whereby soil particles are detached from the soil surface and blown away by wind (ABS 1992, 4140.0). Wind erosion mainly degrades soil in the dry climates and where the material is aeolian material (material found in sand dunes, sand plains or previously deposited sediments consisting of organic matter, fine clays, silts etc.) (Leeper & Uren 1993).

Wind erosion is difficult to measure as it is often impossible to predict when and where such erosion will occur. The wind blown sediments are also carried to great heights and scattered in various directions over a great range (McTainsh & Leys 1993). A soil erosion experiment was set up by the Queensland Department of Primary Industries (QDPI), near Charleville. Data collected during the period 1987–1990 found an annual average soil loss of between 2.8 and 5.2 tonnes/hectare/ year (0.2 to 0.4 mm/year soil loss). Miles and McTainsh (1994) state that there are few other published soil loss data to compare with these results but they believe the Charleville rates would be at the low end of the scale (Miles & McTainsh 1994). Figure 1.3.8 shows wind erosion rates in NSW.

Over the last two million years Australia experienced several arid phases, and it is likely that both desert conditions and erosion rates were extensive during these periods. One of the

1.3.8 Wind erosion rates, New South Wales



Source: Leys et al. 1994 p.13.

earliest recorded dust storms was experienced by Sturt in 1844. During his expedition to South Australia he recorded:

"It however came on to blow ... very hard ... being encamped on sandy ground we were at times nearly buried" (Brock 1975 cited in McTainsh & Leys 1993, p. 54).

Research into wind direction and strength has identified four regions in Australia which have suffered excessive wind erosion in the form of dust storms. These are the Mallee Riverina region, the Charleville area, Longreach and Urandangi, and the Channel Country. These four areas have differing soil structures, ranging from erodible sandy red earths to cracking clays. The cracking clay areas are, however, rich in water deposits of fine clay and silt, and it is these deposits which have been eroded by the wind (Ecos 1990/1).

About 63% of the land area of the SA Murray Mallee, for example, has soils with sand surface textures that are prone to wind erosion. Monitored wind erosion studies have clearly shown that dust removed is highly enriched with nutrients, and that soils with low fertility are those most susceptible to degradation. Erosion occurring in Victoria and the South Australian Mallee has resulted in the nutrients being lost to the sea or even falling on New Zealand (Bell 1990/1 printed in Ecos 1990/1; Davidson 1991 printed in Ecos 1990/1; Leeper & Uren 1993; Butler, McDonough & Leys 1994).

In contrast wind erosion also can assist in soil development. Research undertaken by the CSIRO in conjunction with the Australian National University (ANU) during the 1980s has shown that, during the past two million years, fine sands, silts and clays have been blown from the Riverina plains of western New South Wales onto the higher lands to the east. This dust has increased the essential elements and nutrients and has improved the soil structure on the higher lands. Similarly essential elements and nutrient-rich dusts from the pastoral semi-desert areas are often carried and deposited onto the coastal towns (Ecos 66 Summer 1990/1 pp. 6–7; ABS cat. 4140.0 1992). In February 1983, for example, a dust storm over Melbourne was estimated to have deposited 106 kg of dust per hectare on Melbourne suburbs (Raupach, McTainsh & Leys 1994).

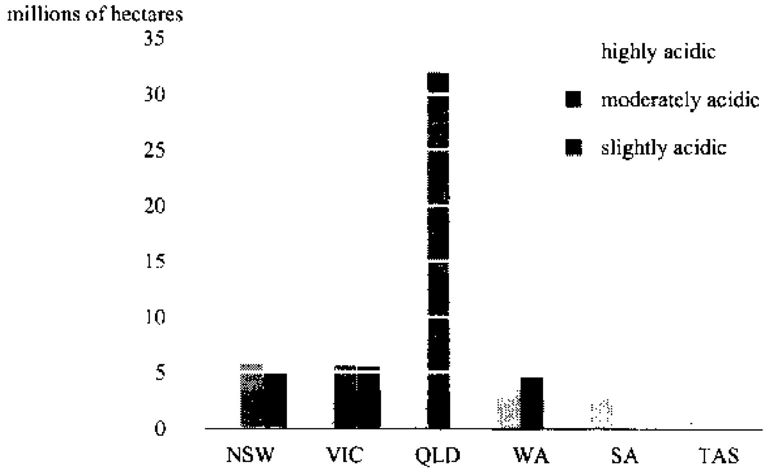
Even though some beneficial effects may occur from wind erosion, those areas which have experienced erosion are often significantly reduced in productive capacity due to the depletion of nutrient content and water-holding capacity (Shao, Raupach & Short 1994).

Soil acidification — many Australian soils are naturally acid (having a pH value below 7.0). The pH range most suitable for plant growth lies between pH 4.0 and pH 8.0 (Office of the Commissioner for the Environment 1991). Soil acidification occurs at a slow rate in natural ecosystems. Naturally occurring acidity develops because of the nature of the parent materials, and the great age and longer exposure to acidifying process. Other natural factors believed to cause acidity are the accumulation of soil organic matter and the leaching of nitrates produced in the soil. A number of chemical problems are apparent in acid soils such as toxicities of aluminium and manganese, and a deficiency of molybdenum (Office of the Commissioner for the Environment 1991).

Much of the research into acidic soils has been aimed at lands used for agricultural purposes, and present indicators suggest that about 35 million hectares of land are highly acidic (having a pH less than 4.8), and fifty five million hectares are moderately or slightly acidic (having a pH between 4.9 to 5.5). The moderately or slightly acidic soils have the potential to degrade to high acidic status (LWRRDC 1995a).

Figure 1.3.9 shows that New South Wales has the largest area of highly acidic soils, 13.5 million hectares. Queensland has 8.4 million, Western

1.3.9 Extent of acid soils in Australia



Source: LWRRDC 1995a p. VIII.

1.3.10 Types of degradation of soil structure

Field Soils

	No Human Input	Indirect Human Input	Direct Human Input
Causes of Structure Degradation	Bare soil surface High intensity rainfall	Tree clearing Pasture depletion Topsoil removal Pulverisation of aggregates Breaking organic matter bonds	Farm machinery -tillage tools -tractor wheels Farm animals -hoofs
Energy Input	Rainfall	Rainfall or irrigation	Normal load (stress)
Processes	Aggregate breakdown on soil surface → slaking		Compression & shear (c) (compaction) (smear)
	on drying dispersion (b) → aggregate (a) reformation (e.g. self-mulching)	**on drying**	
Effects	**Hardsetting and Crusting** Massive topsoil Surface crust High soil strength Poor seed bed Poor root environment Poor water infiltration		**Solely human-induced degradation of soil structure** Massive upper subsoil Discontinuous pores Reduced porosity High soil strength

(a) Aggregate reformation, high clay %, low exchange Na %, high exchange Ca %, clay with large surface area.
(b) Dispersion dominance of fine sand and silt, low organic matter %, clay dominated by illite or kaolin high exchange Na %.
(c) Compression and shear high clay %, large water holding capacity, low wet strength.
Source: McGarry 1993 p. 273.

Australia 4.7, Victoria 3.0, South Australia 2.8 and Tasmania 1.0 million hectares of acidic soils. Queensland has the largest area of moderately to slightly acidic soils, 32 million hectares. This is followed by New South Wales with 5.7 million, Victoria 5.6 million and Western Australia with 4.7 million hectares. Victoria and New South Wales have some slightly acidic soils (pH 5.6 to 6.0) (Barr & Carey cited in Aplin et al. 1995; LWRRDC 1995a).

Salinity is the process where salt accumulates in soil (or water) to such an extent that it affects the use of the soil for plant growth. Salinisation is widespread in Australia. It is estimated that dryland and irrigated salinity in Australia affects two and a half million hectares (Prime Minister's Science and Engineering Council 1995). There are two main forms of salinity.

Primary salinity relates to areas where high salinity levels occur naturally, e.g. salt marshes, salt flats, salt lakes, playa lakes and floodouts adjacent to major rivers, and undulating uplands and mesa country mantled by desert loams and red or brown clays (ABS 1992, 4140.0).

Primary salinity occurs as a result of natural landscape process. The widespread aridity, the extensive marine sedimentary rocks and internally draining river basins create the conditions which contribute to a continent being made up of about 5% saline soils and 30% soils with sodic features. Some rivers transport large amounts of salt, e.g. the Swan/Avon River in Western Australia carries an average of 2.0 million tonnes per year. The Murray-Darling river is estimated to carry 1.1 million tonnes into South Australia. Research by Northcote and Sken (1972) found about 5.3% of the continent suffering from primary salinity (cited in Peck 1993). The additions of salt from rainfall and weathering rocks involve very slow processes and can take thousands of years before the concentration of salt in the soil becomes a problem (Rengasamy & Walters 1994).

1.3.11 Water infiltration of different structured soils

Infiltration rate *mm/hr*	*Soil structure*
0–10	very poor
10–30	poor
30–70	adequate
>70	good

Note: Soils with low infiltration often have surface crusts, ploughpans, dispersible surface soil or other problems.
Source: LWRRDC 1995b.

Secondary salinity — the affected areas have increased salt levels probably resulting from two main activities. These are firstly the removal of trees and changing the vegetation cover on sub-humid hill country, and secondly the increasing or excessive use of irrigation mainly on arid-zone soils which have large amounts of salt stored in the subsoil or ground water. Further details are to be found in Section 6.7 (Alpin et al. 1995; ABS 1992, 4140.0).

Sodicity occurs when there is sufficient sodium attached to the clay in soil to affects soil structure. These soils are referred to as sodic and are difficult to manage and susceptible to soil degradation such as erosion. Sodium weakens the bonds between soil particles when wetted, resulting in the clay swelling and often becoming detached. On drying the detached fine particles can easily be moved by water or wind.

About 30% of agricultural land in Australia is known to be sodic. This is about five times the area of land estimated to be saline.

A saline soil becomes sodic through the leaching of salt (for example sodium chloride). This process may have occurred in the last 20 years or 10,000 years (Rengasamy & Walters 1994).

Soil structure decline is an undesirable change or breakdown in soil structure. It is common to find poorer soil surface structure in Australian soils when compared with Northern Hemisphere soils. Runoff, erosion and reduced productivity can occur in poorly structured soil (SoE 1996). This form of degradation is widespread, second only to water erosion. It is often caused by land management practices (e.g. excessive cultivation, stubble burning), as shown in Figure 1.3.10.

However, soil structure decline in the form of hard setting and crusting is often a naturally occurring phenomenon (although it can be made worse by human interference). Hard setting and crusting result when raindrops impact on bare soil, and destroy surface aggregates. The soil dries out and forms a surface crust and/or sets hard. The result is a reduction of infiltration, runoff and the potential for soil erosion as bare patches of earth occur. Infiltration is just one of the things affected by soil structure but it can give an indication of structural condition (see Table 1.3.11).

Crusting can, however, reduce wind erosion as it seals the surface of the soil. Where soil structure decline is severe, bare patches occur. This is where there is surface crusting and surface disaggregration of greater than 5m^2 per hectare. Slaking and dispersion are the mechanism by which soil aggregates fail. Soil crusting is found inherently in fine sand and silt soils (Office of the Commissioner for the Environment 1991)

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1.4 State of flora and fauna

1.4.1 Biodiversity and health of the terrestrial and aquatic ecosystem

This section begins by discussing the state, abundance and composition of Australia's biodiversity (the diversity of species of plants and animals), and looking at some of the threats to that biodiversity. It then examines the contaminants in Australia's animal and plant life (its 'biota').

Biological diversity refers to "the variability among living organisms from all sources, including ... terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part" (UNEP 1992, p. 184). It is commonly defined at three levels:

- ecosystem diversity, which includes the diversity of plant, animal and micro-organism communities, in association with the non-living environment, and their interactions in a given area;
- species diversity, which refers to the variety of species within a defined area; and
- genetic diversity, which refers to the variety of genes contained within and between species in a given area.

This section presents information on Australia's ecosystem and species diversity. Australia's wealth of genetic diversity is not easily quantified and, as such, will not be explored here. For a discussion of genetic diversity, see the State of Environment Report, Chapter Four — Biodiversity (SoE 1996).

Australian ecosystems

Terrestrial

This section begins with an assessment of the diversity and status of Australia's ecosystems. Ecosystems may be defined and their diversity measured on many scales, provided they are described using a consistent set of criteria. In the first instance, the largest and easiest component of any landscape to detect, quantify and interpret is vegetation. As continental datasets of vegetation structural type for Australia exist (AUSLIG 1990), and the level of disturbance of each of these landcover types has been quantified, the measurement of ecosystem diversity and status by landcover type based on vegetation type is a useful one.

In this instance, a particular landcover type and its associated fauna are equated to an ecosystem. An assumption is made that there exists a robust relationship between vegetation, soils and fauna, and hence changes in vegetation are used to infer changes in the other two (Graetz, Wilson & Campbell 1995).

For the purposes of determining the state of the ecosystem, Graetz, Wilson and Campbell (1995) divided the continent into two broad regions based on the principal disturbance (or potential disturbance) occurring in these two zones. These zones are defined as the Intensive Landuse Zone (ILZ) and the Extensive Landuse Zone (ELZ) (see Figure 1.4.1.1). Figure 1.4.1.2 shows the relative size and distribution of the various landcover types used in this assessment.

Table 1.4.1.3 refers to the Intensive Landuse Zone (ILZ). This zone covers 39% of the continent and contains about 90% of the population, and the principal threat in this landuse zone is clearing (for crops, pasture, forestry, urbanisation).

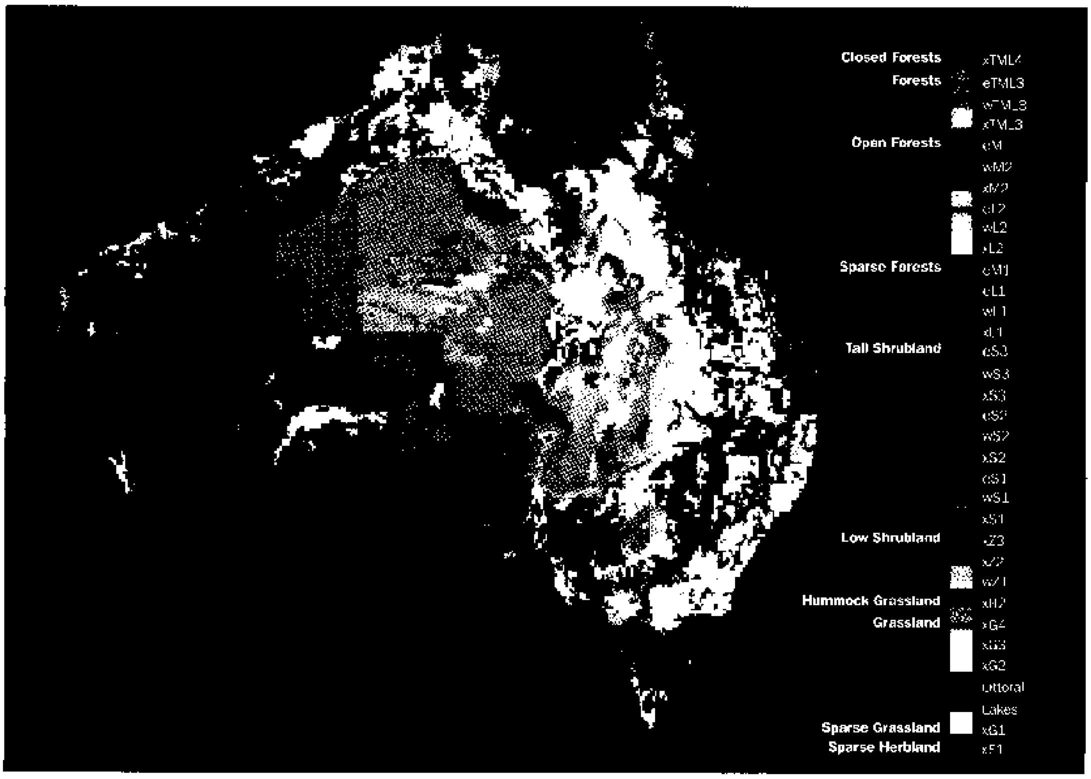
Table 1.4.1.4 refers to the Extensive Landuse Zone (ELZ), covering 61% of the continent but

1.4.1.1 Stratification of the Australian continent by principal landcover disturbance threat (ILZ and ELZ)

Note: The outermost region (red) encompasses those areas where the principal landcover disturbance threat is clearing for crops, pastures and forests. However, not all of this area is cleared. In the innermost region (green), the principal landcover disturbance results from grazing and burning.

Source: Graetz, Wilson & Campbell 1995, p. 14.

1.4.1.2 Relative size and distribution of 34 landcover types



Source: Graetz, Wilson & Campbell 1995, p. 18.

carrying as little as 5% of the population. The principal landcover disturbance in this zone results from grazing and (to a lesser extent) burning. Thus, measurement of landcover disturbance differs depending on which basic landuse zone it occurs in. See also Section 12.2.1 for further discussion of the Extensive and Intensive Landuse Zones.

A geocoded digital mosaic of Landsat MSS data was the primary dataset used for quantifying landcover disturbance. See Graetz, Wilson and Campbell (1995) for more detail on the methodology applied and techniques used in this analysis.

Specific contributing factors to the decline of, and threats to, biological diversity such as invasion by feral animals and exotic plants, changing climate, and certain human activities are covered elsewhere in this publication.

Table 1.4.1.3 shows the extent to which vegetation types have been cleared since European settlement in the Intensive Landuse Zone. Within this zone, 1,029,640 km^2, or 51.9% of the area, are either cleared or thinned. This represents about 20% of the whole continent.

The most extensive landcover type in this zone is the open, medium height eucalypt forests (or woodlands), ranging from tropical to temperate climates. This landscape type occupies 26% of the ILZ, and 12.7% of the total continent. Hence, in terms of total area cleared or thinned, this vegetation type is the most disturbed, with about 506,000 km^2 cleared or thinned. An estimated 206,000 km^2 remain uncleared.

The highest degree of disturbance suffered by a landcover type in this landuse zone was by the tall Eucalyptus shrubland complex. Occupying only 0.3% of the continent, 99%, or nearly 20,000km^2, of this vegetation type has been cleared or thinned.

Within the Extensive Landuse Zone (see Table 1.4.1.4), and the continent as a whole, by far the most extensive landcover type is the tall, sparse Acacia shrublands that cover much of the arid sandplains.

The assessment of landcover disturbance for this landuse zone is far more subjective and less quantitative than for the ILZ.

The most significantly disturbed landcover types are the open grasslands, the low sparse Acacia shrublands and the tall open shrublands (excluding Eucalyptus dominated shrublands). In addition, 95% of grassland were rated as substantially disturbed, with all of the remaining landcover types in the ELZ at least slightly disturbed.

1.4.1.3 Relative distribution of clearing (since 1788) within each landcover type for the intensive landuse zone, Australia

	Disturbance							
	Uncleared		Thinned		Cleared		Unknown	Loss (a)
Vegetation type	km^2	%	km^2	%	km^2	%	%	%
FOREST								
Tall, medium and low								
xTML4 closed: dominant overstorey genus other than Eucalyptus or Acacia	32 517	73.9	7 585	17.2	3 929	8.9	0.0	26.1
eTML3 dominant overstorey genus Eucalyptus	271 355	61.6	75 008	17.0	88 498	20.1	1.3	37.1
wTML3 dominant overstorey genus Acacia	21 269	19.7	39 595	36.7	47 097	43.6	0.0	80.3
xTML3 dominant overstorey genus other than Eucalyptus or Acacia	5 641	29.1	3 284	17.0	10 429	53.9	0.0	70.9
Medium open								
eM2 dominant overstorey genus Eucalyptus	206 336	26.7	174 296	22.5	331 281	42.8	8.0	65.3
wM2 dominant overstorey genus Acacia	200	19.6	145	14.2	676	66.2	0.0	80.4
xM2 dominant overstorey genus other than Eucalyptus or Acacia	6 056	43.3	3 445	24.7	4 470	32.0	0.0	56.7
Low open								
eL2 dominant overstorey genus Eucalyptus	29 405	18.6	16 232	10.3	46 344	29.3	41.9	39.6
wL2 dominant overstorey genus Acacia	20 126	13.6	31 524	21.3	96 081	65.0	0.0	86.4
xL2 dominant overstorey genus other than Eucalyptus or Acacia	107 518	90.3	2 321	2.0	9 164	7.7	0.0	9.7
Medium sparse								
eM1 dominant overstorey genus Eucalyptus	13 441	7.8	74 262	43.3	83 840	48.9	0.0	92.2
Low sparse								
eL1 dominant overstorey genus Eucalyptus	30 646	20.5	16 519	11.0	32 633	21.8	46.6	32.9
wL1 dominant overstorey genus Acacia	40 962	96.5	8	0.0	1 491	3.5	0.0	3.5
xL1 dominant overstorey genus other than Eucalyptus or Acacia	41 454	60.7	2 834	4.1	24 005	35.1	0.0	39.3
SHRUBLAND								
Tall								
eS3 dominant overstorey genus Eucalyptus	205	1.0	300	1.5	19 388	97.5	0.0	99.0
wS3 dominant overstorey genus Acacia	12 944	37.5	6 381	18.5	15 188	44.0	0.0	62.5
xS3 dominant overstorey genus other than Eucalyptus or Acacia	8 513	43.8	597	3.1	10 310	53.1	0.0	56.2
Tall open								
eS2 dominant overstorey genus Eucalyptus	41 926	17.6	45 516	19.1	151 005	63.3	0.0	82.4
wS2 dominant overstorey genus Acacia	25 798	97.1	593	2.2	174	0.7	0.0	2.9
xS2 dominant overstorey genus other than Eucalyptus or Acacia	17 338	38.8	8 247	18.4	19 130	42.8	0.0	61.2
Tall sparse								
eS1 dominant overstorey genus Eucalyptus	4 123	14.0	3 422	11.6	21 898	74.4	0.0	86.0
wS1 dominant overstorey genus Acacia	21 279	100.0	0	0.0	0	0.0	0.0	0.0
xS1 dominant overstorey genus other than Eucalyptus or Acacia	5 632	100.0	0	0.0	0	0.0	0.0	0.0
Low								
xZ3 dominant overstorey genus other than Eucalyptus or Acacia	3 135	38.7	1 321	16.3	3 644	45.0	0.0	61.3
Low sparse								
wZ1 dominant overstorey genus Acacia	0	100.0	0	0.0	0	0.0	0.0	0.0
LITTORAL								
variable canopy structure and composition	0	100.0	0	0.0	0	0.0	0.0	0.0

Note: All (significant) change detected is assumed to have occurred in the last 200 years.
(a) Equals thinned plus cleared.
Source: Graetz, Wilson & Campbell 1995.

1.4.1.4 Relative degree of disturbance within each landcover type (since 1788) for the extensive landuse zone, Australia

Vegetation type	*Slight* %	*Substantial* %	*Significant* %	*Unknown* %
FOREST				
Tall, medium and low				
xTML4 closed: dominant overstorey genus other than Euc. or Acacia	100	0	0	0
eTML3 dominant overstorey genus Eucalyptus	75	25	0	0
wTML3 dominant overstorey genus Acacia	100	0	0	0
xTML3 dominant overstorey genus other than Eucalyptus or Acacia	100	0	0	0
Medium open				
eM2 dominant overstorey genus Eucalyptus	100	0	0	0
xM2 dominant overstorey genus other than Eucalyptus or Acacia	100	0	0	0
Low open				
eL2 dominant overstorey genus Eucalyptus	100	0	0	0
wL2 dominant overstorey genus Acacia	100	0	0	0
xL2 dominant overstorey genus other than Eucalyptus or Acacia	44	56	0	0
Medium sparse				
eM1 dominant overstorey genus Eucalyptus	65	0	0	35
Low sparse				
eL1 dominant overstorey genus Eucalyptus	100	0	0	0
wL1 dominant overstorey genus Acacia	24	0	76	0
xL1 dominant overstorey genus other than Eucalyptus or Acacia	58	42	0	0
SHRUBLAND				
Tall				
wS3 dominant overstorey genus Acacia	66	0	0	34
xS3 dominant overstorey genus other than Eucalyptus or Acacia	97	0	0	3
Tall open				
eS2 dominant overstorey genus Eucalyptus	100	0	0	0
wS2 dominant overstorey genus Acacia	37	0	63	0
xS2 dominant overstorey genus other than Eucalyptus or Acacia	12	0	88	0
Tall sparse				
eS1 dominant overstorey genus Eucalyptus	65	35	0	0
wS1 dominant overstorey genus Acacia	68	0	32	0
xS1 dominant overstorey genus other than Eucalyptus or Acacia	25	0	75	0
Low				
xZ3 dominant overstorey genus other than Eucalyptus or Acacia	44	0	0	56
Low open				
xZ2 dominant overstorey other than Eucalyptus or Acacia	34	66	0	0
Low sparse				
wZ1 dominant overstorey genus Acacia	3	0	97	0
GRASSLAND				
xH2 Hummock: dominant genus variable	100	0	0	0
xG4 Closed: dominant genus is variable	81	19	0	0
xG3 dominant genus variable	5	95	0	0
xG2 Open: dominant genus variable	3	0	97	0
xG1 Sparse open: dominant genus variable	21	79	0	0
xF1 Sparse open: dominant genus variable	16	0	84	0
LITTORAL				
Littoral complex of variable canopy structure and composition	100	0	0	0

Note: The assessment of landcover disturbance was based on expert interpretation of the satellite image data. All (significant) change detected is assumed to have occurred in the last 200 years.

Source: Graetz, Wilson & Campbell, 1995.

Marine

A description of the regionalisation of marine ecosystems and a summary of their condition is provided in the 1996, State of Environment Report, Chapter 4 — Biodiversity.

Of particular significance among marine ecosystems is the Great Barrier Reef. Covering an area of 350,000 km^2, it is the largest coral reef system in the world. Its extraordinary diversity includes: some 400 species of corals; 1,500 species of fish, 4,000 species of molluscs, 23 species of marine mammals and 6 species of turtle (DEST 1994, p. 55).

Other major coastal ecosystems include Australia's various estuarine habitats. Estuaries are ecologically highly productive and important fish habitats, yet have often been the focus of urban, industrial and recreational activities (Zann 1995, p. 5). Table 1.4.1.5 presents the distribution and areas of several estuarine habitat types.

Australia also has the largest seagrass beds in the world with the largest number of seagrass species. The extensive and diverse areas of tropical species in northern Australia are associated with large populations of dugongs, turtles and prawn fisheries (Walker & McComb 1992). Table 1.4.1.6 shows the area of seagrass loss, where known.

With the exception of Indonesia and Brazil, Australia has the most extensive areas of mangroves of any of the 80 countries supporting this species (DEST 1994, p. 37). The area of mangrove forests in Australia is shown in Table 1.4.1.7.

Mangroves function as important nurseries for fish and other marine life. Australia's

1.4.1.6 Major areas of seagrass die-back

	Area lost	
Region	*ha*	*% of total area*
New South Wales		
Clarence River	445	60
Lake Macquarie	700	44
Tuggerah Lakes	1 300	na
Botany Bay	257	58
Victoria		
Gippsland Lakes	'major losses'	
Western Port	17 800	85 (a)
Queensland		
Torres Strait	over 10 000 (b)	
Hervey Bay	90000 (b)	
Moreton Bay	'some losses'	
South Australia		
Holdfast Bay	7 000	
Gulf St. Vincent	5 000	
Western Australia		
Cockburn Sound	3 300	97
Princess Royal Harbour	810	66
Oyster Harbour	720	46
Tasmania		
Smithton	362	
Birch Point	397	
Ralphs Bay	430	
Pittwater	1 201	
Norfolk Bay	2 148	
Northern Territory		
Gulf of Carpentaria	15 000 (c)	20

(a) Proportion of total biomass.
(b) Lost in 1992–93 floods.
(c) Lost in 1985 cyclone.
Source: Zann 1995, p. 11.

1.4.1.5 Distribution and areas of estuarine habitats, by State and Territory

	Open water (a)	*Intertidal flats (b)*	*Mangroves*	*Seagrass*	*Saltmarsh*	*Total*
State	*km^2*	*km^2*	*km^2*	*km^2*	*km^2*	*km^2*
New South Wales	1 323	na	107	153	57	1 487
Victoria	2 682	444	41	364	125	3 292
Queensland	4 093	1 574	3 424	68	5 322	14 413
Western Australia	17 825	2 891	1 561	11	2 965	25 241
South Australia	760	219	111	na	84	1 173
Tasmania	1 825	274	na	na	37	2 136
Northern Territory	5 187	821	2 952	23	5 005	13 966
Australia	**33 694**	**6 223**	**8 195**	**6 001**	**13 595**	**61 707**

(a) Includes subtidal seagrass beds
(b) Includes intertidal seagrass beds
Source: Zann 1995, p. 5.

1.4.1.7 Area of mangrove forests, by State and Territory

	Area	
State/Territory	*km²*	*%*
New South Wales	99	0.9
Victoria	12	0.1
Queensland	4 602	39.8
Tropics	4 117	35.6
Subtropics	485	4.2
South Australia	211	1.8
Western Australia	2 517	21.8
Tropics	2 507	21.7
Subtropics	10	0.1
Tasmania	0	0.0
Northern Territory	4 119	35.6
Total	**11 558**	**100.0**

Source: Zann 1995, p. 10.

approximately 35 species of mangroves span 14 families and 25 genera, with the greatest diversity occurring in the northern tropics (DEST 1994, p. 38). For a detailed account of the state of Australia's marine ecosystems, refer to the State of the Marine Environment Report for Australia (Zann 1995).

Species diversity

The distribution and abundance of many types of organisms have changed substantially since European settlement. This has been brought about by a number of factors such as extensive farming and grazing, clearing of forests, changes in fire regimes, mining and urbanisation (see Table 1.4.1.8).

It should be noted, however, that it is often difficult to determine a specific one to one relationship between an activity and a response in the biota. The combined effects of various activities, meanwhile, cause pressures which often have far-reaching and complex effects because of the interactions between species and between species and their environment.

It is estimated that Australian ecosystems support about one million species. Table 1.4.1.9 and Figure 1.4.1.10 reveal the extent to which micro-organisms and invertebrates contribute to Australia's biodiversity. Groups such as arthropods, protozoans, bacteria and fungi are essential for the functioning of ecosystems, yet it is estimated that less than 50% of the species are known to science.

Invertebrates

Knowledge of the identity and status of invertebrates is relatively low (see Tables 1.4.1.9 and 1.4.1.11) but it is considered that endemism (ie the organism's uniqueness to Australia) at the genus and species level is frequently high in this faunal group, with 75% of beetle genera (Coleoptera) unique to Australia, and endemism at the species level approaching 100% for some groups.

Insect species threatened with extinction include certain springtails, dragonflies, beetles and butterflies (Beattie et al. 1992, p. 194).

Vertebrates

Knowledge of the status of vertebrates and higher plants, however, is fairly extensive (see Table 1.4.1.11). As can be seen in Figure 1.4.1.10, vertebrates and higher plants contribute only a very small proportion to Australia's total biodiversity. Compared to other organisms, however, our knowledge of these groups is extensive, with greater than 90% of the species described (see Table 1.4.1.9).

A detailed analysis of distributions of species richness, as well as numbers of threatened species, for the four terrestrial vertebrate groups — birds, reptiles, mammals, amphibians — by biogeographic region is presented in the State of Environment Report (SoE 1996, Ch. 4).

Australia has one of the richest reptile faunas in the world, with a remarkable 89% of the estimated 770 reptile species endemic to Australia (see Table 1.4.1.11). In particular, Australia's arid zone shows a high level of species richness, with outback Australia being home to more species of reptiles per square kilometre than anywhere else in the world (Concar 1994). Most of Australia's threatened reptile species occur in the south-east region of the continent. This region also supports high numbers of threatened bird species (SoE 1996, Ch. 4).

Due to a number of climatic conditions, including the flow of warm currents down the east and west coasts, and the presence of the world's largest coral reef, Australia has one of the richest fish fauna in the world (DEST 1994, p. 50).

While the northern tropical zone boasts the highest levels of fish species diversity, the southern temperate zones have less species diversity but a high level of endemism. Of the estimated 600 inshore fish species in temperate southern Australia, about 85% are endemics, and 11% are shared with New Zealand (DEST 1994, p.

1.4.1.8 Sources of threats (a) to Australian birds, marsupials, rodents, reptiles and freshwater fish

	Bird species affected	Mammal species affected		Reptile species affected	Freshwater fish species affected
		Marsupials	Rodents		
Threat	*No.*	*No.*	*No.*	*No.*	*No.*
Habitat clearance and/or fragmentation	32 (4)	13 (3)	3 (4)	(35)	
Altered fire regimes	16 (35)	1 (16)	(2)	(10)	
Grazing and/or trampling	10 (35)	5	1 (6)	(21)	
Fishing	(3)				
Disease	(3)	(1)			
Pollution	(7)			(7)	
Erosion	1 (1)				
Environmental weeds	2 (9)			(5)	
Forestry operations	3 (14)	2 (1)	(1)	(6)	
Changed hydrological regimes	1 (3)				5 (4)
Climatic variations	2 (7)			(5)	
Shortage of nesting hollows	3 (20)	1			
Predation	8 (29)	9 (13)	1 (4)	(14)	
Competition	3 (20)	1 (11)	(1)		
Direct exploitation	10 (33)	2			3 (1)
Cropping				(21)	
Urban development	4 (3)			(14)	
Pasture improvement				(12)	
Soil degradation				(9)	
Visitor disturbance				(8)	
Mining	2 (4)			(6)	
Rabbit grazing		(11)	1 (2)	(6)	
Habitat drainage				(4)	
Rock removal				(4)	
Geomorphic alteration					12 (6)
Water quality					4 (1)
Introduced exotic species		9	1 (10)		5 (10)
Introduced native species		(14)			(3)
Loss of genetic diversity		1 (1)			(2)
Road kills		1			
Unknown		4	(3)		

Note: A species may be affected by more than one threatening process.
(a) Refers to current, confirmed threats except where figures appear in parentheses. Figures in parentheses are speculative estimates.
Source: SoE 1996, pp. 4–8.

51). See the 1996 State of Environment Report, Chapter Four — Biodiversity for the distribution of species richness of Australian fish and prawns.

Forty-five per cent of Australia's estimated 777 native bird species are endemic (Table 1.4.1.11). The vast majority of Australia's bird fauna occur along the eastern and south-eastern regions of the continent. Twenty Australian birds are presumed extinct and another 50 classified as endangered or vulnerable.

Australian mammal fauna includes members of all three of the major groups of mammals i.e. monotremes, marsupials and placentals.

As with the reptiles and amphibians, a prominent feature of Australia's mammal fauna is its high degree of endemism (84% of terrestrial mammals).

As well, the mammalian fauna is distinct in the abundance and diversity of marsupials compared with other groups. Of the estimated 268 mammals occurring on the Australian continent, 144 species are marsupials, of which over 90% are endemic.

The highest levels of species richness occur along the eastern and south-eastern region of the continent, the south-west, far north, and a pocket in the arid zone.

1.4.1.9 Estimated number of species of major groups of organisms, Australia

Major groups of organisms	Species No.	Percent described %
Micro-organisms		
Protozoans	65 000	40.0
Fungi	160 000	5.0
Bacteria	40 000	0.1
Invertebrates		
Arthropods		
Coleoptera (beetles)	33 550	55.0
Lepidoptera (moths, butterflies)	21 870	47.0
Hymenoptera (ants, wasps, bees)	18 166	41.0
Diptera (flies, mosquitos)	10 110	49.0
Other insects	41 304	40.0
Arachnids (e.g. spiders)	2 000	50.0
Crustaceans (e.g. crabs, prawns)	18 000	5.0
Springtails	25 000	33.0
Other arthropods	na	na
Molluscs (e.g. snails, oysters, squid)	90 000	50.0
Sponges	1 350	33.0
Nematodes	125 000	25.0
Other invertebrates	na	na
Vertebrates	5 588	>90.0
Plants		
Higher plants	20 000	>90.0
Algae	22 000	50.0
Estimated total (a)	**1 008 000**	na

(a) Estimates are taken from a variety of sources, each of which is not comprehensive. Tallies, therefore, are not consistent within the table.
Source: SoE 1996, p. 4-30.

However, with 19 terrestrial mammals presumed extinct (7% of the total estimated number of species), and a further 43 (16%) species classified as endangered or vulnerable, the continent's mammals appear to be faring the least well (see Table 1.4.1.12). Of particular significance are the high numbers of threatened mammals in the arid interior, where species richness is not necessarily high, as well as high levels of threatened species in the high growth regions along the eastern coast (SoE 1996, Ch. 4).

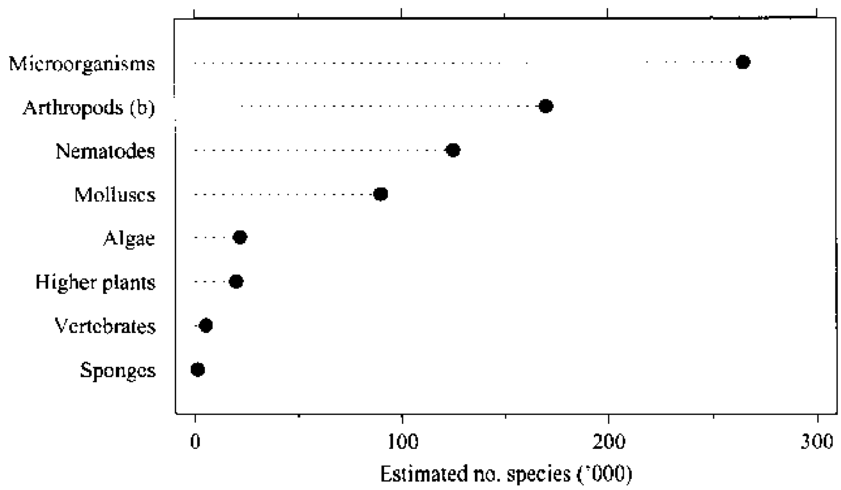
Higher Plants

Seventy-six of Australia's estimated 20,000 flowering plants have become extinct within the last 200 years, with about another 1,000 listed as endangered or vulnerable.

Figure 1.4.1.13 shows high numbers of threatened plant species occurring in discrete densely populated/high growth areas along the south-west and eastern coast.

Western Australia has 43% of all Australia's rare or endangered species, the majority are in the south-west province. Other areas with high levels of endangered species are Cape York Peninsula, the Moreton district of south-east Queensland, and the southern tablelands of New South Wales (Beattie et al. 1992, p. 196). See the 1996 State of the Environment Report for a description of the major causes of extinction and past and present threats to endangered plant species.

1.4.1.10 Relative size of major groups (a) of organisms, Australia



(a) Excludes 'other invertebrates'.
(b) Excludes 'other arthropods'.
Source: SoE 1996 (Based on data in table 1.4.1.9).

1.4.1.11 Current status of various groups of organisms, Australia

	Est. number of species	*Percent endemic*	*Presumed extinct (a)*	*Endangered species*	*Vulnerable species*	*Introduced*
Taxonomic group	*No.*	*%*	*No.*	*No.*	*No.*	*No.*
Flowering plants	20 000	85	76	301	708	1 500–2 000
Fish						
Fresh	195	90	0	9	8	21
Marine	4 000		0	0		8
tropical inshore		13				
temperate inshore		85				
Amphibians	203	93	3	10	19	1
Reptiles	770	89	0	11	40	2
Birds	777	45	20 (b)	25	25	32
Mammals (terrestrial)	268	84	19	25	18	25
Non-marine invertebrates	na	na	3	40	78	na
Algae	na	na	0	0	1	na
Lichens	na	na	2 (c)	94	74	na
Bryophytes	na	na	12 (c)	83	43	na

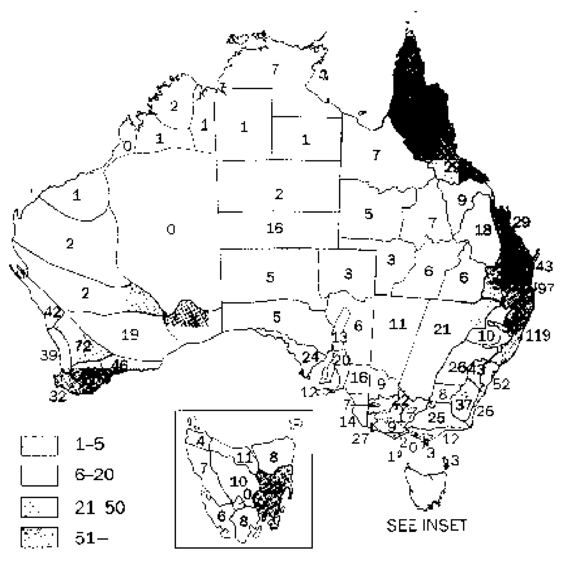
(a) Since 1788.
(b) Nineteen once existed on Australian territorial islands, including Lord Howe and Norfolk Islands. Only one is extinct on the mainland.
(c) Not found during recent surveys.
Source: SoE 1996, pp. 4-34–4-35.

1.4.1.12 Status of Australian terrestrial (a) native mammals

	Described species	*Extinct (b)*	*Endangered*	*Vulnerable*
Major group	*No.*	*No.*	*No.*	*No.*
Monotremes	2	0	0	1
Marsupials				
Dasyurids	51	1	6	12
Bandicoots and bilbies	11	3	2	4
Marsupial mole	1	0	0	1
Wombats, possums and kangaroos	81	6	11	23
Placentals				
Dingo	1	0	0	0
Rodents	53	8	6	
Bats	68	1	0	

(a) Excluding External Territories.
(b) Since 1788.
Source: SoE 1996, p. 4-35.

1.4.1.13 Numbers of threatened plant species in each of 80 regions across Australia



Source: Leigh & Briggs 1988.

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1.4.2 Contaminants in biota

Whereas the previous section looked at species distribution and abundance, and ecosystem disturbance, as measures of the state of Australia's biodiversity, this section looks at the levels of selected contaminants in the Australian biota.

Uptake of contaminants may occur via the food chain, or by direct extraction from the medium in which they exist via the processes of bioaccumulation, bioconcentration or biomagnification.

The accumulated loads may exert acute toxic effects, but more commonly the impacts are sub-acute and not easily detectable (CSIRO 1992, cited in Fabris 1995, p. 1).

Caution is needed in comparing levels of contaminants in biota. A paucity of data, differing biochemical regulation by organisms, different analytical techniques used, and changing technologies in the measurement of contaminants over time, make conclusions difficult to draw.

Much of the focus of this section is on marine systems, as information on the biota of freshwater ecosystems is poor. Many other contaminants of more recent concern (e.g. PAHs, oestrogen-mimics and industry-specific chemicals such as fluorine and others) have not been covered either, and information presented reflects the availability of data to a certain extent.

Organochlorine compounds

Organochlorine compounds used in Australia include pesticides, polychlorinated biphenyls (PCBs), and dioxins and furans.

The properties of many of the more complex chlorinated organic compounds of greatest concern to the biota are persistence and toxicity. Many are strongly soluble in fatty substances, including the fatty tissues of living organisms. In addition, persistent organochlorines are excreted slowly by vertebrates. Hence, the sub-lethal and long-term effects of organochlorine compounds to organisms are cause for concern.

Observed effects on biota include: histological change; metabolic, respiratory and behavioural effects; decreases in tolerance levels and primary productivity; growth and reproduction effects (ANZEC 1991, p. 17).

Pesticides

Due to the properties of organochlorines, relatively small amounts of organochlorines present in water may accumulate in the fats of aquatic plants and animals, resulting in concentrations much higher than in the surrounding waters (Richardson 1995, p. 54). DDT and dieldrin, not being readily metabolised and not readily excreted, result in higher concentration factors than occur with some of the other organochlorines.

The use of DDT in Australian agriculture became widespread in the 1950s. Restrictions were applied in the late 1960s, culminating in a total ban on use of DDT in Australia in 1987.

1.4.2.1 Organochlorine pesticides residues in marine fish, 1987

		Heptachlore-poxide		*Benzene-hexachloride (BHC)*		*Heptachloro-benzene (HCB)*		*DDT+DDD+DDE*		*Dieldrin*	
		Range	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*
Species	*Location*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
Red Morwong (a)	Malabar, NSW	0.8–4.9	2.60	0.3–2.5	1.22	0.00	0.00	0.03–0.82	0.30	0.03–0.18	0.10
Snook	Spencer Gulf, SA	na	na	na	na	0–0.11	0.05	0–1.63	0.53	0–0.54	0.08
Flathead, Dusky	Kangaroo Island, SA	na	na	na	na	0–0.05	0.03	0–1.50	0.75	0.45–2.2	1.30
Whiting, Spotted	Eyre Peninsula, SA	na	na	na	na	0–0.1	0.02	0–0.21	0.02	0–0.33	0.10
NHMRC MRL		**0.05**	. .	**0.01**	. .	**0.1**	. .	**1.00**	. .	**0.1**	. .

MRL = Maximum Residue Limit

(a) Red Morwong figures refer to samples collected in 1987. Red Morwong sampled in 1988 showed no difference in the concentration of dieldrin or DDTs between years. BHC, however, was absent in 1988 and chlordane and HCB, not present in 1987, were present in 1988.

Sources: State Pollution Control Commission 1988, p. 73; State Pollution Control Commission 1989; Olsen 1988.

Overall, work to date has revealed relatively low concentrations of pesticides such as DDT, DDE and lindane, although elevated levels have been found where discharges arise from urbanised areas or intensively farmed runoff.

Due to their proximity to sites of major industries, and the fact that effluent discharges occur in their waters, coastal biological communities are particularly vulnerable to pollution (ANZEC 1991, p. 10).

Studies on bioaccumulation of pollutants in the Sydney region conducted in 1987 revealed that concentrations of several chlorinated organic compounds in red morwong, a carnivorous fish near the top of the food chain, exceeded maximum recommended limits for human consumption by various degrees near the Malabar outfall (Table 1.4.2.1).

Heptachlor epoxide was present in the highest concentrations in fish muscle at this site. The average concentration of BHC in this species was 122 times the NHMRC recommended limit.

Selected results from areas of South Australia are also shown in Table 1.4.2.1. Dieldrin and DDT plus metabolites were the more widely distributed pesticides found during this survey (heptachlor epoxide was not tested for). Overall, twenty-eight of the total seventy-nine marine fish sampled exceeded the maximum recommended level for dieldrin, with eight and five samples exceeding the maximum residue limit (MRL) for DDT (plus metabolites) and HCB, respectively (Olsen 1988, p. 1).

Limited studies have been carried out on pesticide levels in marine mammals. Pesticide (and PCB) levels in an Australian fur seal breeding colony at Seal Rocks, Victoria revealed all animals sampled (14) to contain pesticide and PCB residues. PCB concentrations in these animals, shown in Table 1.4.2.2, were low by world standards. Total DDT levels, however, were at least as high as some reported for the Northern Hemisphere.

The main metabolite of DDT — DDE — has been shown to be responsible for eggshell thinning in several species of Australian birds, the major adverse effect of which is widespread

1.4.2.2 Organochlorine concentrations (a) in marine mammals, 1987

		Total PCB		*Total DDT*		
	Location	*Range*	*Mean*	*Range*	*Mean*	
Marine mammal	*Latitude*	*µg/g*	*µg/g*	*µg/g*	*µg/g*	*Study*
Australian Fur Seal	Temperate 38°S	0.05–3.87	0.69	0.03–12.05	4.03	Smillie and Waid 1987.
Weddell Seal	Temperate 69°S	0.04	0.04	0.17	0.17	Hidaka et al. 1983.
Ross Seal	Antarctic 70°S	0.01–0.76	0.09	0–0.15	0.07	McClurg 1984.
Atlantic Walrus	Arctic 76°N	0.06–1.10	0.23	0.01–0.40	0.06	Born et al. 1981.
Harbour Seal	Temperate 53°N	22.0–576.0	189.42	0.51–25.40	10.85	Druinker et al. 1979.
Harp Seal	Temperate 48°N	1.0–11.0	4.00	0.60–3.10	1.70	Addison et al. 1984.
Grey Seal	Temperate 48°N	9.90–21.50	15.70	2.50–4.50	3.50	Addison et al. 1984.
California Sea Lion	Temperate 33°N	12.0–25.0	17.10	51.0–203.0	103.20	DeLong et al. 1973.

(a) Concentration measurements are made wet weight.
Source: Smillie & Waid 1987.

1.4.2.3 Average shell thickness for six raptor species (a) since 1946, Australia

	1947–51	*1952–56*	*1957–61*	*1962–66*	*1967–71*	*1972–76*	*1977–81*	*1981–86*	*1987*
Species	*STI*	*STI*	*STI*	*STI*	*STI*	*STI*	*STI*	*STI*	*STI*
Whistling Kite	1.98	2.01	1.93	1.93	2.02	1.95	1.95	na	na
White-bellied Sea Eagle	2.95	2.95	2.71	2.94	2.94	2.90	2.81	na	na
Swamp Harrier	1.95	1.84	1.64	1.74	1.82	1.64	1.53	na	na
Collared Sparrowhawk	1.25	1.28	1.26	1.22	1.28	1.23	1.22	na	na
Peregrine Falcon	1.75	1.81	1.80	1.73	1.83	1.69	1.57	1.53	1.81
Australian Hobby	1.55	1.41	1.37	1.41	1.42	1.38	1.35	na	na

STI = Shell Thickness Index. An expression of relative egg weight and highly correlated with actual shell thickness.
(a) Species which showed a significant decrease in shell thickness.
Source: Olsen, Fuller & Marples 1993.

reproductive impairment. Being at the top of the food chain, raptors are especially vulnerable to the effects of pesticides, as well as being physiologically more sensitive to DDT than many other bird groups (Olsen, Fuller & Marples 1993). The degree of eggshell thinning has been used as an indicator of DDE levels.

Table 1.4.2.3 reveals a general decline in shell thickness since 1946 (when broad-scale use of DDT commenced) for Australian raptors for which data were available at five year intervals. The greatest reduction was in the period 1977–81. Maximum levels of thinning (expressed as a per cent of the pre-1947 mean) ranged from 45% for the Whistling Kite to 22% for the Collared Sparrowhawk (Olsen, Fuller & Marples 1993). Since 1981, data have been collected for the Peregrine Falcon only. Although this sample size was small, there is evidence of some recovery in recent years.

Polychlorinated Biphenyls (PCBs)

PCBs have unintentionally escaped to the environment as a direct consequence of their diversity of use (ANZEC 1991, p. 7). The amounts used in Australia have declined dramatically since 1975. PCBs have been shown to affect the growth and reproduction of organisms at all levels of the food chain. In certain circumstances, they are toxic even in minute concentrations (Richardson & Waid 1982).

Some fragmentary information on the amounts of PCBs in biota have been collected. The findings are summarised in Table 1.4.2.4. The pattern of PCB contamination shows highest concentrations in the vicinity of large urban centres such as Brisbane, Sydney and Melbourne. No PCBs were detected in mullet obtained from Wallis Lake or the Clarence River (both some distance from Sydney). Fish samples from Cockburn Sound in Western Australia were also below the limit of detection (not shown) (Richardson & Waid 1982).

In recent years, few studies of PCBs in Australian marine and estuarine environments have been undertaken, and little sampling over time has been carried out. Some of the more recent studies have been mentioned under the previous heading. Studies on the PCB content of mullet in Port Jackson have shown a decrease to a mean value of 0.4 parts per million (ppm) (Richardson, 1985 cited in Thompson, Chapman & Richardson 1992). Levels as high as 7.2 ppm were detected in the muscle of red morwong caught off Sydney's Malabar sewer outfall in studies by Scribner et al. (1987), with a continued improvement being recorded in subsequent studies (PCB concentrations of 0.2 to 0.3 ppm in the muscle tissues of red morwong from near the Malabar outfall (State Pollution Control Commission 1989).

1.4.2.4 Concentrations of PCBs in Australian biota, various years

Species	Location	PCB ppm (a) (b)	Study
Mullet	Wallis Lake, NSW	0.00	Woollard and Settle 1978.
	Clarence River, NSW	0.00	Woollard and Settle 1978.
	Port Jackson, NSW	0–5.2	Woollard and Settle 1978.
	Botany Bay, NSW	0–6.03	Woollard and Settle 1978.
	Brisbane River, Qld	0.1–1.0	McMahon 1975.
	Brisbane River Estuary, Qld	0–2.9	Shaw and Connell 1980.
	Port Phillip Bay, Vic.	0.39–0.41	Richardson and Waid 1980.
Bony Bream	Brisbane River Estuary, Qld	0.02–0.33	Shaw and Connell 1980.
Whiting	Brisbane River Estuary, Qld	0.07–0.71	Shaw and Connell 1980.
Crabs	Brisbane River Estuary, Qld	0–0.26	Shaw and Connell 1980.
Mussels	Brisbane River Estuary, Qld	0–0.25	Shaw and Connell 1980.
	Port Phillip Bay, Vic.	0.0–0.14	Richardson and Waid 1980.
Polychaetes	Brisbane River Estuary, Qld	0–0.29	Shaw and Connell 1980.
Pacific Black Duck	South-eastern Australia	0–0.40	Olsen et al. 1980.
Pelican	Brisbane River Estuary, Qld	0–15.7	Shaw and Connell 1980.
Peregrine Falcon Eggs	Port Phillip Bay, Vic.	0.10–4.30	Pruett-Jones et al. 1981.

Note: Methods of detecting PCB varies between studies.
(a) Parts per million (10^{-6}).
(b) Wet weight.
Source: Richardson & Waid 1982.

There is still a lack of knowledge of baseline concentrations in areas of Australia remote from the influences of humans. Studies by Olafsen (1978), however, did not detect PCB contamination in corals, fish and molluscs sampled from the Great Barrier Reef (Richardson & Waid 1982).

Dioxins and furans

Unlike pesticides and PCBs, dioxins and their close chemical relatives the dibenzofurans are produced unintentionally during the manufacture of other organochlorines, during the chlorination of waste materials, or by combustion processes. Dioxins and dibenzofurans are usually present in environmental samples at extremely low concentrations (Batley 1995).

The extent of contamination of the Australian marine environment by dioxins is unclear due to a lack of data. Limited evidence indicates that dioxins have high acute toxicity towards aquatic organisms and are easily taken up and accumulated, especially in fatty tissues. Little is known about the effects of sub-lethal concentrations of dioxins on ecosystems (ANZEC 1991, p. 17).

In Sydney, dioxins have been measured in Homebush Bay, adjacent to contaminated landfill sites. The dioxin of most significance, because of its toxicity, is 2,3,7,8-tetra-chlorodibenzo-*p*-dioxin (2,3,7,8-TCDD). Mean concentrations of

1.4.2.5 Dioxin levels in biota from Homebush Bay, Sydney (based on data in Rubinstein and Wicklund 1991)

	Concentrations (a) of 2,3,7,8-TCDD	
	Mean	*Standard error*
Species	*ppt (a)*	*ppt (a)*
Fish		
Barred goby	181	218
Tailor	121	68
Bream	66	66
Serpent eel	60	na
Roach	25	16
Sand mullet	17	9
Flat-tail mullet	<4	na
Invertebrates		
Mussel	116	63
Polychaete worm	112	82
Mud crab	34	4
Prawn	29	4

(a) Parts per trillion. Measured wet weight.
Source: Thompson, Chapman & Richardson 1992.

1.4.2.6 Total toxic equivalent (a) levels in selected fish and crustaceans, Victoria

Location	*Organism*	*Total Toxic Equivalents (a) ppt (b)*
Ninety-Mile Beach	Whiting	0.05
	Flathead	0.15
Continental Shelf (50 km south of Port Fairy)	King crab	0.27
Mornington, Port Phillip Bay	Spider crab	0.44
Hobson's Bay, Port Phillip Bay	Spider crab	11.0

(a) Based on NATO convention of assigning dioxin and furan compounds toxicity equivalence factors (TEFs) on the basis of biochemical responses and toxicity tests on animals (with 2,3,7,8-TCDD being assigned a TEF of 1).
(b) Parts per trillion (10^{-12}).
Source: Nelson 1994, p. 32–34; Mosse & Haynes 1993.

2,3,7,8-TCDD at Homebush Bay, NSW, were as high as 181 pg/g wet weight (wt) in fish and 116 pg/g in invertebrates, but standard errors were also high (Table 1.4.2.5). As a result of these surveys, fishing has been banned in Homebush Bay (Rubinstein & Wicklund, 1991 cited in Thompson, Chapman & Richardson 1992).

Background levels of dioxin gathered from various locations in Victoria showed levels ranging from 0.05 pg/g in Whiting at an uncontaminated site to 11.0 pg/g in a spider crab from a site subject to urban run-off (see Table 1.4.2.6). Environmental guidelines for new bleached eucalypt kraft pulp mills define TCDD equivalent levels at 5 parts per trillion (ppt) in crabs in the receiving waters. This level is one quarter of that set by overseas authorities as acceptable in seafood for human consumption.

Trace Metals

Because organisms bio-accumulate and effectively integrate metal loads, biota provide a more reliable measure of the presence of metal pollution in waters (Batley 1995). In general, Australian studies have found mean concentrations of trace metals in fish and shellfish to be below health limits (Sydney Water Board 1988). Maximum permitted concentrations of heavy metals in seafood are shown in Table 1.4.2.7. There have been isolated incidents of certain organisms exceeding NHMRC set guidelines for concentrations of heavy metals in fish, crustaceans and molluscs, and this has generally been attributable to point source pollution from urban or industrial sources (Batley 1995).

Since 1980, trace metal concentrations in mussels have been studied. These surveys have

1.4.2.7 Maximum permitted concentrations of heavy metals in seafood (a)

Element	Food type	*Maximum permitted concentration* µg/g (b)
Arsenic	Fish and molluscs	1.0 (c)
	Seaweed (edible kelp)	1.0 (c)
Cadmium	Fish (and fish contents of products)	0.2
	Molluscs (and mollusc content of products)	2.0
	Seaweed (edible kelp)	0.2
Copper	Molluscs (and mollusc content of products)	70.0
	All other foods (d)	10.0
Lead	Fish in tinplate containers	2.5
	Molluscs	2.5
	All other foods (d)	1.5
Mercury	Fish and molluscs	0.5 (e)
	All other foods (d)	0.03
Zinc	All other foods (d)	150

(a) From section A12 of the Food Standards Code 1995.
(b) Measured wet weight.
(c) Inorganic As only.
(d) Applicable to seafood when no specific reference is made in the standard.
(e) A mean of 0.5 (the standard specifies a sampling plan).
Source: Fabris 1995, p. 5.

been undertaken mainly at sites located in deep waters away from the direct influence of urban and industrial discharges. Nevertheless, a relatively large dataset is available for mussels and this provides the best opportunity for detecting temporal and regional trends (Phillips et al. 1992) – see Table 1.4.2.8.

In the case of zinc, mean concentrations have been consistently highest from Corio and Hobsons Bays. Copper concentrations (not shown) have remained relatively constant, ranging from about 0.6 to 1.0 micrograms/gram. A long term study conducted between 1980 and 1986 from fixed off-shore sites indicated the absence of any major temporal trends in zinc and copper concentrations in this species (Phillips et al. 1992).

Mean cadmium concentrations in mussels from Corio Bay shore decreased from 9.5 micrograms/g wet weight in 1974 to 2.2 in 1988, a trend also reflected in offshore sites.

Lead concentrations in mussels along the shoreline of Port Phillip Bay, Victoria have been consistently higher than those found offshore. A decrease in lead concentrations with time was observed in Corio Bay. Mean levels from the shoreline decreased from 2.6 µg/g wet wt during 1977–78 to 1.9 µg/g during 1985.

More recent studies of heavy metal concentrations in the biota from Port Phillip Bay indicated that they were mostly below the maximum permitted concentrations listed in the Australian Food Standards Code (1995) (see Table 1.4.2.9). Arsenic concentrations exceed 1 µg/g in many samples, but it is most likely to be present as non-toxic organo arsenic compounds (Fabris 1995).

Elevated concentrations of other metals, such as tributyltin (TBT), have been detected in marine biota.

Tributyltin compounds (TBT) have, in the past, been used in marine anti-fouling paints. Data for TBT in oysters, scallops, and mussels have been collected from a wide range of Australian estuaries. Selected results are given in Table 1.4.2.10.

1.4.2.8 Mean concentrations (a) of trace metals in mussels from two regions of Port Phillip Bay, 1973–1988

	North Port Phillip Bay						Corio Bay					
	Shore			Off-shore			Shore			Off-shore		
	Cd	Pb	Zn	Cd	Pb	Zn	Cd	Pb	Zn	Cd	Pb	Zn
Year	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
1973–74	1.2	3.7	76	1.6	na	27	6.4–9.5	1.4	16–45	na	na	na
1975–76	0.6–2.7	1.4–2	26	na	na	na	4.4–7.4	2.0–2.6	36	na	na	na
1977–78	na	na	na	na	na	na	3.2	na	23	1.7	0.3	28
1981–82	na	na	na	0.3–0.5	<0.3	15–22	na	na	na	1.6–1.7	<0.3	26–28
1983–84	na	na	na	0.3–0.4	<0.3	16–21	na	na	na	1.1	<0.3	22–26
1985–86	na	na	na	0.6	<0.3	20	3.9	1.9	42	1.3	<0.3	30
1987–88	na	na	na	na	na	na	na	na	na	1.1	<0.3	24–27

(a) wet weight
Source: Phillips et al. 1992.

1.4.2.9 Metal concentrations (a) in sand flathead (b), mussels and marine algae from selected sites, Port Phillip Bay, Victoria

	Geelong Arm			*Werribee*			*Hobsons Bay*			*Southern Bay*		
	Sand flathead	*Mussel*	*Marine algae*	*Sand flathead*	*Mussel*	*Marine algae*	*Sand flathead*	*Mussel*	*Marine algae*	*Sand flathead*	*Mussel*	*Marine algae*
	µg/g	*µg/g*	*µg/g*	*µg/g*	*µg/g*	*µg/g*	*µg/g*	*µg/g*	*µg/g*	*µg/g*	*µg/g*	*µg/g*
Arsenic (c)	6.1	3.67	3.16	9.7	2.56	5.30	9.2	2.56	7.35	9.0	3.50	5.92
Cadmium (c)	0.05	0.64	0.06	0.05	0.23	0.06	0.05	0.17	0.05	0.05	0.54	0.05
Chromium (c)	0.06	0.29	0.61	0.05	0.36	0.82	0.06	0.29	0.91	0.08	0.37	0.05
Copper (c)	0.41	1.16	1.05	0.25	1.06	3.61	0.26	0.86	1.47	0.23	1.10	0.40
Mercury (d)	0.11	na	na	0.31	na	na	0.04	na	na	0.12	na	na
Nickel (c)	0.05	0.44	0.77	0.05	0.50	6.71	0.05	0.19	0.61	0.06	0.34	0.18
Lead (c)	0.05	0.17	0.65	0.05	0.09	1.35	0.05	0.37	2.59	0.05	0.21	0.15
Zinc (c)	5.49	30.7	6.49	6.78	24.6	14.20	4.59	34.6	7.74	4.41	47.4	5.69

(a) Wet weight concentrations.
(b) Sand flathead levels are for muscle tissue.
(c) Detection limits are 0.1 µg/g.
(d) Detection limits are 0.05 µg/g.
Source: Fabris 1995.

Sub-tidal species such as scallops and mud oysters exhibited much lower concentrations (rarely exceeding more than 15 nanograms of tin per gram of flesh) than did intertidal oysters.

A ban on the sale and use of TBT-based antifouling paints on boats under 25m in length was instituted in New South Wales in 1989, with similar bans being applied in most other States. In New South Wales some locations are already showing a recovery. In major harbours, however, TBT will continue to have an impact on biota. While there has been clear evidence produced for the impact of TBT on oysters, the sensitivity of oysters to small concentrations of TBT has yet to be demonstrated (Batley & Scammell 1991).

1.4.2.10 Tributyltin (TBT) in Australian aquatic biota

Species	*Location*	*TBT ng/g (a)*
Sydney Rock oyster	Upper Georges River, NSW	40–128
	Lower Georges River, NSW	15–44
	Coba Bay, Hawkesbury River, NSW	7
	Sand Brook Inlet, Hawkesbury River, NSW	350
	Wallis Lake, NSW	2
	Botany Bay, NSW	15
Pacific oyster	Upper Georges River, NSW	175
Mud oyster	Port Phillip Bay, Vic.	<1
Blue mussel	Cockburn Sound, WA	18
	Near slipway, Cockburn Sound, WA	166
Scallop	Port Phillip Bay, Vic.	5

(a) Nanograms of tin per gram fresh weight.
Source: Batley & Scammell 1991.

Analyses for copper on all of the oyster samples analysed for TBT revealed a significant correlation between the presence of both elements.

Petroleum hydrocarbons

In general terms, the sediments and biota have a relatively strong affinity for lipophilic ('fat-loving') hydrocarbons, and concentrations in these media would be expected to be relatively high (Connell 1995).

A range of detrimental physiological responses are possible resulting from exposure to sub-lethal levels of petroleum hydrocarbons. There may be histopathological effects such as abnormal growth, occurrence of tumours and so on. These have not had extensive evaluation in Australian waters (Connell 1995).

Concentrations of petroleum hydrocarbons in biota in Australian waters is shown in Table 1.4.2.11. Many animals and plants produce hydrocarbons which may be difficult to distinguish from petroleum hydrocarbons, hence background concentrations are difficult to define. The levels in Great Barrier Reef biota probably represent background levels, with corals exhibiting the highest concentrations of up to 3.1 mg/kg (lipid weight).

Fish and birds from south Queensland were heavily contaminated, with levels up to 270 and 1038 mg/kg, respectively.

Western Port and Port Phillip Bay contain zones where biota are effectively free of contamination as well as zones where biota are contaminated.

1.4.2.11 Levels of petroleum hydrocarbons in marine biota

Biota	*Location*	*Hydrocarbon*	*Concentration* *mg/kg*
Seabirds	Brisbane River	Petroleum hydrocarbons (a)	<1 038
Fish	South Qld	Kerosene	<270
	Great Barrier Reef	Hydrocarbons	< 0.3
Corals	GBR	Hydrocarbons	0.06–3.1 (b)
Clams	GBR	Hydrocarbons	0.06–0.1 (b)
Mussels	Western Port & Port Phillip Bay	Petroleum	<4.4 (b)
Oysters	Rowley Shelf, WA	Petroleum	<4.9 (b)

(a) Unresolved complex mixture.
(b) Lipid weight.
Source: Connell 1995, p. 49.

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Chapter 2 — Environmental Pressures on Individuals

This chapter presents statistics which reflect the flow in the PEP model from Natural Assets and Processes to Individuals. The chapter examines some *adverse* impacts which the environment may exert on people. Chapter 3 will examine the same flow, and present statistics on some of the *benefits* which flow directly to individuals from the environment.

The adverse impacts of the environment on individuals are presented in terms of:

- Impacts on human health (Section 2.1); and
- Impacts of natural events on individuals (Section 2.2).

2.1 Human health aspects

Human health is a product of biology, life style, environment and health care services. In 1992 the National Health and Medical Research Council noted that human health is dependent on the health of ecosystems, at both the local and global level.

Few specific links between environmental hazards and a particular illness/condition have been determined, due to the many factors contributing to human health (see Table 2.1.1 for a summary of the health of the Australian population, by illness category for 1977–78 and 1989–90). Often, however, various human activities cause or contribute to some of the health conditions summarised in these tables, with the environmental media acting as a carrier. Much of the section refers to the associations between environmental pollutants and human health. Other naturally occurring products or irritants such as ultraviolet radiation, pollen and fungal spores, which may also impact on human health, are also discussed.

Many aspects of social change, including improved sanitation, nutrition, and education about hygiene and child care, have been beneficial to health (McMichael 1992). In Australia, mortality rates have declined in recent decades (see Table 2.1.2).

Between 1971 and 1994 death rates due to heart disease, cerebrovascular disease, motor vehicle accidents, other accidents, and pneumonia and

2.1.1 Persons who experienced longterm conditions, Australia, 1977–78 and 1989–90

	1977–78	*1989–90*
Condition reported	*Rate (a)*	*Rate (a)*
Infectious and parasitic diseases	5	7.7
Neoplasms (cancer)	9	16.1
Endocrine, nutritional and metabolic diseases and immunity disorders	29	55.7
Diseases of blood and blood forming organs	12	8.6
Mental disorders	30	21.8
Diseases of the nervous system and sense organs	141	382.3
Diseases of the circulatory system	187	131.0
Diseases of the respiratory system	218	219.8
Diseases of the digestive system	48	52.7
Diseases of the genitourinary system	18	26.8
Complications of pregnancy, childbirth and the puerperium	1	0.6
Diseases of the skin and subcutaneous tissue	71	56.5
Diseases of the musculoskeletal system and connective tissue	168	258.0
Congenital anomalies	9	0.4
Symptoms, signs and ill-defined conditions	17	42.5
Injury and poisoning	21	13.8
Disability neck	17	6.8
Unspecified	0	0.1
Total (b)	**550**	**661.9**

(a) Per 1,000 population.
(b) Persons may have reported more than one type of condition and therefore components do not add to totals.
Source: ABS 1991 (4364.0).

2.1.2 Crude death rates (a) by cause and sex, Australia, selected years

	1971		1981		1991		1994	
Cause of death	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*
Heart disease	354	264	293	225	233	209	223	206
Malignant neoplasms (cancer)	156	125	185	137	206	156	217	160
Cerebrovascular disease (stroke)	100	142	76	109	56	83	59	85
Chronic obstructive pulmonary disease & allied conditions (incl asthma, emphysema & bronchitis)	50	13	50	18	47	26	46	29
Motor vehicle accidents	41	15	33	12	18	8	15	7
Other accidents	30	17	24	13	20	11	21	11
Pneumonia and influenza	26	23	13	14	10	12	10	11
Diabetes mellitus	12	16	10	12	13	14	15	15
Suicide	17	8	17	6	21	5	21	5
Nephritis, nephrotic syndrome and nephrosis	5	5	6	7	7	9	8	9
Chronic liver disease and cirrhosis	8	4	12	5	9	4	8	4
Other causes	139	130	106	103	114	112	116	119
All causes	**939**	**761**	**826**	**660**	**754**	**646**	**759**	**661**

(a) Average for three years around census years 1971 to 1991, and for 1994. Crude death rates relate to the total number of deaths for specific causes and are the number of deaths for those causes per 100,000 of the estimated mean resident population for the year ended 31 December.

Source: ABS 1994 (3313.0); ABS various years (3303.0).

influenza declined faster than the combined rate for all causes. Cause-specific death rates rose for deaths due to cancers (both sexes), chronic obstructive pulmonary disease and allied conditions (females), suicide (males), nephritis and nephrosis (both sexes), and diabetes mellitus (males). The three main causes of death, contributing to 66.9% of total deaths in 1994, were heart disease (30.2%), malignant neoplasms (26.6%) and cerebrovascular disease (10.1%).

Although mortality rates are declining in Australia, new and unfamiliar health hazards are emerging. These include global warming and its associated health impacts, increased exposure to biologically damaging ultraviolet radiation, and the chronic late-adult diseases caused by aspects of societal modernisation (including dietary changes), loss of arable land, destruction of parts of our food chain and urban crowding (McMichael 1992).

Table 2.1.2 presents data from the National Health Survey which show an increase in the number of Australians reporting long-term illnesses between 1977–78 and 1989–90.

Although Tables 2.1.1 and 2.1.2 present a national picture, there are many sub-populations living in conditions which expose them to greater health risks. One such group are the Australian Aboriginals.

Aboriginal health

Australian Aboriginals have the poorest health of any identifiable sub-population in Australia (National Health Strategy 1992, p. 86). Table 2.1.3 presents data from the National Aboriginal and Torres Strait Islander Survey on self-reported illness. Table 2.1.4 identifies those diseases disproportionately affecting the Aboriginal population, according to various objective studies and reports.

It has been estimated that over 30% of Aboriginals are homeless or live in inadequate accommodation (Aboriginal Development Commission 1988, cited in National Health Strategy 1992, p. 88). The sub-standard conditions are generally characterised by inadequate water and washing facilities, poor sanitation and sewage disposal, limited food storage and sub-optimal food preparation facilities (National Health Strategy 1992), contributing to poor environmental health.

Ambient air pollution

Air pollution generated from human activity is one of the environmental influences on health. The focus of air quality and health initiatives in Australia is on the potential effects of ozone, oxides of nitrogen and particulates. Recently the NHMRC has changed its guidelines relating to ozone levels because health effects, particularly adverse lung function, were still being experienced at the old levels.

2.1.3 Aboriginal people reporting a recent illness by age, 1994

	0–14 years		*15–44 years*		*45 years+*	
Condition	*'000*	*%*	*'000*	*%*	*'000*	*%*
No illness	75.0	63.2	90.4	61.2	12.9	34.9
Infectious and parasitic diseases	2.5	2.1	1.1	0.7	0.5	1.4
Neoplasms	0.0	0.0	0.0	0.0	0.1	0.3
Endocrine, nutritional and metabolic diseases and immunity disorders	0.6	0.5	3.3	2.2	4.6	12.4
Diseases of blood and blood forming organs	0.4	0.3	0.7	0.5	0.1	0.3
Mental disorders	0.3	0.3	3.7	2.5	0.8	2.2
Diseases of the nervous system and sense organs	6.0	5.1	4.4	3.0	1.7	4.6
Diseases of the circulatory system	0.3	0.3	4.4	3.0	8.9	24.1
Diseases of the respiratory system	19.8	16.7	17.3	11.7	6.1	16.5
Diseases of the digestive system	4.0	3.4	3.2	2.2	1.1	3.0
Diseases of the genitourinary system	0.9	0.8	2.4	1.6	0.9	2.4
Complications of pregnancy, childbirth and the puerperium	0.0	0.0	0.5	0.3	0.2	0.5
Diseases of the skin and subcutaneous tissue	5.8	4.9	4.2	2.8	1.1	3.0
Diseases of the musculoskeletal system and connective tissue	1.5	1.3	5.2	3.5	3.9	10.5
Congenital anomalies	0.2	0.2	0.1	0.1	0.0	0.0
Symptoms, signs and ill-defined conditions	5.4	4.6	13.2	8.9	4.1	11.1
Injury and poisoning	4.7	4.0	9.0	6.1	1.4	3.8
Disability n.e.c.	0.3	0.3	0.3	0.2	0.1	0.3
Unspecified	2.0	1.7	3.3	2.2	1.6	4.3
Total	**118.6**	**100.0**	**147.6**	**100.0**	**37.0**	**100.0**

Source: ABS 1995 (4190.0).

2.1.4 Diseases disproportionately affecting Australian Aboriginals

Disease/disorder	*Description*
Diabetes mellitus	The prevalence of diabetes mellitus peaks at about 40 years for Aboriginals, which is about 30 years earlier than for non-Aboriginals. In the 20–50 year age group, the prevalence is over ten times higher in Aboriginals than in non-Aboriginals.
Circulatory system disorders	For young and middle-aged adults, they are 10–20 times higher.
Respiratory disorders	Most marked differences occur with infective respiratory diseases.
Eye disorders	Studies showed that in those over 60, 20% of Aboriginals were blind compared with 5% of non-Aboriginals. 38% of Aboriginals showed signs of trachoma compared with 1.7% of non-Aboriginals.
Specific communicable diseases	
Invasive diseases caused by Haemophilus influenza	990 cases per 100 000 in Aboriginal children in central Australia compared with 350 cases per 100 000 in non-Aboriginal children in the same area.
Tuberculosis	Incidence is 15–20 times higher among Aboriginals.
Leprosy	Aboriginals accounted for over 25% of all new cases reported in 1984–86.
Sexually transmitted disease	Syphilis notification rate is 60 times higher for Aboriginals than non-Aboriginals in the Northern Territory.
Hepatitis B	The prevalence of chronic carriers of hepatitis B virus ranges from 3–26% in Aboriginals. These levels are well above the prevalence of 0.07% documented for blood donors in Sydney.
Diarrhoeal disease	Hospital separations for these conditions were 16–20 times more frequent for Aboriginal infants than for non-Aboriginal infants in 1981–1986.
Skin diseases/infestations	Separation rates are twice as high for Aboriginals than non-Aboriginals.
Cancer	Overall mortality rates are slightly higher, the most significant differentials being for cancer of the liver (males), and lung cancer and cancer of the cervix uteri (for females).
Urinary tract	Prevalence of disorders ten times that of the general population.
Injuries	Mortality rate at least 3 times that of the general population.

Source: National Health Strategy 1992.

2.1.5 Percentage of persons with reported respiratory conditions (a), 1989–90

State/ Territory	Bronchitis, emphysema	Asthma	Sinusitis	Hayfever	Other respiratory conditions (b)	Total persons with respiratory conditions (c)
	%	%	%	%	%	%
NSW	3.4	8.1	4.1	8.6	16.8	33.3
Vic.	3.2	8.2	3.1	11.0	16.4	33.9
Qld	4.2	10.2	6.7	8.4	17.0	36.3
SA	3.6	8.4	4.6	14.2	15.5	36.9
WA	2.9	8.2	3.7	14.3	17.4	37.7
Tas.	2.9	6.5	2.9	9.1	14.0	30.0
NT	1.3	7.6	2.5	6.2	19.0	30.8
ACT	5.0	9.7	5.3	15.8	18.9	41.9
Aust.	**3.5**	**8.5**	**4.3**	**10.3**	**16.6**	**34.7**

(a) Reported as a recent and/or long term condition.
(b) Includes common cold, influenza, cough and sore throat.
(c) Persons may have experienced more than one type of respiratory condition and therefore components do not add to totals.
Source: ABS 1991 (4373.0).

In particular, individuals with pre-existing chronic lung disease experience adverse effects (Abramson & Voigt 1991), and there is evidence that particulate pollution can cause exacerbations of disease in elderly people with severe cardiopulmonary disease (Marks 1995).

Respiratory illness

Table 2.1.5 presents reported respiratory illness by State for 1989-90, and Table 2.1.6 shows hospital admission rates for various respiratory illnesses over a ten year period in Newcastle.

Over the Newcastle study period (1979–1988), there was a statistically significant decline in admissions for respiratory causes, and rates for chronic obstructive lung disease in the older age groups fell also. However, admissions for asthma in children aged 0–14 years have shown a significant increase over the same period. There was a correlation between living in the industrial part of the city and hospital admission for all causes and respiratory causes (not shown) (Christie, Spencer & Senthilselvan 1992).

Asthma

There has been a worldwide trend during recent decades to an increase in asthma morbidity and mortality (Rennick and Jarman 1992). The prevalence of childhood asthma has increased substantially in Australia in the last decade, and seems to be higher in Australia and New Zealand than in other western countries in the northern hemisphere (Peat et al. 1995).

Although there is a common perception that air pollution may increase childhood asthma, it is difficult to implicate a specific precipitant in the event of an attack (Rennick & Jarman 1992). Confounding factors include cigarette smoking, occupational exposure, pollen and spore counts, meteorological conditions, house dust mites and other variables.

There is evidence that the severity of airway hyperresponsiveness and of asthma morbidity relates to both allergen exposure levels and the degree of sensitisation of the subject. Studies by Peat et al. (1995) on the prevalence and severity of childhood asthma in New South Wales found the prevalence of current asthma in children living in three coastal regions (where sensitisation to house dust mites was high) and in the far west (where sensitisation to alternaria was high) was significantly higher than the

2.1.6 Age-adjusted hospital admission rates, various conditions, Newcastle, 1979–1988

Year	All-cause admissions	Respiratory admissions	Chronic obstructive lung disease (a)	Asthma (b)
	Rate (c)	Rate (c)	Rate (c)	Rate (c)
1979	135.3	9.8	4.7	4.4
1980	137.2	10.0	6.2	4.6
1981	135.9	9.3	5.9	4.3
1982	118.4	8.9	5.2	4.8
1983	118.3	8.3	3.8	5.7
1984	129.3	7.7	4.3	5.3
1985	119.7	7.9	4.7	5.1
1986	135.7	7.7	3.8	5.1
1987	149.8	8.9	4.4	5.5
1988	149.2	9.2	3.6	7.4

(a) Age 55–74 years only.
(b) Age 0–14 years only.
(c) Per 1,000 population.
Source: Christie, Spencer & Senthilselvan 1992.

2.1.7 Prevalence of asthma severity by category, for regions of New South Wales

	Coastal				*Inland*		
	Lismore	*Belmont*	*Sydney*	*Western Sydney*	*Moree/ Narrabri*	*Wagga Wagga*	*Broken Hill*
Asthma severity	%	%	%	%	%	%	%
Current asthma	11.2	11.9	11.6	7.1	8.2	9.5	13.0
Asymptomatic AHR (a)	7.8	7.8	6.8	7.4	5.1	8.6	11.4
Important morbidity	2.6	2.5	2.4	3.3	5.2	3.1	3.5
Episodic symptoms	15.9	10.4	6.7	8.2	9.7	7.3	6.1
Trivial symptoms	4.8	3.6	4.0	4.5	6.5	4.0	4.4
Past asthma	8.9	13.2	5.2	10.7	7.3	9.2	6.6
Asymptomatic	55.9	50.6	63.3	58.8	58.0	58.3	55.2
Total number	**805**	**920**	**1 339**	**904**	**770**	**850**	**794**

(a) Airway hyperresponsiveness. Measured by histamine inhalation test.
Source: Peat et al. 1995.

prevalence of current asthma in children living in three inland regions (where sensitisation to these allergens was lower) — see Tables 2.1.7 and 2.1.8.

Motor vehicle emissions

Fossil fuel combustion, particularly by motor vehicles, has been identified as the largest single contributor to atmospheric pollution in Australia, so vehicle emissions are a focus of several current initiatives. The Australian Medical Association has called for tougher car emission standards because of the threat cars pose to public health from diseases such as cancer and asthma. The potential health effects of motor vehicle emissions are described in Table 2.1.9.

The pollutants NOx, CO, and SO_2 do not currently, and are not expected in the foreseeable future to exceed 'acceptable levels', for which the evidence indicates no health risk (National Road Transport Commission 1995).

Atmospheric lead levels have been excessive, but with the reduction in use of leaded fuels, future atmospheric lead levels for Melbourne are estimated to remain below the tighter proposed acceptable level of 1.0 $\mu g/m^3$ (ibid).

The scientific literature suggests that the health conditions that may be exacerbated by vehicle pollution are primarily respiratory disease, such as asthma and bronchitis, and cancers (ibid). Table 2.1.10 presents the results of the total burden of illness attributed to ozone and air toxicants.

"More recent evidence demonstrates a potential impact on cardiopulmonary disease through inhalable particles, although it is not clear that levels of inhalable particles common in Australia pose any excess health risk" (National Road Transport Commission 1995, p. 29).

Air toxicants are chemicals, including heavy metals and organic compounds, known or suspected to pose a risk to human health or to the environment.

Certain chemicals present a particular concern in terms of inherent toxicity and overall quantity emitted to the environment. These include benzene, 1,3-butadiene, carbon tetrachloride,

2.1.8 Prevalence of allergic sensitisation to common allergens, by regions of NSW

	Coastal				*Inland*		
	Lismore	*Belmont*	*Sydney*	*Western Sydney*	*Moree/ Narrabri*	*Wagga Wagga*	*Broken Hill*
Allergens	%	%	%	%	%	%	%
Allergic sensitisation	34.9	39.3	42.4	42.1	39.9	39.9	36.9
Individual allergens (a)							
House-dust mites	28.6	30.3	34.4	29.9	26.4	20.7	12.7
Alternaria	4.0	7.6	7.7	8.6	15.2	15.4	23.1
Ryegrass	7.0	13.9	19.0	18.0	21.9	22.8	16.7
Cockroach	11.3	11.8	11.4	11.0	13.6	4.9	8.1

(a) Sensitisation to allergens was determined by skin-prick tests, weal size >=3mm.

2.1.9 Health effects of vehicle pollution

Pollutant	*Source*	*Health effect*
Nitrogen dioxide (NO_2)	One of the nitrogen oxides emitted in vehicle exhaust.	May exacerbate asthma and possibly increase susceptibility to infections.
Sulphur dioxide (SO_2)	Mostly produced by burning coal. Some SO_2 is emitted by diesel vehicles.	May provoke wheezing and exacerbate asthma. It is also associated with chronic bronchitis.
Particulates PM10, Total suspended particulates, Black smoke	Includes a wide range of solid and liquid particles in air. Those less than 10 micrometres in diameter (PM10) penetrate the lung fairly efficiently and are most hazardous to health.	Associated with a wide range of respiratory symptoms. Long term exposure is associated with an increased risk of death from heart and lung disease. Particulates can carry carcinogenic materials into the lungs.
Acid aerosols	Airborne acid formed from common pollutants including sulphur and nitrogen oxides.	May exacerbate asthma and increase susceptibility to respiratory infection. May reduce lung function in those with asthma.
Carbon monoxide (CO)	Comes mainly from petrol car exhaust.	Lethal at high doses. At low dose can impair concentration and neuro-behavioural function. Increases the likelihood of exercise related heart pain in people with coronary heart disease. May present a risk to the foetus.
Ozone (O_3)	Secondary pollutant produced from nitrogen oxides and volatile organic compounds in the air.	Irritates the eyes and air passages. Increases the sensitivity of the airways to allergic triggers in people with asthma. May increase susceptibility to infection.
Lead	Compound present in leaded petrol to help the engine run smoothly.	Impairs the normal intellectual development and learning ability of children.
Volatile organic compounds (VOCs)	A group of chemicals emitted from the evaporation of solvents and distribution of petrol fuel. Also present in vehicle exhaust.	Benzene has given most cause for concern in this group of chemicals. It is a cancer causing agent which can cause leukaemia at higher doses than are present in the normal environment.
Polycyclic aromatic hydrocarbons (PAHs)	Produced by incomplete combustion of fuel. PAHs become attached to particulates.	Includes a complex range of chemicals, some of which are carcinogens. It is likely that exposure to PAHs in traffic exhaust poses a low cancer risk to the general population.
Asbestos	May be present in brake pads and cloth linings, especially in heavy duty vehicles. Asbestos fibres and dust are released into the atmosphere when vehicles brake.	Asbestos can cause lung cancer and mesothelioma, cancer of the lung lining. The consequences of the low levels of exposure from braking vehicles are not known.

Source: Read 1994 cited in NSW Health Department 1994, p. 12.

chloroform, formaldehyde, lead and radon (Nelson & Duffy 1994).

In the National Road Transport Commission report (1995); relationships between air toxicants and excess cancer risk developed by the U.S. Environmental Protection Agency were applied to Melbourne air quality data, in order to estimate additional cancer deaths per year attributable to air toxins. The estimated health impact of air toxins in Melbourne for 1990 was an additional 10.4 to 18 new cases of cancer/year. When related to all new cases of cancer in Victoria (15,174), air

2.1.10 Burden of illness — respiratory disease and respiratory cancers, Australia, 1989

Disease	*Deaths* *No.*	*Years of potential life lost (a)* *No.*	*Hospital admissions* *No.*	*Health service cost (b)* *$m*
Pneumonia	2 065	8 026	28 447	120
Influenza	261	746	2 892	28
Asthma	962	11 769	63 195	315
Total Diseases of the respiratory system	**10 703**	**46 605**	**264 889**	**1 636**
Lung cancer	6 308	43 504	14 884	82
Total Cancers	**30 699**	**237 218**	**238 579**	**1 077**

(a) Assuming life expectancy of 75 years.

(b) Covers some 85% of the health budget and includes hospital admissions, GP visits, other medical services, allied health referrals from GPs, nursing home care, and pharmaceuticals. Excluded are outpatient services, community based services, health promotion/disease prevention activities.

Note: Studies suggest 0.1% of cancer morbidity and mortality, and 0.1% morbidity/mortality in relation to respiratory illness may be attributable to road vehicle emissions. (National Road Transport Commission 1995, p. 32).

Source: National Centre for Health Program Evaluation and the Australian Institute of Health and Welfare 1996 unpub.

2.1.11 Estimated additional cancer cases per year attributed to air toxicants due to motor vehicle emissions, Melbourne

	Additional cancer cases	
	1990	*2005*
Hazardous emission	*No.*	*No.*
Diesel particulates	1.6–8.1	0.26–13.0
Petrol particulates	6.80	2.20
Benzene	0.97	0.7–1.9
Butadiene	0.47–1.3	0.37–1.6
Formaldehyde	0.50	0.3–0.37
Benzopyrene	0.00	0.00
Asbestos	0.0001–0.3	na
Total	**10.4–18.0**	**6.2–19.1**

Source: National Road Transport Commission 1995.

toxicants possibly account for 0.1% of all cancer cases (see Table 2.1.11).

Lead

Petrol containing tetraethyl lead — now being phased out as an additive in Australia — is the biggest source of environmental lead (Wright 1992).

Nearly 90% of the absorbed lead is deposited in the skeleton, although small amounts can be found in the liver, kidneys and blood. The metal accumulates in the body early in life until it reaches an equilibrium level at which the rate of absorption equals the rate of loss (Wright 1992). Research findings show low dose effects on the psychoneurological development of children (Galvin et al. 1993).

In 1993, the NHMRC set a national goal for all Australians to have a blood lead level below 10 μg/dl. This replaced the previous level of concern of 25 μg/dl (Donovan 1995).

2.1.12 Distribution of blood lead levels, inner Sydney

Blood lead level	*Children*	
Micrograms/dl	*No.*	*%*
0–4	4	3
5–9	74	47
10–14	53	34
15–19	15	9
20–24	8	5
25–29	3	2
30–34	1	1
Total	**158**	**100**

Source: Fett et al. 1992.

A recent national survey found that the mean blood level in Australian children aged 1 to 4 years was below the current level of concern, and only 7% had levels exceeding 10 μg/dl.

However, sub-populations exist with past and continuing lead pollution from sources such as industrial facilities and occupational exposure.

For example, urban lead studies conducted in Sydney (Fett et al. 1992) consistently found high levels of lead in the blood of children who live in places with high levels of lead in house dust and backyard soils. The blood in half the children studied exceeded 10 micrograms/dl (see Tables 2.1.12 and 2.1.13).

Exposure assessment of lead-contaminated residential sites near a lead and zinc smelter in New South Wales showed a range of mean values for blood lead concentration of 11 μg/dl to 17 μg/dl, in four study groups. The proportions of children within these groups having blood lead concentrations of 10 micrograms/dl or greater (the current level of known health effect) ranged from 57% to 85% (Galvin et al. 1993) (see Table 2.1.14).

"The relationship between soil lead and blood lead of one to four year olds showed a highly statistically significant correlation (P<0.0001)" (Galvin et al. 1993, p.376).

The toxic effects of lead at the concentrations typical among workers in the lead industry include reducing the ability of brain cells to convert glucose into amino acids, and inhibiting

2.1.13 Mean home environmental lead levels, inner Sydney

		Lead value	
	No. samples	*Mean*	*Standard deviation*
Source		*mg/kg*	*mg/kg*
Play soil	24	627	713
Sink soil	18	1 944	1 785
Background soil	9	455	469
Vegetable soil	3	1 566	974
Other soil	3	920	841
Pavement dust	25	1 175	1 992
Ceiling dust	12	2 300	1 497
Vacuum dust	22	2 255	4 783
Exterior paint	53	13 000	13 000
Interior paint	59	2 000	3 000

Source: Fett et al. 1992.

2.1.14 Cumulative percentages of blood lead levels exceeding selected standards in children, Boolaroo and Argenton, New South Wales, 1991

	One to four years of age						*Primary school age*					
	Combined		*Boolaroo*		*Argenton*		*Combined*		*Boolaroo*		*Argenton*	
Blood lead category	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
>=25 µg/dl (a)	8	6	7	11	1	2	8	4	7	8	1	1
20–24 µg/dl	18	20	12	30	6	12	6	7	4	13	2	3
15–19 µg/dl (b)	38	49	16	56	22	47	44	30	27	43	17	19
10–14 µg/dl (c)	45	84	18	85	23	84	73	68	33	81	40	57
<10 µg/dl	20	100	9	100	10	100	62	99	17	100	45	100
	No.	*µg/dl*	*No.*	*µg/dl*	*No.*	*µg/dl*	*No.*	*µg/dl*	*No.*	*µg/dl*	*No.*	*µg/dl*
Mean	129	15	62	17	62	14	193	13	88	14	105	11

(a) Level of concern at time of study, NHMRC.
(b) Level of clinical investigation.
(c) Level of concern, CDC (US); Current level of concern (10ug/dl), NHMRC.
Source: Galvin et al. 1993.

an enzyme affecting the transmission of signals between neurons (Wright 1992).

Indoor pollutants

Pollutants are common in indoor air and many are at concentrations high enough to affect the health of building occupants. Typical pollutants are radon (from soil beneath buildings and some building products), formaldehyde and volatile organic compounds (from most synthetic building materials and contents), nitrogen oxides (from fuel combustion for heating, cooking) and microbes (from moist surfaces). As most people spend 70–90% of their time indoors, this is a major source of exposure to environmental pollutants (Nelson & Duffy 1994). The associations between indoor air pollutants such as NO_2 and health effects, however, are inconclusive, and little data are available.

Occupational

More evidence is available regarding occupational exposures to hazardous substances and the associated impacts on health. Table 2.1.15 presents estimates of deaths attributable to occupational exposure to chemicals. Estimates are based on percentages assigned in the literature to diseases known to be caused by occupational exposure to chemicals. Table 2.1.16 lists a number of chemicals used in the workplace and their reported effects.

The greatest number of chemical-related deaths (due to occupational exposure) during 1989–1992 were due to malignant neoplasm. This was the biggest killer for males and the second highest for females. Within this category, lung cancer was the biggest killer, followed by malignant mesothelioma.

The other main categories were major diseases, dust diseases, and chemical poisoning. Major causes of death in these categories included cardiovascular disease, asbestosis and gas

2.1.15 Estimated number of deaths attributable to occupational exposure to chemicals, by sex, Australia, 1989–1992

	1989		*1990*		*1991*		*1992*	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*
Cause of death	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Neoplasm	1 134	161	1 127	177	1 111	185	1 116	175
Major diseases (a)	641	329	600	308	591	302	573	302
Dust diseases	51	1	47	1	46	0	42	3
Acute chemical poisoning	25	6	26	7	34	9	21	7
Total	**1 851**	**497**	**1 799**	**493**	**1 782**	**496**	**1 752**	**487**

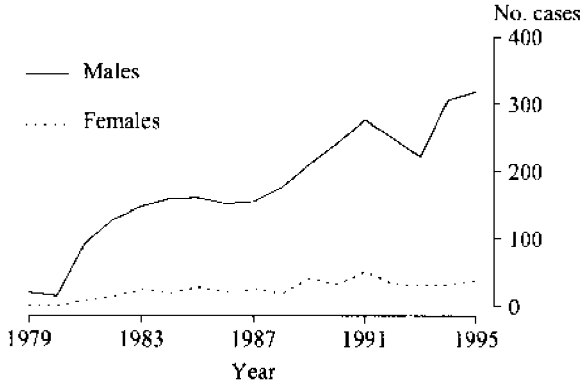
(a) Renal, cardiovascular, neurological and chronic respiratory disease mortality.
Source: Kerr et al. 1994.

2.1.16 Occupational exposures with valid epidemiological evidence of harmful outcomes

Chemical	*Major harmful outcomes*	*Source*
Aerosols, Vapour, Gases		
Carbon monoxide	Neurological/behavioural; Cardiovascular	Gilbert, Glaser 1959; Kleinman et al. 1989.
Dyes		
Aniline dyes	Bladder cancer	Ward et al. 1991.
Reactive dyes	Asthma	Brooks 1992.
Benzidene	Bladder cancer	Rehn 1985.
Betanapthalanine	Bladder cancer	Case et al. 1954.
Inorganic dusts		
Asbestos	Lung cancer, pleural, peritoneal mesothelioma, asbestosis	Mossman, Gee 1989.
Coal dust	Pneumoconiosis, emphysema, bronchitis	Attfield, Castellan 1992.
Silica	Silicosis, lung cancer	Holt 1987.
Pesticides		
Phenoxyacetic (TCDD contaminated)	Chloracne	Tindall 1985.
Organophosphates, carbamides	Neurological	Davies 1987.
Pyrethrins, organochlorines	Neurological	Ecobichon et al. 1990.
Paraquat, diquat	Tissue destruction	Smith 198(sic)
Multiple	Dermatitis	Abrams et al. 1991.
Metals, Metal fumes		
Aluminium	Chronic respiratory	Hensley 1990.
Arsenic	Skin, lung, liver cancer; Neurological; Gastrointestinal, cardiovascular	Pinto et al. 1978; Cavanaugh 1978; Landrigan 1992.
Beryllium	Chronic respiratory	Eisenbud, Lisson 1983.
Cadmium	Chronic respiratory; renal disease	Kjellstrom 1979; Nomiyama 1983.
Chromium	Lung cancer	IARC 1990.
Potassium dichromate	Dermatitis	
Lead	Neurological/behavioural; Renal; Anaemia	Baker et al. 1979; Landrigan et al. 1984; Schwartz et al. 1984.
Manganese	Neurological	Wang et al. 1989.
Mercury	Neurological	Fitzgerald, Clarkson 1991.
Nickel	Nose, lung cancer	IARC 1987.
Nickel sulphate	Dermatitis	
Organic dust		
Cotton	Chronic respiratory	Beck, Schuster 1983.
Wood	Nasal cancer; Chronic respiratory	Acheson et al. 1984; Enarson, Chan-Yeung 1990.
Multiple	Asthma	Brook 1992.
Petrochemical		
Coal-tar, PAHs, bitumen	Skin, larynx, lung, oral, bladder cancer	Hansen 1989.
Plastics		
Acrylamide	Neurological	Fullerton 1969.
Vinyl chloride	Liver angiosarcoma	Forman et al. 1988.
Multiple	Asthma	Brooks 1992.
Sensitising and miscellaneous agents		
Isocyanate	Asthma, chronic respiratory	Diem et al. 1982.
Nitroglycerine, nitroglycerol	Cardiovascular	Kristensen 1989.
Multiple	Dermatitis	Tucker, Kay 1992.
Solvents		
Benzene	Leukaemia, lymphoma	Rinsky et al. 1987.
Carbon disulphide	Cardiovascular; Neurological	Hernberg et al. 1970; Cavanaugh 1973.
n-Hexane	Neurological	Haskowitz et al. 1971.
Multiple	Asthma	Brooks 1992.
Multiple	Dermatitis	Tucker, Kay 1992.
Multiple	Neurological	Demers et al. 1991.

Note: Excludes reproductive outcomes and acute toxic episodes.
Source: Kerr et al. 1994.

2.1.17 Number of mesothelioma cases notified per year, 1979–95



Source: Leigh, Hull & Davidson 1995.

poisoning (Kerr et al. 1994).

Asbestos is a more potent carcinogen than cigarette smoke (Gray 1992). Very low exposures to asbestos give a very low risk of contracting mesothelioma, and high exposures a high risk (Leigh 1995).

Although exposure is quite restricted, annual mesothelioma incidence rates have increased from 27 per million for men and 3.5 per million for women in 1982–1985, to about 45 per million for men and 5 per million for women in 1994 (Leigh 1995).

Figure 2.1.17 shows the number of mesothelioma cases notified per year, from 1979 to 1994. About 75% of mesothelioma cases had occupational and 7% non-occupational asbestos exposure, respectively (Leigh & Davidson 1996).

Pesticides

Exposure to pesticides in Australia occurs by:

- skin contact;
- inhalation; and
- ingestion.

The NHMRC's Pesticides and Agricultural Chemicals committee (PACC), in liaison with its committee on Toxicity, recommends Maximum Residue Limits (MRLs) for chemicals allowable in foods (ANZECC 1991).

The Market Basket survey provides the only regular survey of the levels of intake of noxious substances from foods consumed by people in Australia, and its findings have been used by the NHMRC as a means of assessing the significance of dietary exposure to certain substances (see Tables 2.1.18 and 2.1.19).

2.1.18 Summary of National Residue Survey results, 1992

		Samples with detectable residues	
	Samples	*Total*	*High (a)*
Food group	*No.*	*%*	*%*
Meat	39 807	10.0	1.0
Grains	2 811	27.6	0.5
Fruit and vegetable	1 863	69.2	0.9
Eggs, honey & dairy products	1 363	2.6	0.1
Total	**45 884**	**13.7**	**0.9**

(a) Samples with more than maximum permitted concentration of heavy metal or other contamination, excluding pesticides.
Source: Bureau of Resource Sciences 1996.

Of particular concern are communities living in high pesticide use areas and population sub-groups such as children, the elderly, pregnant women, and the sick and frail.

Table 2.1.20 describes some of the symptoms which may be experienced in the event of pesticide poisoning.

The less direct or unknown long term effects of pesticide exposure may be classified as:

- cancers;
- birth defects, and effects on reproduction;
- neurological; and
- respiratory conditions.

Because of the difficulties in measuring chronic effects in humans, as well as multiple exposure variables, including environmental factors which may have an effect, the data on adverse human health effects are limited and the subject of much debate (ANZECC 1991).

Ambient air was monitored for pesticides at four sites in Coffs Harbour, a coastal town surrounded by banana plantations. The findings of this study suggest that exposure to pesticides in ambient air is very low when Acceptable Daily Intakes (ADIs) are used as a guide (Beard, Westley-Wise & Sullivan 1995) (see Table 2.1.21).

It is estimated that 24-hour inhalational exposures to heptachlor in typical ambient air in Coffs Harbour would represent, at most, about 3.8% of the ADI set by the World Health Organisation. Similarly, 24-hour exposure to the typical ambient air concentrations of chlorpyrifos in Coffs Harbour would represent, at most, 0.05% of the ADI (Beard, Westley-Wise & Sullivan

2.1.19 Estimated daily intake of pesticides and other contaminants (a), 1995

	Adult		*12 years*				
	Male	*Female*	*Male*	*Female*	*2 years*	*9 months*	*ADI*
Pesticide	*ng/kg (b)*	*ng/kg (b)*	*ng/kg (b)*	*ng/kg (b)*	*ng/kg (b)*	*ng/kg (b)*	*ng/kg (b)*
Azinphos-methyl	33.7	45.3	51.6	75.0	203.9	144.8	1 000
BHC total	0.0	0.0	0.0	0.0	0.0	189.2	na
Chlorothalonil	18.8	25.5	15.8	12.7	42.2	56.4	10 000
Chlorpyrifos	26.2	32.9	36.5	50.7	135.5	97.2	3 000
Chlorpyrifos-methyl	242.7	210.7	288.2	243.7	691.4	309.9	10 000
Cypermethin	0.8	0.6	0.8	1.1	5.2	0.8	50 000
DDE	10.1	7.2	12.1	11.0	17.7	1 418.3	2 000
DDT	7.3	5.0	9.9	8.7	15.2	37.1	2 000
Dicloran	8.1	8.9	7.2	8.8	30.9	21.8	70 000
Diazinon	13.3	11.2	14.7	13.5	22.8	18.7	1 000
Dichlorvos	1.6	2.2	2.2	3.0	8.8	5.9	500
Dicofol	11.7	13.6	8.2	15.3	64.1	38.8	1 000
Dieldrin	4.1	4.1	4.8	4.4	7.0	109.4	100
Dimethoate	15.2	18.8	11.7	12.5	85.1	59.3	20 000
Total endosulfan	38.8	46.3	40.4	48.2	93.2	100.4	7 000
Ethion	0.3	0.3	0.3	0.2	1.1	0.6	1 000
Fenthion	4.0	4.5	2.2	3.1	17.2	13.4	1 000
Fenitrothion	100.9	92.3	136.7	110.9	301.1	103.0	3 000
Fenvalerate	0.6	0.6	1.0	1.0	4.7	0.9	20 000
Hexachlorobenzene	0.0	0.0	0.0	0.0	0.0	27.0	na
Iprodione	213.4	244.6	153.5	227.3	1 275.3	803.7	40 000
Maldison	0.7	0.7	1.1	1.2	2.7	1.8	20 000
Methiamidophos	9.3	10.3	4.8	5.5	9.4	17.4	600
Monocrotophos	3.5	2.8	4.1	3.2	7.2	4.7	300
Parathion	1.3	1.7	1.8	2.6	7.1	5.3	5 000
Parathion-methyl	11.4	16.9	12.3	10.5	27.9	37.3	30 000
Permethrin	11.3	11.1	20.1	16.4	27.6	21.1	50 000
Pirimiphos-methyl	17.0	15.0	25.3	20.1	44.3	16.8	20 000
Procymidone	95.6	105.5	122.0	104.9	163.5	153.5	50 000
Tetradifon	1.5	1.8	1.3	2.0	7.2	5.5	20 000
Vinclozolin	38.4	46.9	48.4	58.1	135.5	112.3	300 000

(a) Diets based on the average energy intake.
(b) Nanograms per kilogram of body weight.
Note: The Acceptable Daily Intake (ADI) is the level of pesticide intake, at or below which there will be no appreciable health effects, if consumed over a whole lifetime. Pesticides tested for which no residues were detected include: aldrin, azinphos-ethyl, chlordane, chlorfenvinphos, chlorpropham, cyhalathrin, DDD, deltamethrin, dioxathion, heptachlor, heptachlor epoxide, mevinphos, PCBs, trithion.
Source: National Food Authority 1996.

1995). Exposure to these pesticides in ambient air may largely relate to their non-agricultural use (ibid).

The survey failed to detect any evidence of the only pesticide applied by aerial spraying in the district (Propiconazole). Further work needs to be done to quantify the degree of drift of particulates after aerial application (Beard, Westley-Wise & Sullivan 1995).

Water-borne diseases

Table 2.1.22 presents the major marine pathogens and their potential health effects.

Of the introduced bacterial pathogens, salmonellae and shigellas probably survive the longest in marine waters. The most recent outbreak of swimming-associated *Salmonella* illness worldwide was typhoid fever which occurred in Western Australia in 1958 (Anon 1961 cited in Ashbolt 1995). *Shigella* gastroenteritis has only been implicated from swimming in fresh waters (Herwaldt et al. 1991 cited in Ashbolt 1995).

2.1.20 Effects of poisoning by some commonly used pesticides

	Symptoms	
Pesticide group	*Acute poisoning*	*Severe poisoning*
Organonphosphates		
Azinphos	Headache	Muscle twitching
Maldison	Nausea	Weakness
Diazinon	Dizziness	Salivation
Profenofos	Blurred vision	Vomiting
Chlorpyrifos	Sweating	Diarrhoea
Fenthion		Stomach cramps
Mevinphos		Unco-ordination; convulsions
Carbamates		
Aldicarb	Headache	Nausea
Carbaryl	Dizziness	Vomiting
Thiodicarb	Sweating	Diarrhoea
Bendicarb	Muscle weakness	Stomach cramps
Methomyl		Chest tightness; slurred speech; unco-ordination
Organochlorines		
Endosulfan	Headache	Restlessness
Aldrin	Nausea	Muscle twitching
Chlordane	Dizziness	Convulsion
Heptachlor	Unco-ordination; mental confusion; numbness and tingling in extremities	Respiratory; depression; coma
Pyrethroids		
Deltamethrin (synthetic)	In some cases: allergic skin reactions; nasal irritation; sneezing	

Source: Australian Agricultural Health Unit 1994.

2.1.21 Estimated inhalational exposure (a) to various pesticides, Coffs Harbour, New South Wales, 1992

	Concentration	*Infant (b)*	*Child (b)*	*Adult (b)*
	ng/m³	*ng/kg*	*ng/kg*	*ng/kg*
Heptachlor				
Mean All sites	2.7	3.8	1.0	0.9
Mean Site 4 (c)	7.2	10.1	2.7	2.3
Maximum	133.0	186.0	50.5	43.3
NSW indoor average	9.5	136.0	37.1	31.8
Chlorpyrifos				
Mean All sites	3.6	5.0	1.4	1.2
Mean Site 2 (d)	7.4	10.3	2.8	2.4
Maximum	210.0	294.0	79.8	68.4
NSW indoor average	35.6	49.8	13.5	11.6
Propiconazole (e)				
10ng tube measurement	6.9	9.6	2.6	2.2
20ng tube measurement	13.6	19.4	5.3	4.5

(a) Exposure in 24 hour period.
(b) Assumed air intakes are: 22.8m³ for adult, 3.8m³ for child and 6.99m³ for infant.
(c) Heptachlor was detected almost exclusively from Site 4.
(d) Chlorpyrifos was detected most often at Site 2.
(e) No Propiconazole was detected. Therefore concentrations are below the detectable limits shown here.
Source: Beard, Westley-Wise & Sullivan 1995.

2.1.22 Major potential pathogens/indicators in the marine environment

Organism	*Source*	*Symptom*
Viruses		
Adenovirus	Animal/human faeces	Carditis; conjunctivitis; fever; gastroenteritis; hepatitis; respiratory infection
Astrovirus	Human faeces	Gastroenteritis
Calicivirus	Human faeces	Gastroenteritis
Coronavirus	Human faeces	Gastroenteritis
Coxsackie A&B	Human faeces	Carditis; diabetes; encephalitis-meningitis; fever; hepatitis; respiratory infection; skin infection
Echovirus	Human faeces	Carditis; encephalitis-meningitis; fever; gastroenteritis; respiratory infection; paralysis; skin infection
Hepatitis A	Human faeces	Hepatitis
Poliovirus	Human faeces	Carditis; fever; encephalitis-meningitis; paralysis; respiratory infection;
Reovirus	Animal/human faeces	None known
Rotovirus	Animal/human faeces	Gastroenteritis
Bacteria		
Aeromonas spp	Animal/human faeces	Gastroenteritis; skin infection; wound infection
Campylobacter jejuni	Animal/human faeces	Gastro+fever
Enterotoxigenic Escherichia coli	Animal/human faeces	Gastroenteritis;
Faecal coliforms	Animal/human faeces	Indicator organism
Faecal streptococci	Animal/human faeces	Indicator organism
Mycobacterium marinum	Seawater	Skin infection; wound infection
Salmonella spp	Animal/human faeces	Gastro+fever
Shigella spp	Animal/human faeces	Bloody diarrhoea
Vibrio spp	Seawater, faeces	Gastroenteritis; wound infection
Yersinia enterocolitica	Animal/human faeces	Appendicitis-like gastroenteritis
Protozoa		
Cryptosporidium parvum	Animal/human faeces	Watery diarrhoea; fever
Entamoeba histolytica	Faeces	Gastroenteritis/dysentery
Giardia intestinalis	Animal/human faeces	Diarrhoea/bloating
Helminths		
Ascaris spp	Animal/human faeces	Roundworm
Taenia spp	Animal/human faeces	Tapeworm
Dinoflagellates		
Alexandrium spp	Ballast/seawater	Paralytic shellfish poisoning
Gambierdiscus toxicus	Seawater	Ciguatera shellfish poisoning
Gymnodinium	Ballast/seawater	Paralytic shellfish poisoning

Source: Ashbolt 1995 p. 33.

2.1.23 Some case reports of illnesses associated with exposure to cyanobacteria (Blue-green algae)

Study date	*Location*	*Algae*	*Source*	*Number cases*	*Symptoms*
1979 (a)	Palm Island, Qld	*Cylindrospermopsis raciborskii*	Open reservoir — drinking water	139 children 10 adults	Hepatitis-like syndrome with malaise
1991 (b)	Lake Alexandrina and Meadows, SA	Mainly *Nodularia* and *Microcystis*	Water contact	3 children 5 adults	Skin rashes, sore red eyes, sore throat, hay fever, asthma
1992 (c)	River Murray towns, SA	*Anabaena*	River water; rainwater tanks — drinking water and water contact	26 — aged 1–64	Skin, systemic and multiple symptoms.

(a) Byth 1980; Bourke et al. 1983.
(b) Soong et al. 1992.
(c) El Saadi & Cameron 1993.
Source: Ressom et al. 1994.

2.1.24 Health conditions reported by beachgoers, Sydney, 1989–90

	Swam			
	Low pollution (b)	High pollution (c)	Did not swim	Total
Condition reported(a)	%	%	%	%
Vomiting	1.0	0.6	0.9	0.9
Diarrhoea	3.7	3.2	2.2	3.2
Cough, cold, flu	17.3	23.4	10.2	15.3
Ear infection	3.9	5.8	1.3	3.2
Eye infection	2.4	3.9	1.0	2.0
Fever	1.8	5.2	1.1	1.7
Other conditions	8.0	13.0	4.7	7.2
Any condition reported	26.9	35.7	16.5	24.0

(a) Symptoms were self-reported; respondents could report multiple symptoms.

(b) Geometric mean faecal coliform count of less than 300 colony-forming units per 100mL recorded on day of initial interview.

(c) Geometric mean faecal coliform count of more than 300 colony-forming units per 100mL recorded on day of initial interview.

Source: Corbett et al. 1993.

Pathogenic *Vibrios parahaemolyticus* and *V. vulnificus* are endemic to temperate Australian seawaters and are two of the most common causes of bacterial food poisoning from shellfish (Dufour 1986 cited in Ashbolt 1995). Norwalk-like viruses have been the main cause of viral food poisoning from sewage contaminated oysters in Australia (Grohmann et al. 1980 cited in Ashbolt 1995).

For the general population, cysts of *Giardia* and oocytes of *Cryptosporidium* are probably the most important parasites in Australian sewage.

At least 19 of the more than 50 genera of cyanobacteria (Blue-green algae), comprising 41 species, have been shown, or are implied, to have toxic properties (Scott, 1991 cited in Ressom et al 1994). Table 2.1.23 presents information on some cases of illness associated with exposure to cyanobacteria in Australia.

There is a paucity of data on viral illness associated with direct contact (swimming) in polluted waters.

The microbiological guidelines for recreational waters in Australia are expressed in terms of concentrations of colony forming units (cfu) of faecal coliforms and enterococci. Table 2.1.24 presents the results of a study on swimmers at a Sydney beach. The prevalence of reported fever and respiratory, eye, ear, and other symptoms increased with increasing bacterial counts measured on the day of interview.

2.1.25 Melanoma incidence — age standardised rates per 100 000

	NSW		Vic.		Qld		SA		WA		Tas.	
Year	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
1977	14.7	14.8	na	na	na	na	13.0	17.4	na	na	na	na
1978	16.4	17.7	na	na	na	na	15.0	16.5	na	na	7.9	10.3
1979	17.8	16.7	na	na	na	na	12.1	17.8	na	na	9.6	13.3
1980	18.7	15.5	na	na	na	na	12.3	15.0	na	na	12.3	16.5
1981	16.2	16.1	na	na	na	na	12.9	18.7	na	na	13.9	15.2
1982	16.4	14.3	13.9	16.0	30.7	28.5	16.7	15.2	18.3	20.8	12.6	15.2
1983	18.0	17.8	14.9	17.1	31.6	31.1	14.8	18.2	18.2	19.4	12.5	19.1
1984	21.7	19.8	15.0	17.3	36.1	32.9	15.1	17.9	20.2	20.8	13.0	11.9
1985	np	np	18.1	20.3	36.2	36.6	20.2	21.6	23.5	25.4	12.5	18.0
1986	np	np	16.6	18.4	40.2	38.6	19.2	21.3	24.0	21.4	13.5	19.6
1987	30.6	27.0	19.5	19.7	49.8	42.1	21.2	22.1	28.4	22.8	16.2	26.2
1988	34.3	27.8	22.8	21.3	46.0	36.1	26.9	24.8	32.0	27.5	22.7	22.6
1989	33.5	23.9	20.3	18.8	42.5	36.4	26.2	21.6	28.9	23.2	20.9	20.4
1990	31.2	24.3	22.4	18.5	42.6	34.5	25.1	25.9	31.5	22.1	23.4	31.8
1991	30.5	23.9	20.9	19.9	nya	nya	25.9	22.6	34.2	25.6	26.6	23.5
1992	32.0	24.8	25.9	23.2	nya	nya	31.8	28.4	nya	nya	24.7	19.2
1993	nya	nya	nya	nya	nya	nya	28.8	25.9	nya	nya	nya	nya
1994	nya	nya	nya	nya	nya	nya	31.9	29.8	nya	nya	nya	nya

Source: Jones et al. 1992; Australian Institute of Health and Welfare 1996, unpub.

2.1.26 Mortality rates (a) and total number of deaths by melanoma of skin by State

	1970–74		1975–79		1980–84		1985–89		1990–94	
	No.	*Rate*	*No.*	*Rate*	*No.*	*Rate*	*No.*	*Rate*	*No.*	*Rate*
NSW	762	3.5	952	4.2	1145	4.6	1434	5.2	1673	6.2
Male	465	4.2	620	5.5	735	6.4	916	6.8	1 113	7.6
Female	297	2.8	332	2.9	410	2.7	518	3.5	560	4.8
Vic.	413	1.8	517	2.5	716	3.5	836	4.2	915	4.3
Male	212	2.0	281	2.8	398	4.0	476	4.9	557	5.0
Female	201	1.7	236	2.2	318	3.0	360	3.4	358	3.5
Qld	339	3.2	439	4.4	515	3.7	682	5.5	827	5.2
Male	206	3.8	272	5.7	331	4.9	448	7.1	554	7.1
Female	133	2.6	167	3.1	184	2.5	234	3.8	273	3.2
SA	160	2.6	197	3.2	224	3.7	297	4.4	305	3.4
Male	84	2.5	112	3.4	127	3.3	180	5.3	181	3.4
Female	76	2.8	85	2.9	97	4.0	117	3.6	124	3.3
WA	149	2.4	197	2.9	231	3.5	319	4.8	365	4.4
Male	88	2.0	117	3.2	163	5.0	217	6.4	222	4.2
Female	61	2.8	80	2.5	68	2.1	102	3.2	143	4.6
Tas.	31	2.3	62	4.0	78	2.8	93	5.3	92	2.5
Male	19	np	30	2.4	40	4.2	55	7.6	54	3.0
Female	12	np	32	5.8	38	1.4	38	3.1	38	2.1
NT	3	np	9	np	9	np	9	np	26	3.6
Male	1	np	6	np	7	np	6	np	21	5.7
Female	2	np	3	np	2	np	3	np	5	np
ACT	12	np	22	2.3	31	2.1	45	5.2	56	3.7
Male	8	np	17	np	22	1.7	23	5.2	37	5.4
Female	4	np	5	np	9	np	22	5.2	19	np
Aust.	**1 869**	**2.7**	**2 395**	**3.5**	**2 949**	**3.9**	**3 715**	**4.8**	**4 259**	**5.0**
Male	**1 083**	**3.1**	**1 455**	**4.3**	**1 823**	**5.0**	**2 321**	**6.2**	**2 739**	**6.0**
Female	**786**	**2.3**	**940**	**2.8**	**1 126**	**2.8**	**1 394**	**3.5**	**1 520**	**3.9**

(a) No. deaths per 100,000 population mid-year estimate.
Source: ABS various years (3303.0).

Climate

Skin cancer

Strong evidence links both melanoma and non-melanocytic skin cancer with exposure to ultraviolet radiation over many years in susceptible individuals. Australia has the highest incidence of cutaneous malignant melanoma (CMM) in the world (Ewan et al. 1991). The incidence of non-melanocytic skin cancer (NMSC) in Australia is the highest recorded for any cancer in any population in the world (Marks 1989).

Tables 2.1.25 and 2.1.26 present age-standardised incidence rates and mortality rates, respectively, for cutaneous malignant melanoma (CMM) for Australia. This is the rarest and most dangerous form of skin cancer (NHMRC 1989). Both the incidence and mortality rates of CMM in Australia are increasing, with Queensland recording the highest rates of melanoma and Tasmania the lowest.

Between 1970 and 1994, mortality rates have increased from 2.7 to 5.0 deaths per 100,000 of the Australian population. There was a significantly higher CMM mortality in men than women.

It is unlikely that changes in the ozone layer have had so far any measurable effect on skin cancer rates in Australia. Exposure of the Australian population to ultraviolet radiation is more likely a product of changing fashions and sun-related behaviours this century (Giles 1989).

Ozone layer depletion

The health effects of ozone depletion have been largely divided into those related to the skin, those to eyes, and those to the immune system. Of more interest to dermatologists is the relationship of skin cancers (melanoma, basal cell carcinoma and squamous cell carcinoma) to ultraviolet radiation (UVR) exposure. Predictions for the increase in these cancers which might be seen as a result of ozone depletion are based on

2.1.27 Potential health effects of climate change

Condition	*Description*
Skin cancer	Due to increased exposure to ultraviolet radiation (UVR) as ozone layer depletion progresses. Also ocular damage.
Respiratory effects	Increases exposure to allergens.
Water-borne diseases	Potential increase in diarrhoeal and gastro-intestinal diseases due to more favourable conditions for bacteria, viruses and protozoa.
Heat stress	Particularly among vulnerable groups such as the elderly, the frail and workers in heavy or exposed occupations.
Transmission of vector-borne diseases	Mosquitos (the main vector in Australia) may invade presently uninfested areas. Potential diseases include: malaria, Australian encephalitis, epidemic polyarthritis (Ross River fever) and dengue.

Source: Ewan, Bryant & Calvert 1990.

the changes seen in incidence and mortality rates for the tumours at different latitudes where ambient UVR levels are known or have been estimated (Marks & Fraser 1995).

In general, estimates for increases in the incidence and mortality rates for melanoma and non-melanoma skin cancers are that there is a 0.5–2% increase in the incidence of these cancers for every 1% increase in UVR to which the populations are exposed over a lifetime. Recent research suggests that behaviours may be changing such that forward projections based on skin cancer incidence as a result of these past behaviours may be misleading (Marks & Fraser 1995).

In addition, UVR alters elements of the immune system in the skin and it may influence the natural history of several human diseases including cancer, herpes simplex viral infection, and some protozoal infections (Jose 1989).

Eye damage

Exposure to UVR is believed to be the major cause for the development of pterygium and CDK (climatic droplet keratopathy), as well as a cause of ocular cataracts. It is estimated that a 1% increase in UVR would increase the incidence of pterygium by 2.5% in Aboriginals and 14% in non-Aboriginals (Favilla 1989, p. 96).

Climate change

Table 2.1.27 presents a summary of some potential health effects of climate change.

Respiratory diseases

Many asthmatics are allergic to some agent, and any increase in rainfall and temperature together may stimulate plant growth (and hence increase pollen), and increase moulds and dust mites. Climatic factors such as heat stress, combined with high humidity, seem to be the main triggering agents (Ewan et al. 1991).

Water-borne diseases

Potentially serious diseases such as melioidosis, which has followed recent high rainfall periods in northern Australia, could increase. At least two other water-borne diseases, amoebic meningoencephalitis and endemic riverine cholera, could become more prevalent in the event of changed climates and increased water temperatures (in the case of the latter).

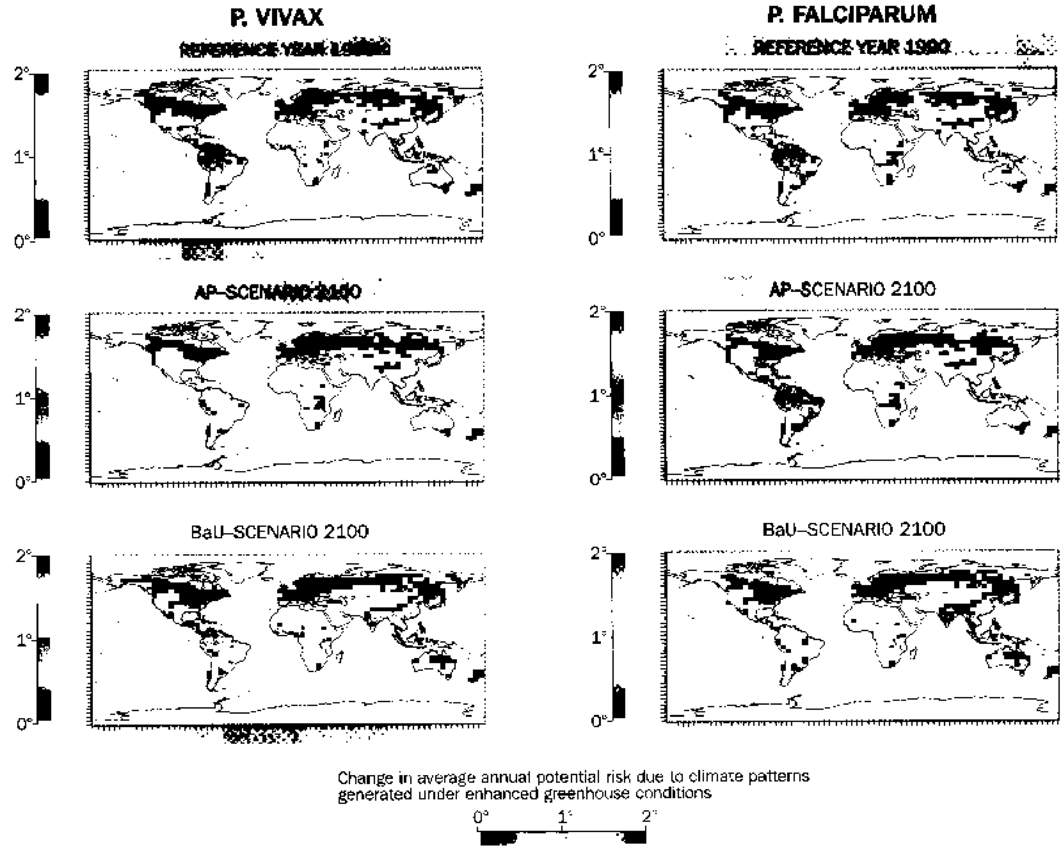
Heat stress

Of particular concern are people obliged to live in sub-standard housing, without adequate insulation, ventilation or air conditioning, and those whose occupations oblige them to perform strenuous work regardless of weather: in 1986–87 there were more than 2800 compensated workplace injuries related to extreme temperature (Ewan et al 1990).

Vector-borne disease

An increase in summer rainfall may increase the range of breeding areas for many mosquitoes and therefore increase the likelihood of disease. The re-establishment of malaria in northern Australia would depend on how vulnerable and how receptive the region is, and how readily the disease can be combated. An increase in winter temperature would extend the zone in which malaria parasites could become endemic (Ewan et al. 1990). Figure 2.1.28 presents potential malaria risk areas based on various climate change scenarios, for the year 2100.

2.1.28 Changes in average annual potential malaria risk between 1990 and 2100 for *Plasmodium vivax* and *P. falicparum*



Note: Based on climate patterns generated by the UK Meteorological Office with the accelerated greenhouse gas reduction policies (AP) and business-as-usual (BaU) greenhouse gas emission scenarios.
Source: Martens et al. 1995.

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2.2 Natural events

Australia regularly experiences the impacts of a range of natural events and processes. These can be described as hazardous when they interact with settlements, agriculture, industry and communication, posing a threat to human life and a risk of damage to property. A natural disaster occurs when a natural hazard is bigger, more frequent or continues for longer than would normally be expected. This usually results in death, injury, property damage or a combination of these (Dolan 1994, p. 2).

Section 4.1 discusses the impact of natural events and processes on the Australian economy.

2.2.1 Major natural disasters since 1900, Australia and the world

Date	*Place*	*Event*	*Lives lost*
Australia			
1908 Jan.	SA	Heatwave	105
1908 Apr.	Mile Beach, WA	Tropical cyclone	50
1910 Nov.	Broome, WA	Tropical cyclone	40
1911 Mar.	Cairns - Innisfail, Qld	Tropical cyclone	120
1916 Dec.	Clermont, Qld	Flood	62
1923 June	Central & North coast, NSW	Extra-tropical cyclone	46
1926 Jan–Feb	Warburton-Noojee, other areas, Vic.	Bushfire	31
1934 Mar.	Townsville, Cape York areas, Qld	Tropical cyclone	75
1934 Oct	Yarra and other rivers, Vic.	Floods	35
1939 Jan.	Southern Australia	Heatwave	144
1939 Jan.	Central and eastern Vic.	Bushfires	71
1940 —	Southern and eastern Australia	Heatwave	66
1944 Jan.	Western districts, Vic.	Bushfire	51
1955 Feb.	Eastern NSW	Floods	50
1959 —	Southern Australia	Heatwave	105
1967 Feb.	Near Hobart, Tas.	Bushfire	62
1974 Dec.	Darwin, NT	Tropical cyclone Tracy	65
1983 Feb.	Parts of Vic. and SA	Bushfires 'Ash Wednesday'	71
1989 Dec.	Newcastle, NSW	Earthquake	13
1991 Apr.	WA	Tropical cyclone Fifi	29
Rest of World			
1900 Sep.	Texas, USA	Tropical cyclone	6 000
1902 May.	Martinique	Eruption of volcano Mt Pelee	26 000
1908 Dec.	Italy	Earthquake	83 000
1912 Apr.	N Atlantic Ocean	Iceberg strikes ocean liner Titanic	1 513
1918 Oct.	Minnesota, USA	Forest fire	750
1920 Dec.	China	Landslide	1 000
1920–21	Russia	Drought	>1 000 000
1923 Sep.	Tokyo, Japan	Earthquake	143 000
1931 Feb.	Hawke's Bay, NZ	Earthquake	256
1931 July	China	Flooding of Yangtze Kiang River	1 000 000
1949 Oct.	Guatemala	Floods	40 000
1951 Nov.	New Guinea	Eruption of Mt Lamington volcano	300
1952 Dec.	London, England	Freak fog and associated air pollution	>4 000
1953 Jan.	England; Netherlands	Coastal flooding due to storm surges	1 800
1959 July	Northern China	Floods	2 000 000
1959 Sep.	Ise Bay, Japan	Typhoon Vera	5 100
1963 Oct.	Haiti	Tropical cyclone Flora	4 800
1970 May.	Peru	Earthquake and landslide	52 000
1970 Nov.	Bangladesh	Tropical cyclone Gorky	300 000
1973–74	Sahel zone, Africa	Drought	100 000
1974–75	Ethiopia	Drought	40 000
1976 Feb.	Guatemala	Earthquake	23 000
1976 July	Tang-shan, China	Earthquake	665 000
1985 Sep.	Mexico	Earthquake	7 000
1988 Dec.	Armenia	Earthquake	25 000
1990 Jun.	Iran	Earthquake	40 000
1991 Apr.	Bangladesh	Tropical cyclone	140 000
1993 Oct.	India	Earthquake	21 000

Source: Bell 1989; Information provided courtesy of the Disaster Awareness Program, Emergency Management Australia 1995, unpub.

International comparisons

Table 2.2.1 shows major natural disasters this century in terms of lives lost, in Australia and other parts of the world. There are far fewer deaths in Australia as a result of natural disasters than in many other countries. Australia has a small population with many sparsely populated or uninhabited areas. Therefore, while Australia experiences many potentially hazardous events, many do not affect human systems to the extent of causing a disaster. For example, Cyclone Tracy was a disaster because its path crossed directly above Darwin. Many similar cyclones cross uninhabited sections of the Australian coastline with minimal impact.

The pattern of natural events also helps to explain Australia's low death rate. Floods, cyclones and bushfires account for many of the deaths in Australia. Drought, although frequent and often severe, causes economic hardship rather than the massive loss of life experienced in some parts of the world. Earthquakes and volcanoes, responsible for high death tolls in some countries, occur most frequently in zones away from Australia.

Further explanation is provided by the fact that Australia is a developed country with the technology to predict and monitor natural events, and the resources to deal with hazards and disasters when they do occur.

Wider impacts

The impact of natural events and processes on individuals is felt not only through deaths, but also through injury, damage or destruction of personal property and loss of income. Viewed in this way, the lives of many Australians are disrupted by natural events each year. In Australia the effect of natural events is felt through economic hardship and personal trauma rather than loss of life.

Table 2.2.2 shows the number of people who have died, been injured, left homeless or affected in some way by major natural disasters since 1967. Many events where no lives were lost still had an impact on thousands of people. As Table 2.2.2 shows, droughts in particular have affected millions of people.

Another notable feature of these data is the impact heatwaves have had. Heatwaves are not as dramatic an event as, for example, bushfires or cyclones, but have caused a significant number of deaths and illnesses (some possibly unrecorded) and affected many thousands more people.

Severe storms are responsible for a number of deaths each year. On average, 5 to 10 deaths and over 100 injuries are caused annually by lightning. In fact, lightning poses a greater threat to individuals than almost any other natural hazard in Australia. Deaths also occur when strong winds cause tree limbs to fall, debris to become projectiles and small boats in open water to capsize. A less known fact is that tornadoes occur in Australia; 41 tornado-related deaths have been recorded.

The significance of the geographic location of natural events, as mentioned earlier, is an important factor in their impact. Those which occur in or near major population centres have the potential to create a major disaster, while the same event in a non-populated area could go unnoticed. For example, severe storms in Sydney, Melbourne, Brisbane and Perth have resulted in flash flooding and wind and hail damage, while similar events in remote areas may not even be recorded; bushfires near Melbourne, Adelaide, Sydney and Hobart have affected many people through deaths, injuries and loss of homes and property, while worse fires in country areas have burnt out thousands of hectares of bush without having such a major impact on people; cyclones which cross the coast near towns can cause loss of life and massive destruction.

Risk factors

In some circumstances, people are increasing their risk of being affected by natural events through their practices and behaviour. For example, major losses from bushfires have occurred when a single fire burnt into a residential area, either a major town or on one of the city fringes, as shown in Table 2.2.3. Whereas in the past the perimeter of major cities between the urban area and the bushland was well defined with a substantial fire break, the recent trend is towards larger blocks of land on the outskirts of cities and towns that are uncleared or regenerated with native vegetation. People are not only living more intimately with fuels, but also tend to be uneducated about bushfires or fire behaviour. With fewer precautions being taken to clear fuels around such houses, the concentration of house losses is likely to be greater than in the past (ABS 1995, 1301.0, p. 520).

In urban areas, development has increased the flooding of certain areas and the exposure of people to this risk. Urban development increases run-off and changes in river channels exacerbate the problem. With increased demand for land, development spreads into flood-prone areas (AUSLIG 1992, p. 76). A good example of this

2.2.2 Impacts on individuals of selected (a) major natural disasters in Australia

Date	Disaster	Dead	Injured (b)	Affected (b)	Homeless (b)	Details
1967 Feb.	Bushfires	62	900	8 000	3 000	Hobart, Tas.
1958–68	Drought	0	0	5 000 000	0	Most of Australia – worst since 1895–1903
1968 Oct.	Earthquake	0	16	3 900	400	Meckering, WA - most buildings destroyed. (56 000 buildings damaged in Perth)
1968 Nov.	Bushfires	14	70	15 000	800	NSW (Blue Mtns, Illawarra and North coast)
1969 Jan.	Bushfires	23	100	6 000	1 000	Southern Vic.
1970 Jan.	Cyclone	14	100	2 000	50	TC Ada Whitsunday Is Qld
1971 Jan.	Flood	7	5	500	0	Canberra, ACT
1971 Dec.	Cyclone	3	25	20 000	800	TC Althea–Townsville Qld
1973 Jan.	Heatwave	26	750	10 000	0	Southern Australia - crop damage
1974 Jan.–Feb.	Cyclone/flood	16	300	35 000	5 000	TC Wanda–Brisbane, Qld
1974 Dec.	Cyclone	65	640	45 000	35 000	TC Tracy–Darwin, NT–80% buildings destroyed
1975 Mar.	Flood	0	7	12 000	700	Sydney, NSW
1977 Jan.	Severe storm	1	4	8 000	100	NSW–thunderstorms
1977 Feb.	Bushfire	8	60	3 000	150	Western districts, Vic.
1977 Dec.	Bushfires	3	12	2 000	70	Blue Mts, NSW
1978 Feb.	Severe storms	0	8	70 000	50	Sydney, Newcastle. Wollongong, NSW
1978 Feb.–Mar.	Floods	5	50	10 000	200	Sydney, Penrith, NSW
1978 June	Severe storm	2	10	25 000	60	Sydney, NSW–winds/flooding
1979 Mar.	Cyclone	15	5	2 000	10	WA–TC Hazel–15 deaths at sea
1979 Dec.–1980 Feb.	Bushfires	5	10	5 000	60	NSW widespread
1980 Dec.	Cyclone	0	3	20 000	20	Brisbane, Qld–wind and flood damage
1982 Nov.	Severe storm	2	25	40 000	50	Melbourne and region
1983 Feb.	Bushfires	76	1 100	300 000	8 000	Vic. and SA 'Ash Wednesday'
1981–83	Drought	0	0	4 000 000	0	South–eastern Australia. associated dust storms
1985 Jan.	Severe storm	0	20	25 000	300	Brisbane, Qld–hailstorm and tornado
1984 Sep.–1985 Feb.	Bushfire	6	20	25 000	0	Central and southern NSW - worst fire season for 10 years
1986 Jan.	Cyclone	3	12	8 000	200	Cairns to Ingham, Qld–TC Winifred
1986 Aug.	Severe storm	4	10	10 000	100	Sydney, NSW–hail/rainstorms and flash floods
1987 Dec.–1988 Jan.	Bushfires	3	15	5 000	0	Areas of NSW
1988 Mar.–Apr.	Flood	3	20	500	na	Alice Springs and region, NT
1989 Apr.	Cyclone	2	13	2 300	110	Ayr, Home Hill, Clare, Qld–TC Aivu, included storm surge
1989 Apr.	Cyclone	2	20	1 000	60	WA–TC Orson
1989 Apr.	Flood	9	40	5 000	400	Southern Qld and northern NSW
1989 Dec.	Earthquake	13	150	300 000	1 000	Newcastle, NSW
1990 Jan.	Heatwave (c)	5+	100	150 000	0	SA and Vic.
1990 Feb.	Cyclone	6	25	10 000	100	Southern Qld and northern NSW–TC Nancy
1990 Mar.	Severe storm	0	25	10 000	200	Auburn, Sydney, NSW–hailstorm
1990 Apr.	Flood	7	60	17 000	5 000	Qld/NSW/Vic. 'Great Floods'
1990 Dec.	Heatwave (c)	4+	60	500 000	0	Melbourne, Vic.
1990 Dec.–1991 Jan.	Cyclone	6	35	30 000	200	Qld–TC Joy
1991 Jan.	Severe storm	1	100	350 000	600	Northern Sydney, NSW–extreme wind/hail/rain storm, possible tornado
1991 Feb.–Mar.	Flood	6	20	15 000	100	Gulf country, central and southern Qld and northern NT
1991 Apr.	Cyclone	29	10	2 000	0	WA–TC Fifi
1991 Oct.– 1992 Jan.	Bushfires	3	5	10 000	100	Areas of NSW
1993 Feb.	Heatwave (c)	17+	500+	3 000 000	0	South-east Australia–crop and stock losses
1993 Oct.	Flood	1	30	15 000	5 500	North-east Vic.
1994 Jan.	Bushfires	4	120	250 000	900	Eastern seaboard, NSW–> 800 fires
1994 Jan.	Heatwave (c)	5	150	100 000	0	Townsville, Qld
1994 May	Severe storm	2	20	240 000	200	Perth, WA
1994 Nov.	Severe storm	1	54	2 500 000	50	Vic., ACT, NSW–land gales
1995 Feb.	Cyclone	7	15	7 000	30	Onslow, WA–TC Bobby
1995 Apr.	Tornado	0	34	4 500	120	Merimbula and Pambula, NSW

(a) Details cover natural disasters since 1967, and only those which caused at least 3 deaths, or 20 injuries (This information covers the period 1/6/67 to 18/9/95.)

(b) Figures for Injured. Affected and Homeless are in some cases estimates based on similar events where accurate figures are known.

(c) It is likely that additional heat-related deaths and illnesses went unreported.

Source: Information provided courtesy of the Disaster Awareness Program, Emergency Management Australia 1995, unpub.

2.2.3 Significant single fires in urban/rural bushfire disasters in Australia

Year	Date	Location	Area burnt Hectares	Homes destroyed No.
1964	14 January	Dandenong Ranges, Victoria	2 000	454
1967	7 February	Hobart, Tasmania	6 600	310
1983	16 February	Upper Beaconsfield, Victoria	9 200	238
1983	16 February	Macedon, Victoria	29 500	628
1983	16 February	Mt Osmond, South Australia	3 885	9 100+
1994	8 January	Como/Jannali, New South Wales	476	101

Source: CSIRO Division of Forestry in ABS 1995 (1301.0), p. 521.

process is the Brisbane floods of 1974, the worst city flooding in Australia's history. One third of the city was inundated by flood waters, forcing 8,000 people from their homes. The human contribution to these floods was significant. It included opening up new housing and industrial areas, filling in natural creek beds to create building sites, building additional bridges, and the construction of major roads alongside rivers (Dolan 1994, pp. 83–84).

A storm surge is a raised dome of water about 60–80 km across and typically about 2 to 5 m higher than the normal tide level. It is created by pressure differences within a tropical cyclone. Storm surges are thought to cause about 90 % of deaths from tropical cyclones world-wide. Although infrequent in Australia, they pose a great threat to coastal settlements situated on low land along river mouths. Towns such as Cairns, Mackay and Townsville all have low lying areas that could be inundated if a tropical cyclone occurred in conjunction with high tides. In Townsville about 35,000 people would be endangered by a major surge (Dolan 1994, p. 134).

Causes of death

When deaths from external causes are coded according to the International Classification of Diseases (WHO 1977), a different perspective is provided on the impact of the environment on the individual. Table 2.2.4 shows a selection of causes of death that can be directly attributed to the natural environment. Apart from the direct impact of natural events covered in previous tables, such as bushfires, heatwaves and storms, the effect of venomous snakes, spiders, marine animals and plants, sharks and crocodiles is apparent.

The proportion of deaths directly attributable to environmental causes is very small, and varies considerably from year to year, from about 1

2.2.4 Deaths resulting directly from environmental causes, by sex, Australia

Cause of death	1980 & 1981 No.	1982 & 1983 No.	1984 & 1985 No.	1986 & 1987 No.	1988 & 1989 No.	1990 & 1991 No.	1992 & 1993 No.	1980–93 Male %	1980–93 Female %	1980–93 Total No.
Fire	17	90	12	8	9	7	4	80.3	19.7	147
Excessive heat, weather	12	22	4	8	8	15	20	56.2	43.8	89
Excessive heat, unspecified	3	6	1	1	1	9	3	62.5	37.5	24
Excessive cold, weather	3	7	9	14	15	21	12	60.5	39.5	81
Excessive cold, unspecified	2	2	12	9	13	11	17	59.1	40.9	66
Venomous plants & animals										
Snakes	3	5	2	3	5	5	10	66.7	33.3	33
Spiders	1	0	0	0	1	2	1	80.0	20.0	5
Marine plants & animals	4	1	4	1	2	1	0	84.6	15.4	13
Sharks, crocodiles, moray eels	1	2	4	4	4	2	5	81.8	18.2	22
Lightning	6	2	5	5	1	4	8	74.2	25.8	31
Storms and floods from storms	16	18	6	8	27	17	14	72.6	27.4	106
Earth surface movements	0	0	0	0	2	13	0	46.7	53.3	15
Total	**68**	**155**	**59**	**61**	**88**	**107**	**94**	**68.5**	**31.5**	**632**
Total deaths all causes	**217 698**	**224 855**	**228 722**	**232 302**	**244 098**	**239 208**	**245 259**	**54.2**	**45.8**	**1 632 142**

Sources: ABS (3302.0), various years; ABS, unpub.

death per 1000 deaths to 1 death per 2500 deaths (ABS, unpub.). Further, the number of deaths each year is not predictable because the events that cause them are not.

While the impact of extreme heat and cold is greatest in the older age groups, most deaths occur across all ages. There are consistent and significant differences between males and females, in that deaths of males outnumber those of females by about 2 to 1 for the causes of death analysed.

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2.3 Public perceptions about environmental conditions

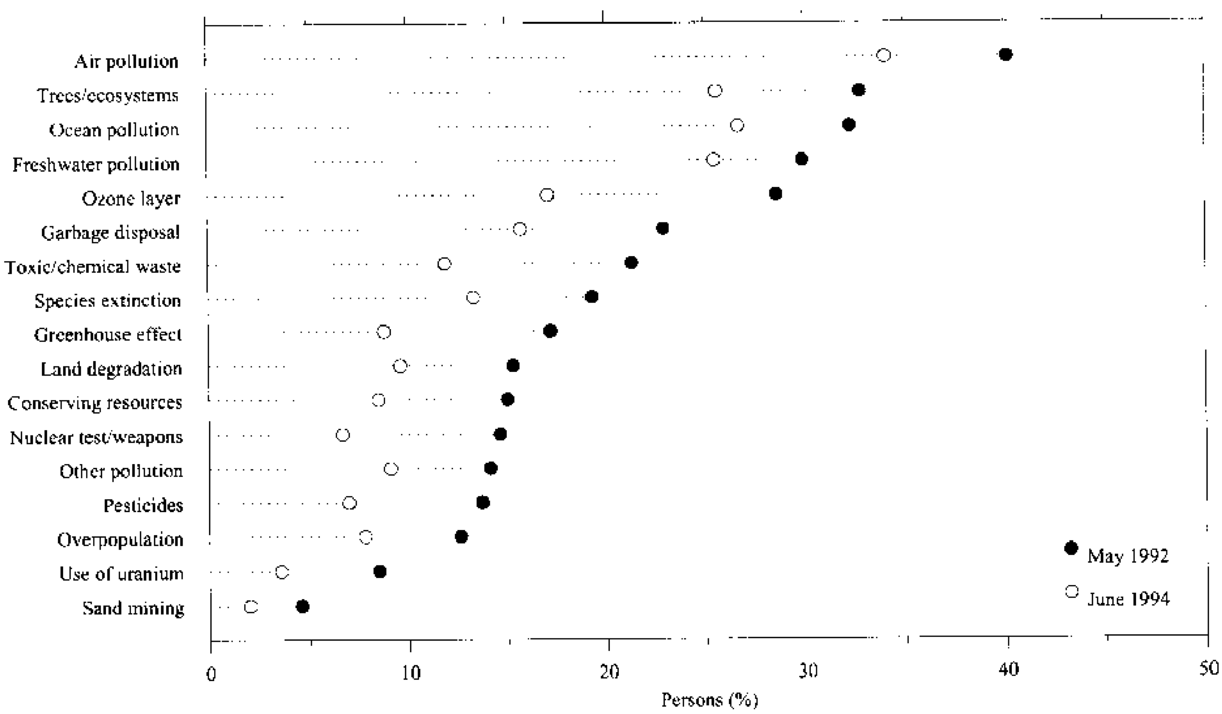
In May 1992 and June 1994 the Australian Bureau of Statistics conducted surveys on environmental issues as part of the Monthly Labour Force Supplementary Survey program. Both surveys collected data relating to people's perceptions about specific environmental problems.

Environmental concerns

Based on the survey responses, in June 1994 69% of the Australian population aged 18 years and over were concerned about at least one specific environmental problem. This was less than for May 1992, when survey responses indicated that 75% of people aged 18 years and over were concerned about environmental problems. By comparison, a similar survey on environmental issues conducted by the ABS in April 1986 indicated that, of people aged 15 years and over, 47% were concerned about problems with the environment in Australia.

As illustrated in Figure 2.3.1 and Table 2.3.2, the major environmental concern in the two recent surveys was air pollution (34% of the target population in 1994 and 40% in 1992).

2.3.1 Concern for environmental problems



Source: ABS 1992, 1994 (4602.0).

2.3.2 People's environmental concerns, 1992–1994

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Aust.
Environmental problem	%	%	%	%	%	%	%	%	%
June 1994									
Air pollution	39.5	34.1	29.2	31.1	29.5	27.0	33.4	27.7	34.1
Ocean pollution	31.9	22.8	25.7	29.0	19.3	26.3	25.0	20.7	26.7
Destruction of trees/ecosystems	26.1	22.4	29.3	24.6	26.3	21.6	34.3	26.7	25.6
Freshwater pollution	30.2	21.8	22.5	29.5	21.1	24.6	27.0	24.9	25.5
Ozone layer	15.8	18.7	15.6	20.7	17.7	13.1	20.4	18.7	17.1
Garbage disposal	16.1	16.0	14.7	18.9	13.5	12.4	13.4	16.7	15.7
Extinction of species	15.8	11.2	14.9	10.8	10.4	9.9	20.3	11.6	13.3
Toxic chemical waste	12.0	12.2	13.3	12.0	9.5	10.2	8.9	5.9	11.9
Land degradation	10.3	8.7	9.9	10.5	7.9	8.3	13.6	10.8	9.6
Other pollution	10.9	6.9	9.7	10.7	6.0	7.9	10.2	11.8	9.1
Greenhouse effect	9.4	9.7	6.9	10.8	6.1	6.2	8.3	9.9	8.8
Resource conservation	8.6	8.4	9.4	7.3	6.7	9.3	12.9	8.5	8.5
Overpopulation	9.5	6.4	8.7	5.5	6.4	6.2	11.3	7.3	7.8
Use of pesticides	8.2	6.4	7.9	5.4	4.7	5.4	9.5	4.0	7.0
Nuclear tests/weapons	7.8	7.1	6.4	5.1	4.3	5.9	8.0	2.6	6.7
Use of uranium	3.7	3.9	3.8	3.2	3.0	2.9	5.9	1.9	3.6
Sand mining	2.5	1.3	3.3	1.3	0.9	0.9	* 1.6	* 0.7	2.0
Other	5.5	4.8	7.0	5.5	6.5	4.1	* 3.0	9.1	5.7
No concerns or don't know	30.8	32.8	31.5	27.0	29.9	38.7	27.8	25.8	31.1
Percentage point change 1992–94									
Air pollution	−2.8	−9.3	−7.7	−4.7	−5.2	−7.0	−8.0	−16.3	−6.1
Ocean pollution	−2.5	−6.4	−10.7	−0.4	−8.5	−8.4	−16.7	−8.7	−5.6
Destruction of trees/ecosystems	−6.1	−8.6	−7.8	−6.8	−4.9	−14.3	−1.2	−13.8	−7.2
Freshwater pollution	0.3	−8.8	−8.7	0.4	−4.5	−5.6	−2.6	−6.9	−4.4
Ozone layer	−11.7	−13.1	−10.6	−8.4	−8.0	−15.0	−18.1	−15.6	−11.5
Garbage disposal	−8.5	−6.9	−7.0	−2.6	−5.8	−12.1	−17.9	−5.3	−7.2
Extinction of species	−3.5	−9.4	−6.4	−6.3	−2.8	−10.1	−9.1	−8.2	−6.0
Toxic chemical waste	−9.5	−10.8	−8.1	−6.5	−8.1	−11.8	−22.3	−12.4	−9.4
Land degradation	−3.1	−9.8	−6.4	−3.3	−3.8	−8.2	−9.8	−4.7	−5.7
Other pollution	−4.3	−5.4	−5.4	−2.9	−6.2	−8.8	−5.7	−1.8	−5.0
Greenhouse effect	−7.7	−10.8	−8.3	−4.6	−6.8	−13.0	−12.5	−9.1	−8.4
Resource conservation	−6.3	−8.4	−6.1	−6.0	−4.0	−7.3	−6.5	−6.7	−6.5
Overpopulation	−3.5	−6.3	−6.3	−3.5	−2.7	−7.8	−7.5	−5.3	−4.8
Use of pesticides	−4.6	−9.7	−7.7	−5.2	−3.7	−11.6	−18.1	−4.1	−6.7
Nuclear tests/weapons	−6.7	−10.8	−8.1	−6.7	−4.6	−10.0	−14.5	−5.7	−7.9
Use of uranium	−4.7	−6.0	−4.5	−4.5	−2.9	−7.6	−5.9	−2.0	−4.9
Sand mining	−2.4	−4.0	−1.8	−1.4	−1.4	−4.7	* −2.9	* −0.7	−2.6
Other	0.2	−0.4	0.5	−2.0	0.6	−1.5	* −7.5	3.9	−0.1
No concerns or don't know	4.4	8.0	5.5	4.0	5.9	9.4	7.4	9.3	5.9

Source: ABS 1992, 1994 (4602.0).

Between May 1992 and June 1994 the numbers of people who expressed concern about environmental problems dropped across all the age groups in the scope of the surveys, with responses for the 65 and over age group showing the largest fall, as illustrated in Table 2.3.3. The smallest decrease was recorded for those aged between 35 and 44.

The 1994 survey results indicated that, by a substantial margin, the greatest environmental concern of metropolitan populations was with air pollution (rated highest by 38% of respondents), followed by ocean pollution (rated highest by 28%), as shown in Table 2.3.4. For people in non-metropolitan areas, destruction of trees and

Table 2.3.3 Environmental concerns by age group – persons (a)

	18–24	*25–34*	*35–44*	*45–54*	*55–64*	*65 +*	*Total*
Environmental problem	%	%	%	%	%	%	%
June 1994							
Air pollution	36.2	37.2	39.2	35.6	29.0	22.5	34.1
Ocean pollution	33.4	30.1	31.5	25.7	21.4	13.7	26.7
Destruction of trees/ecosystems	30.2	26.6	29.2	25.9	22.6	16.5	25.6
Freshwater pollution	25.9	27.3	30.2	27.4	24.4	15.0	25.5
Ozone layer	25.0	22.5	19.9	13.6	11.4	5.9	17.1
Garbage disposal	16.1	20.0	18.2	14.8	13.1	8.5	15.7
Extinction of species	18.1	14.7	15.5	11.6	10.6	7.8	13.3
Toxic chemical waste	12.5	12.4	14.3	13.7	9.3	6.9	11.9
Land degradation	9.0	9.1	12.5	10.4	9.3	6.1	9.6
Other pollution	9.0	10.1	10.5	10.1	8.3	5.6	9.1
Greenhouse effect	12.4	11.0	9.7	8.1	5.4	3.9	8.8
Resource conservation	8.2	9.1	10.3	8.4	7.8	5.7	8.5
Overpopulation	7.0	8.0	9.5	8.0	7.5	5.9	7.8
Use of pesticides	5.3	6.9	8.1	8.5	7.0	5.5	7.0
Nuclear tests/weapons	8.0	7.2	7.8	6.5	5.8	4.0	6.7
Use of uranium	5.2	3.8	4.0	3.5	3.0	1.9	3.6
Sand mining	2.1	2.1	2.5	1.8	1.7	1.3	2.0
Other	4.4	5.2	5.9	6.9	7.1	4.9	5.7
No concerns or don't know	26.4	26.6	24.2	28.4	37.0	50.3	31.1
Percentage point change 1992–94							
Air pollution	−5.0	−7.4	−7.4	−4.0	−6.3	−4.8	−6.1
Ocean pollution	−1.8	−8.4	−6.5	−6.5	−3.8	−3.4	−5.6
Destruction of trees/ecosystems	−6.1	−11.8	−6.9	−4.9	−3.7	−6.4	−7.2
Freshwater pollution	−3.0	−7.5	−4.2	−2.6	−2.3	−4.1	−4.4
Ozone layer	−15.3	−13.0	−12.4	−11.4	−6.8	−6.2	−11.5
Garbage disposal	−6.6	−10.0	−9.4	−6.8	−1.9	−4.7	−7.2
Extinction of species	−4.0	−10.3	−6.8	−5.2	−3.0	−2.8	−6.0
Toxic chemical waste	−7.5	−14.4	−13.0	−7.7	−5.3	−3.8	−9.4
Land degradation	−2.8	−8.4	−7.3	−5.0	−4.3	−4.1	−5.7
Other pollution	−5.7	−6.1	−6.0	−3.6	−3.5	−3.1	−5.0
Greenhouse effect	−9.0	−11.0	−11.2	−6.7	−5.3	−4.2	−8.4
Resource conservation	−5.9	−9.3	−7.7	−6.2	−4.3	−3.5	−6.5
Overpopulation	−4.4	−6.6	−6.3	−4.6	−2.3	−2.5	−4.8
Use of pesticides	−4.9	−9.9	−9.9	−6.2	−3.4	−2.3	−6.7
Nuclear tests/weapons	−8.0	−10.7	−10.0	−8.2	−3.7	−3.5	−7.9
Use of uranium	−3.0	−7.5	−6.5	−4.7	−2.6	−2.0	−4.9
Sand mining	−1.9	−3.8	−3.8	−2.7	−0.8	−0.9	−2.6
Other	0.6	0.3	−2.1	−0.7	2.2	0.4	−0.1
No concerns or don't know	5.3	6.4	3.5	4.6	5.7	9.6	5.9

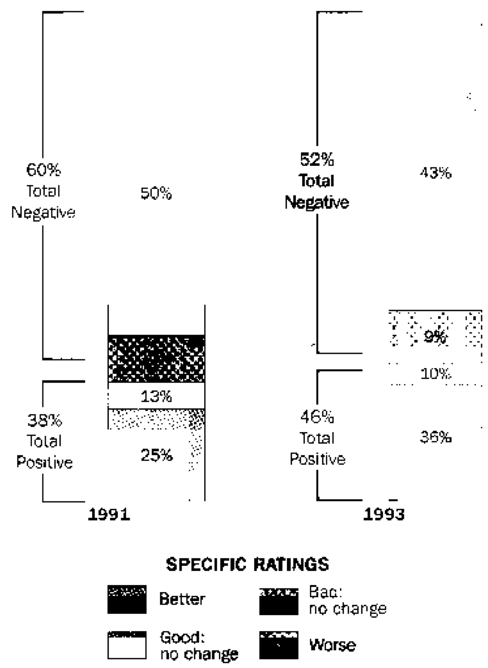
(a) Totals do not equal the sum of environmental problems in each column because a person may report more than one concern.
Source: ABS 1992, 1994 (4602.0).

2.3.4 Environmental concerns by metropolitan/non-metropolitan areas—persons(a)

	Metropolitan	Non-metropolitan	Total
Environmental problem	%	%	%
June 1994			
Air pollution	38.0	27.6	34.1
Ocean pollution	27.9	24.7	26.7
Destruction of trees/ecosystems	24.1	28.1	25.6
Freshwater pollution	25.7	25.2	25.5
Ozone layer	16.8	17.6	17.1
Garbage disposal	15.3	16.3	15.7
Extinction of species	11.8	15.9	13.3
Toxic chemical waste	10.9	13.5	11.9
Land degradation	6.5	14.9	9.6
Other pollution	9.0	9.3	9.1
Greenhouse effect	8.2	9.7	8.8
Resource conservation	7.0	10.9	8.5
Overpopulation	6.5	10.1	7.8
Use of pesticides	5.3	9.8	7.0
Nuclear tests/weapons	5.4	8.9	6.7
Use of uranium	3.0	4.7	3.6
Sand mining	1.5	2.9	2.0
Other	5.8	5.5	5.7
No concerns or don't know	29.7	33.4	31.1
Percentage point change 1992–94			
Air pollution	−5.6	−6.9	−6.1
Ocean pollution	−5.4	−5.9	−5.6
Destruction of trees/ecosystems	−8.3	−5.3	−7.2
Freshwater pollution	−4.2	−4.6	−4.4
Ozone layer	−11.7	−11.2	−11.5
Garbage disposal	−7.4	−6.9	−7.2
Extinction of species	−6.3	−5.5	−6.0
Toxic chemical waste	−9.4	−9.3	−9.4
Land degradation	−5.3	−6.0	−5.7
Other pollution	−5.5	−4.1	−5.0
Greenhouse effect	−9.3	−7.1	−8.4
Resource conservation	−7.4	−5.1	−6.5
Overpopulation	−5.6	−3.3	−4.8
Use of pesticides	−6.7	−6.5	−6.7
Nuclear tests/weapons	−8.8	−6.4	−7.9
Use of uranium	−5.0	−4.5	−4.9
Sand mining	−2.7	−2.2	−2.6
Other	0.1	0.0	−0.1
No concerns or don't know	4.9	7.5	5.9

(a) Totals do not equal the sum of environmental problems in each column because a person may report more than one concern.
Source: ABS 1992, 1994 (4602.0).

2.3.5 Perceived state of the environment in Australia



Source: ANOP 1993.

of ecosystems ranked among the greatest concerns, along with air pollution.

Respondents in the capital cities, particularly Sydney and Melbourne, recorded the highest concern for air pollution. The destruction of trees and of ecosystems was rated higher by respondents in non-urban areas.

The perceptions of the Australian population about the state of the environment, both worldwide and for Australia, were surveyed by Australian National Opinion Polls (ANOP) in December 1991 and September 1993, as part of a report prepared for the Department of Environment, Sport and Territories (see Figure 2.3.5). The results, illustrated in Table 2.3.6, showed that the state of the global environment was perceived more negatively than the state of the Australian environment (ANOP, 1993). In 1993 36% of survey respondents indicated a belief that the Australian environment had improved over the preceding five years, compared to 25% in 1991. The percentage of respondents indicating a belief that the Australian environment had deteriorated dropped from 50% in 1991 to 43% in 1993. In the 1993 survey 59% of respondents believed that the world environment had been getting worse over the preceding five years, while 23% considered that it had improved.

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Australian Bureau of Statistics (ABS) 1992, 1994, *Environmental Issues — People's Views and Practices* (4602.0) AGPS, Canberra.

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2.3.6 Perceived state of the environment in Australia and worldwide

	December 1991	*September 1993*
	%	%
In the last 5 years the environment in Australia has been:		
Getting better	25	36
Getting worse	50	43
No change — good	13	10
No Change — bad	10	9
Unsure	2	2
In the last 5 years the environment worldwide has been:		
Getting better	18	23
Getting worse	65	59
No change — good	6	4
No change — bad	9	10
Unsure	2	4

Source: ANOP 1993.

Chapter 3 — Environmental Benefits to Individuals

This chapter presents statistics which reflect the flow in the PEP model from Natural Assets and Processes to Individuals. It examines some *benefits* to people of the natural environment. This is the reciprocal of the material presented in Chapter 2 which examined the same relationship, but focusing on the adverse impacts of the environment on individuals.

The direct benefits of the natural environment to individuals are examined in terms of:

- the recreation benefits of the natural environment (Section 3.1); and
- Impacts of natural events on individuals (Section 3.2).

The chapter concludes by presenting statistics which indicate individuals' perceptions of environmental conditions (Section 3.3).

3.1 Recreation benefits

What is recreation?

The Macquarie Dictionary defines recreation as "A pastime, diversion, exercise, or other resource affording relaxation and enjoyment". However, as most surveys on activities undertaken by people in Australia do not ask about relaxation or enjoyment associated with the activity, it is very difficult to determine from the available data whether an activity is recreation or not.

For example, in the 1992 Time Use Survey, gardening is classified as unpaid work, rather than as recreation. However, another survey has estimated that 81% of Victorians who garden at least once a month either enjoy or greatly enjoy gardening (ABS 1994, unpub.). While many people get a great deal of pleasure from their paid or unpaid work, these activities are generally excluded from analyses of recreation.

In the present analysis, recreation is defined by a list of activities generally associated with discretionary time spent on leisure or entertainment. This approach does not consider whether or not an activity is enjoyable.

Benefits from recreation

There is a very large range of activities that people undertake for recreation, and the benefits they receive from these activities are equally diverse. Some of these benefits are relaxation, personal development, improved health, and enjoyment (Howat et al. 1992).

Analysis of recreation benefits is useful for planning and managing recreational sites, such as National parks. It is also useful for health research, to develop recreation strategies for better health.

Some insight into one reason people select an environmental site for recreation can be gained by examining why people use botanical gardens. These data cannot be extrapolated to explain why people select other environmental sites.

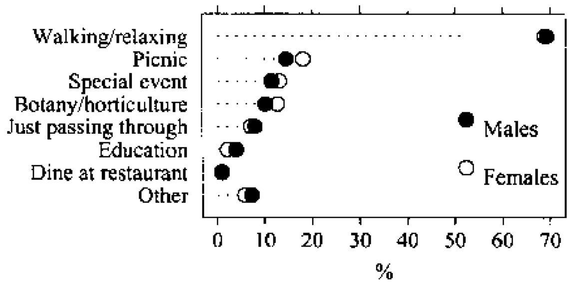
An ABS survey has found that, of the 39% of people who visited botanical gardens in the year to June 1995, almost 7 out of 10 gave walking or relaxing in pleasant surrounds as a key reason (see Figure 3.1.1). Some of the other survey responses also reflect the major attraction of the Botanical gardens as a pleasant place. For example, selecting the botanical gardens as a site for a picnic or special event often reflects their recreational potential.

Environmental recreation

While all activities can, to some degree, have an environmental component, many are not directly associated with the environment. There are no generally accepted criteria to determine whether an activity is environmental or not.

Watching television at home is the most popular recreational activity in Australia. However any links to the environment through the transmission of television waves, the manufacture

3.1.1 Reason visited botanical gardens (a), 1995



(a) People who visited botanical gardens in previous 12 months. People may visit gardens more than once, or for more than one reason. Therefore components will not add to total.
Source: ABS Population Survey Monitor 1995, unpub.

3.1.2 Environmental components of selected leisure activities

Environmental component and activity (b)	Participation rate (a) 1986 %	1991 %
No direct environmental component		
Watching TV at home	93	94
Reading	65	70
Uses environmental processes		
Gardening	40	41
May take place in a natural environment		
Walking	31	28
Driving	19	20
Walking the dog	13	15
Visiting parks	9	11
Involves relating to the natural environment		
Art, photography, writing etc away from home	3	4
Nature sketching, bird watching	1	3

(a) Participation by people aged 14 years and over, in the week prior to the survey in February.
(b) Activities are only selected if they were undertaken for pleasure. Not all leisure activities were selected, so this list is not exhaustive.
Source: DASETT 1991.

of television sets, or being in the built environment, is tenuous.

Other activities shown in Table 3.1.2, such as gardening, directly use environmental processes and resources as part of the activity. Other common activities such as walking or driving for recreation may, in some instances, occur in a natural environment.

Some of these activities may also produce pressures on the environment (discussed in Section 9.4).

3.1.4 Time spent per day on selected activities, 1992

Activity	Participation rate %	Average time spent: By participants h:min	By all people h:min
All recreational activities (a)	98.4	5:47	5:42
Indoors	97.9	4:49	4:43
Outdoors	22.3	1:46	0:24
Walking for exercise	7.5	0:51	0:04
Fishing, bushwalking etc	7.0	1:53	0:08
All activities	100.0	24:00	24:00
Indoors	99.9	21:03	21:01
Outdoors	63.4	1:59	1:15

(a) Social and leisure activities.
Source: ABS Time Use Survey 1992, unpub.

3.1.3 Open space needs for recreational activities of specific age groups

Age	Open space need
0–14	Provision of small parks with play equipment within walking distance of users. Formal playing fields and areas for informal sport. Fullest possible range of other sporting facilities, e.g. swimming pools.
	Access to large natural and/or parkland areas for passive pursuits.
15–19	Provision of formal playing fields and areas for informal sport. Wide range of recreational opportunities. Fullest possible range of other sporting facilities.
20–24	Provision of formal playing fields and areas for informal sport. Wide range of recreational opportunities.
	Access to large natural and/or parkland areas for passive pursuits.
25–29	Provision of formal playing fields and areas for informal sporting facilities.
	Versatile areas that provide for a wide range of recreational opportunity.
	Access to natural and parkland areas
30–39	Provision of demand facilities, e.g. tennis and golf.
	Access to sporting areas and playing fields and to large natural areas and parkland areas.
40–59	Provision of local parks and demand facilities.
	Access to large natural areas and parkland areas and to sporting facilities.
60+	Provision of demand facilities, especially bowls. Small parks in vicinity of users.
	Access to large natural areas and parkland areas.

Source: NSW Department of Planning, cited in Gilpin 1990.

Table 3.1.3 shows that people have recreational needs from the environment throughout their lives. While these needs differ between age groups, and between individuals, people of all ages have a need for outdoor recreation and, for most ages, large natural areas are an important recreational need.

While Table 3.1.2 lists only a selected range of recreational activities, it shows that a large part of society gets recreational benefits from the environment.

Time spent on recreation

The 1992 ABS Time Use Survey found that people in Australia spent an average of 5 hours, 42 minutes a day on recreation (Table 3.1.4). Every day, almost all of them (98%) undertook some recreation. However, only 22% had any outdoor recreation on a given day. These people spent an average of 1 hour and 46 minutes on outside recreation.

3.1.5 Time spent on recreation outdoors (a), 1992

Characteristic	Participation rate %	Time spent by participants Hours:mins	Proportion of all recreation %
Sex			
Males	23.6	2:08	8.8
Females	21.0	1:22	5.1
Section of State			
Capital	20.6	1:42	6.1
Other Urban	24.1	1:52	7.7
Rural	30.1	1:51	10.4
Age			
15–24	25.8	2:26	10.3
25–34	20.6	1:33	6.2
35–44	20.0	1:45	7.4
45–54	19.4	1:20	5.1
55–64	22.3	1:32	5.7
65–74	27.2	1:39	6.0
75+	23.0	1:11	3.5
All persons	**22.3**	**1:46**	**6.9**

(a) All social and leisure activities undertaken outdoors. Excludes activities undertaken while in transit.
Source: ABS Time Use Survey 1992, unpub.

On average, people in Australia spent about 5% of their day (one and a quarter hours) outdoors, and 7% (24 minutes) of their recreation time outdoors.

For some recreational activities, being outside is an integral part of the activity, as the environment is providing some of the benefit associated with the activity. Examples include bushwalking, fishing, playing sport, or thinking and relaxing. For other activities, such as socialising or conversing, the location may be incidental to the recreational benefit. Using this distinction to indicate environmental activities is arbitrary; it treats playing tennis outdoors as an environmental activity, while playing tennis indoors is not. Despite these problems, this analysis gives some indication of environmental recreation.

Table 3.1.5, based on the results of the 1992 Time Use Survey, shows that participation in all forms of outdoor recreation is highest among older people (65–74 year olds), with 27% participating. Younger people (15–24 year olds) also have high participation rates. The 26% of 15–24 year olds who participated in outdoor recreation on a given day, spent an average of nearly two and a half hours on it.

Outdoor recreation is closely linked to geographic location. People living in capital cities have much less outdoor recreation than those in other urban areas, or those in rural areas. To some extent this probably reflects access to indoor recreational facilities, such as cinemas.

Only 18.6% of Victorians participated in outdoor recreation, the lowest percentage of the 5 largest States, for which survey data are separately available. Only 5% of Victorian recreation was undertaken outdoors.

3.1.6 Recreational fishing, 1992

State	Participation rate (a) %	Recreational catch tonnes	Annual catch per household (b) kg	Recreational fishing of total catch %
NSW	14.2	6 586.3	22.2	21.7
Vic.	15.0	5 173.1	22.0	25.9
Qld	22.8	7 284.3	29.6	21.5
SA	21.6	4 755.5	39.3	29.4
WA	28.0	5 192.9	30.7	10.9
Tas.	23.8	1 191.1	29.3	3.1
NT	29.5	471.4	30.4	13.7
ACT	15.6	288.6	18.5	100.0
Aust.	**18.3**	**30 943.2**	**27.1**	**12.3** (c)

(a) Proportion of households in which one or more member caught seafood for home consumption in the year to April 1992.
(b) Of households participating in recreational fishing.
(c) Total catch includes commercial catch from Commonwealth fisheries. Recreational fishing accounts for 19.4% of the total catch from fisheries under State jurisdiction.
Source: ABS 1992 (7110.0).

Fishing

Fishing is a very popular activity in which the recreational benefit comes primarily from environmental elements. However, recreational fishing can also place pressure on the environment in sensitive areas (discussed in Section 9.4).

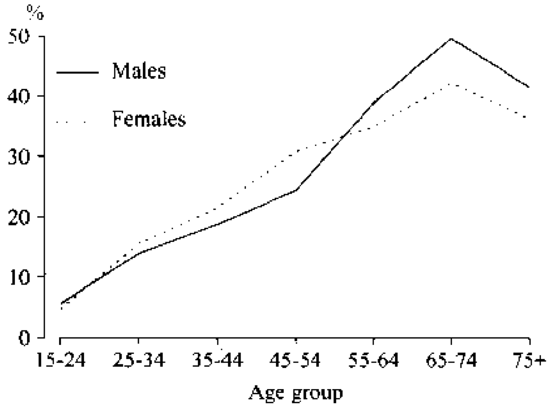
An ABS survey in April 1992 found that 18% of households included people who had undertaken recreational fishing in the previous 12 months (see Table 3.1.6). The highest participation rates were in the Northern Territory and Western Australia, but South Australians who fished had the greatest success, averaging catch of 39kg per year per fishing household.

In South Australia, this fishing accounted for 29% of the State's total fish catch. Whether Australia's fisheries could support a level of harvesting of this order is discussed in Section 6.2.

Gardening

Gardening is an activity which uses environmental processes more than almost any other activity. Gardens can be environmentally positive. For example, gardens which attract local

3.1.7 Proportion of people gardening on an average day, 1992



Source: ABS Time Use Survey 1992, unpub.

fauna or gardens of sustainable horticulture have environmental benefits.

However gardening can also introduce weeds into an area which then invade natural bushland. Use of water, fertilisers and pesticides can also have negative impacts on the environment (see section 1.1 and 6.5).

As indicated at the outset, an ABS survey has found that 81% of Victorians who garden at least once a month enjoy (46%) or greatly enjoy (35%) gardening (ABS 1994, unpub.). On the basis of such results it can reasonably be regarded as a recreational activity.

The 1992 Time Use Survey found that each day 22% of people in Australia did some gardening. Not only are older people more likely to garden, as Figure 3.1.7 shows, but when they garden they spend much longer doing it.

There were similar proportions of men and women gardening in each age group. However, men spent an average of 50% more time in the garden than women, a ratio which was relatively constant across all age groups.

The survey found that ethnic background affects the type of leisure that people in Australia undertake. For example, Australians born in Italy, the Former Yugoslav Republics, or the Netherlands, spent about twice as much time gardening as Australian born people, while New Zealand and Vietnamese born Australians spent significantly less time gardening. This in part reflects the age structure of these populations, but it primarily reflects cultural recreational choices.

National park visits

An ABS survey found that 63% of people visited National or State parks in the 12 months to May 1992. Table 3.1.8 shows that there were significantly higher proportions among people from the Northern Territory and Western Australia. While proximity of National parks to population centres may be part of the explanation, it is probably a relatively minor factor, given the distribution of National and State parks around the capital cities. In all States

3.1.8 People who visited National or State parks, 1992

	Males	*Females*	*Persons*
State	%	%	%
NSW	64.1	61.8	62.9
Vic.	62.8	58.5	60.6
Qld	62.8	60.7	61.8
SA	66.6	63.1	64.8
WA	69.7	66.4	68.0
Tas.	69.2	62.3	65.7
NT	81.0	67.9	74.7
ACT	63.2	62.4	62.8
Australia	**64.6**	**61.4**	**62.9**

Source: ABS Environmental issues survey 1992, unpub.

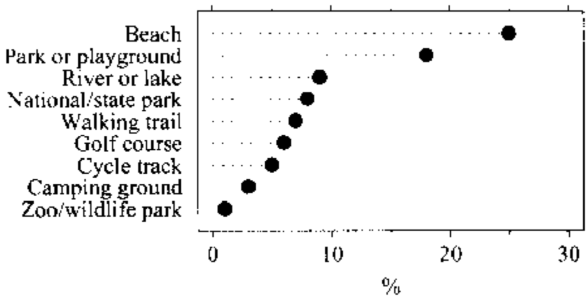
3.1.9 Activities in NSW National Parks, 1994–95

	Winter	*Summer*
Activity	%	%
Look at scenery	79	79
Get away from it all	48	49
Picnic/BBQ	38	38
Short walk (less than 2 hours)	32	36
Scenic drive	26	28
Bird watching/nature activity	25	27
Water activities	9	35
Day walk (more than 2 hours)	15	26
Historic features	15	16
Adventure	13	14
Fishing	9	15
Jogging/exercise	9	11
Educational focus	7	8
Visit caves	8	7
Visit Aboriginal features	7	6
Skiing/snow activities	12	1
Rock climbing/canyoning	5	3
Cycling	3	4
Organised ranger activity	3	4
4 Wheel Driving	4	3
Over night walk	2	2
Painting	0	2
Horse riding	1	1

Note: This survey had a very high non-response level. Therefore numbers are subject to an unacceptably high risk of bias. These numbers should be used with caution.

Source: NSW NPWS 1995.

3.1.10 People using (a) selected environmental facilities for recreation, February 1991



(a) In previous month.
Source: DASETT 1991.

and Territories, men were more likely to visit National or State parks than women.

Facilities used for recreation

While National parks and other nature reserves are important sites for recreation, Figure 3.1.10 shows that the most popular environmental site for recreation is the beach, at least in summer. 25% of people in Australia went to the beach in the month of February 1991, about three times the proportion using rivers or lakes, or National or State parks. While beach usage would be lower at other times of the year, this does indicate the importance people in Australia place on the beach as a recreational environment.

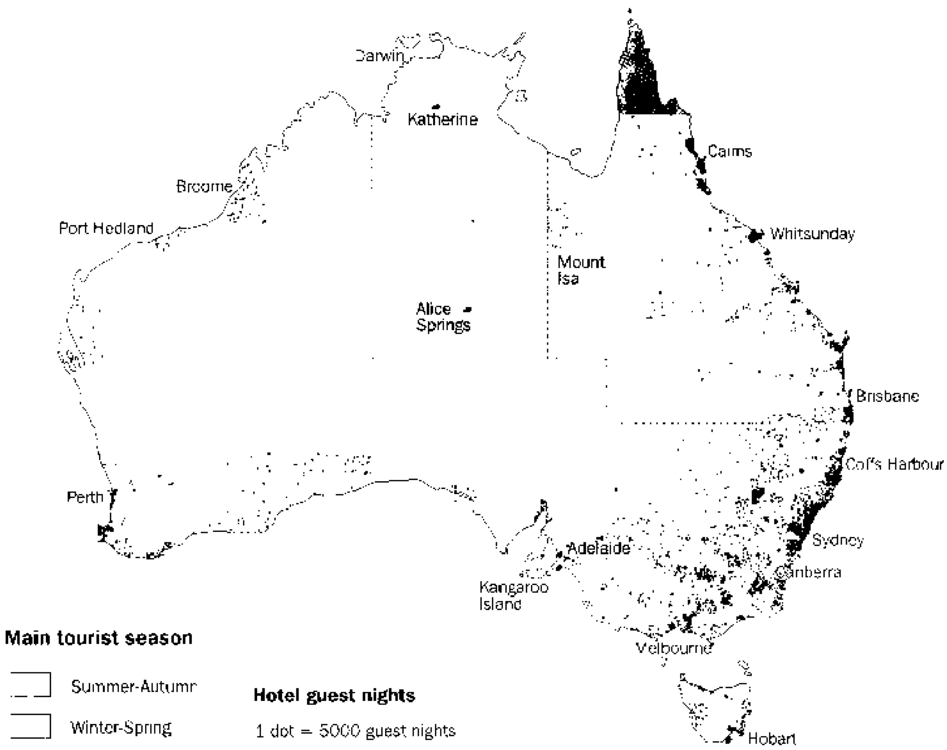
Many environmental sites support a range of recreational activities. For example Table 3.1.9 identifies 23 reasons why people use New South Wales National Parks. Many of these activities are complementary; a person may undertake many activities, such as looking at scenery, getting away from it all, picnicking and having a short walk, possibly all in the one day.

However, some activities may, under some circumstances, intrude on the recreational activities of others. This may occur directly; for example four wheel driving may disturb some people trying to get away from it all. This conflict may also occur indirectly. For example, the infrastructure developed for Alpine skiing may affect some people who want to look at scenery.

Where is recreation undertaken?

People undertake most of their recreation at home, with activities such as watching television. However, when people undertake recreation away from home, they usually tend not to go very far. While 57% of people in Australia aged 15

3.1.11 Guest nights in hotels and motels (a), 1994–95



(a) Grey areas represent SLAs with less than 3 hotels, for which data cannot be released because of confidentiality constraints. These areas contain 15% of guest nights. The Gold Coast is most under-represented, as its hotels are found in a large number of small SLAs.
Note: Dots are randomly distributed across SLAs to represent the guest nights in those SLAs. They do not reflect the actual location of hotels and motels. Main tourist season refers to the 6 months with the majority of tourist nights. Summer – Autumn refers to January to June, while July to December is classified as Winter – Spring.
Source: ABS Survey of Tourist Accommodation, 1995 (8635.0).

years and over daily undertake recreation away from home (Povah & Williams, 1994), this is usually not very far from home. Therefore, the distribution of recreation closely follows the distribution of population across the country.

While tourism does not account for a high proportion of recreational activities it is significant, and its distribution is different to the distribution of the population (this can be seen by comparing the maps in Figures 3.1.11 and 8.1.7).

The map in Figure 3.1.11 only shows the distribution of guest nights in hotels and motels with facilities. It excludes large amounts of tourist activity such as day trips, and people camping, or staying in caravans or with friends or relatives. Different types of accommodation have different distributions. However, hotel guest nights give an indication of the general pattern of tourist activity in Australia.

In 1994–95, Australian residents and overseas visitors spent 62 million nights in Australian hotels. 43% of these were in the capital cities.

However there was also significant tourist activity in other areas around the country, especially along the Queensland coast, and throughout the Murray-Darling Basin.

When is recreation undertaken?

Some recreational activities, such as alpine skiing and beach usage, have distinct seasonal patterns, and are also very regionally specific activities. The annual pattern of when people undertake recreation largely reflects the types of recreational activities they pursue.

Using hotel guest nights and holiday arrivals from overseas as indicators of general patterns in tourism, Figure 3.1.11 and Table 3.1.12 show that tourism has a strong seasonal distribution.

The difference between the seasonal patterns of overseas visitors and all visitors in each State is due to a number of factors:

- Hotels and motels are used by people other than tourists, such as people on business trips, conferences etc;
- Local tourists may only have financial resources for a local holiday, so they may visit areas which are not in their peak season. However international tourists have a wider choice of destinations, and so may select an area only if it is in its peak season;
- The attractions that draw local tourists are not necessarily the same as those that attract overseas tourists;
- The data refer to different periods. Any underlying growth over this period will tend to overestimate seasonal attendance at the end of the year, and underestimate it at the beginning of the year; and
- Some overseas holiday makers arrive in one season and spend most of their holiday in subsequent seasons. However, with only 4% of holiday makers staying more than 3 months, this is only a minor factor.

29% of people who came to Australia in 1994 for a holiday arrived between October and December (Spring), while only 21% arrived between April and June (Autumn).

3.1.12 Annual recreational activity by season

	Hotel guest nights (a), 1994–95						*Short term holiday arrivals from overseas, 1994*					
	Jan–Mar	*Apr–Jun*	*Jul–Sep*	*Oct–Dec*	*Total*		*Jan–Mar*	*Apr–Jun*	*Jul–Sep*	*Oct–Dec*	*Total*	
State	*%*	*%*	*%*	*%*	*'000*	*%*	*%*	*%*	*%*	*%*	*'000*	*%*
NSW	25.2	23.8	25.4	25.6	21 149	34.3	27.5	21.0	24.3	27.1	890	42.2
Vic.	27.2	23.7	23.3	25.8	9 370	15.2	30.1	20.4	19.4	30.0	202	9.6
Qld	23.4	23.2	27.7	25.7	17 424	28.2	24.2	21.6	24.8	29.4	748	35.5
SA	26.3	24.1	23.3	26.3	3 259	5.3	30.8	17.6	21.6	30.0	27	1.3
WA	25.4	26.2	25.2	23.3	5 238	8.5	25.2	21.4	22.0	31.4	197	9.3
Tas.	19.5	25.8	32.6	22.1	1 853	3.0	35.3	14.1	8.2	42.4	9	0.4
NT	30.8	24.2	18.9	26.0	1 992	3.2	15.1	17.4	36.5	31.1	30	1.4
ACT	25.3	25.1	25.1	24.6	1 436	2.3	21.1	21.1	29.6	28.2	7	0.3
Aust.	**25.1**	**23.9**	**25.6**	**25.4**	**61 722**	**100.0**	**26.3**	**21.1**	**23.9**	**28.7**	**2 109**	**100.0**

(a) Guest nights in hotels motels and guest houses with facilities in room.
Source: ABS (3402.0); ABS 1995 (8635.0).

Nationally, Spring is the peak season for both domestic and overseas tourism. Overseas arrivals peak in Spring in Queensland, Western Australia, and Tasmania. On the other hand domestic tourism peaks in Spring in New South Wales, Victoria, South Australia and Western Australia.

Summer and Autumn are, generally, the peak seasons in southern areas of the continent, especially around the coast, while northern and inland areas attract more tourists in Winter and Spring.

The effect of latitude on tourism patterns is quite distinct along the east coast. The New South Wales south coast is predominantly a southern tourist destination, with the Bega Valley receiving 55% of its tourists in Summer – Autumn.

This proportion falls further up the coast, as Winter – Spring tourism increases. In Tweed, on the north coast of New South Wales, only 47% of tourism is in Summer – Autumn, largely because people from Sydney head north in these cooler months.

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3.2 Human health benefits

In addition to the recreational benefits derived from the natural environment described in the previous section, the health and well-being of people is dependent upon these natural resources. Many of our medicines, and all of the food we eat, are derived from products of the environment. All Australians use the water resources required for survival, and most Australians derive food from the domesticated components of biological diversity. The harvesting of these resources is discussed elsewhere (Sections 6.2 Fish and other aquatic resources; 6.3 Wildlife; 6.4 Agricultural plants and animals; and 6.5 Water consumption, limits and management).

This section examines, specifically, foods and medicines derived from Australia's endemic biological diversity. As the use of these resources has been predominantly by the Indigenous Australians, the emphasis is on the indigenous use of Australia's flora and fauna.

3.2.1 Composition of selected Aboriginal plant foods, per 100g edible portion, raw unless otherwise indicated

Species	Description	Energy kJ	Water g	Protein g	Fat g	Carbo-hydrate g	Fibre g	Ash g	Calcium mg	Iron mg	Vit C mg
Acacia coriacea (Dog wood, Wiry wattle)	Dry seed	1 240	4.1	20.9	9.3	33.8	28.2	3.7	318	7.7	
A. tenuissima	Seed	1 469	1.6	25.0	15.6	29.2	25.7	2.9	144	6.8	
Ampelocissus acetosa (Native grape)	Fruit	534	73.1	2.4	0.5	34.3(T)	2.5	0.9	55	1.3	5.0
Araucaria bidwillii (Bunya pine)	Nut	856	43.9	11.0	1.0	39.6	3.5	1.0	7	2.1	na
Buchanania obovata (Wild plum)	Fruit	318	77.8	1.5	0.5	21.1(T)	3.9	0.8	67	1.7	38.0
Calandrinia balonnensis (Broad-leaved parakeelya)	Seed	1 822	5.4	14.6	17.0	55.4		7.3	86		–
Capparis sp. (Wild orange)	Fruit	647	42.0	3.7	4.9	25.2	21.7	2.5	48	2.9	11.0
Chenopodium rhadinostachyun (Green crumbweed, Saltbush	Seed	1 431	7.0	14.4	2.3	65.7(T)		10.5			
Curculigo ensifolia (Grass potato)	Root	300	64.7	2.2	0.3	16.5	11.4	3.5	261	50.0	na
Cyperus bulbosus (Bush onion, Nut grass)	Bulb	674	49.9	2.6	0.8	37.5	5.7	3.5	47	7.0	0.0
Dioscorea bulbifera (Round yam, Cheeky yam)	Tuber	357	70.8	2.7	0.2	25.8(T)	9.8	0.6	19	3.1	78.0
Eragrostis eriopoda (Woollybutt grass)	Seed	1 333	5.2	17.4	2.3	58.2	13.2	3.7	235	31.0	
Eriosema chinense (Bush potato)	Root	401	66.9	2.2	0.5	29.2(T)	8.9	3.5	192	49.5	5.0
Ficus platypoda (Rock fig)	Fruit			5.8	9.6				4 000		
Fimbristylis sp. (Fringe-rush)	Seed	1 713	3.8	13.9	20.9	40.8(T)		20.3	46		
Hicksbeachia pinnatifolia (Monkey nut)	Nut	666	61.0	3.8	2.8	31.4(T)	2.5	0.9	146	2.3	na
Ipomoea costata (Bush potato, Desert yam)	Root	264	84.3	0.7	0.2						3.0
Livistona australis (Cabbage tree palm)	Bud/heart	69	85.7	2.2	0.5	7.6(T)	6.1	1.2	20	0.6	BDL
Microseris scapigera (Yam daisy)	Tuber	249	75.6	1.7	0.8	21.0(T)	9.1	0.9	25	5.0	na
Nymphaea gigantea (Blue waterlily)	Bulbs	563	55.3	2.1	0.3	32.1	na	na	40	22.2	2.0
Pandanus spiralis (Screw palm)	Kernel	2 403	3.0	25.9	46.8	23.3(T)	21.3	1.7	62	6.6	BDL

3.2.1 Composition of selected Australian aboriginal plant foods, per 100g edible portion, raw unless otherwise indicated *(Continued)*

Species	*Description*	*Energy* kJ	*Water* g	*Protein* g	*Fat* g	*Carbo-hydrate* g	*Fibre* g	*Ash* g	*Calcium* mg	*Iron* mg	*Vit C* mg
Panicum australiense (Australian native millet)	seed	1 650	3.1	10.6	2.4	–	–	–	–	–	3.0
Parinari nonda (Nonda plum)	fruit	222	78.3	1.0	0.9	20.0(T)	12.0	1.1	91	1.5	1.0
Persoonia falcata (Geebung)	fruit	231	66.2	3.2	2.3	26.4(T)	31.0	1.1	48	3.6	4.0
Planchonella pohlmaniana (Big green plum)	fruit	314	67.6	0.7	0.2	18.4	12.3	0.8	na	1.1	na
Portulaca oleracea (Pigweed)	seed	874	5.6	18.5	1.1	32.4	30.4	12.0	181	275.0	–
Santalum acuminatum (Quandong, Native peach)	fruit	410	67.7	2.8	–	22.6	4.5	2.4	59	1.1	–
Solanum centrale (Bush raisin)	fruit (dried)	1 273	2.0	8.6	1.1	67.9	15.5	4.9	78	13.1	0.0
Solanum chippendalei (Bush tomato)	fruit	339	78.6	1.1	0.7	18.4(T)	–	1.2	54	2.0	–
Solanum ellipticum (Desert raisin)	fruit	213	86.0	2.6	1.8	5.7(T)	–	1.3	35	–	–
Syzygium sp. (Native apple)	fruit	nd	92.8	0.3	3.3	na	na	na	na	na	BDL
Tamarindus indica (Tamarind)	fruit	nd	19.3	5.6	1.9	na	na	na	120	1.1	BDL
Terminalia carpentariae (Wild peach)	fruit	290	80.6	0.8	0.3	16.7	na	0.9	81	4.4	1 141
Uvaria sp. (Custard finger)	fruit	397	75.3	2.3	0.5	21.2	na	0.7	37	1.0	na
Vigna lanceolata (Pencil yam)	root	254	77.2	1.5	0.2	13.8	4.8	2.5	48	21.5	-
Vitex glabrata (Black fruit)	fruit	362	69.5	0.9	0.2	27.9(T)	6.6	1.0	31	0.9	na

(T) = average *total* carbohydrate content (that is including fibre of food) has been included in calculation.
BDL = below detectable limit.
Source: Brand Miller, James & Maggiore 1993; Brand & Cherikoff.

Food

Plant

An estimated five thousand plant species have been used as food by humans. However, the majority of the world's population today are fed by less than twenty species.

Nutritional data on some Australian native foods are presented in Table 3.2.1. This list presents only a sample of the known edible plant species in Australia.

Europeans in Australia have generally shown little interest in native plants as food, although there is a growing interest by the wider community in traditional Aboriginal foods. For example, the seeds of elegant wattle (*Acacia victoriae*), readily available in the wild, are used most commonly at present in the 'bush tucker' industry (ECOS 1995), along with foods such as the native macadamia and quandong (DEST 1993).

Those same native plants have provided food for Aboriginal Australians for at least 40,000 years (Brand & Cherikoff 1985). Today, however, Aboriginal Australians depend on alternatives and, with few exceptions, Aboriginals are part of the resource-consumption patterns and economy of the rest of Australia (Meek & O'Brien 1992).

Foods indigenous to the southern parts of Australia are less well represented than foods of central and northern Australia. This is most likely the result of a gradually diminishing range of indigenous Australian species, and the loss of Aboriginal knowledge of how they were prepared (Brand Miller, James & Maggiore 1993).

Seeds are valued food items largely because they are typically more nutrient dense than other plant parts. Some 50 of the 800 species of Acacia were used by Aboriginals for food. Many acacia seeds are outstanding in their nutrient content, being much higher in energy, protein and fat than crops such as wheat and rice, or even some meats, and having high levels of nitrogen typical of leguminous plants (ECOS 1995).

In general the Australian native plants are richer sources of minerals such as calcium, and trace elements such as iron, than similar cultivated plants. The levels in some plants are outstanding; for example *Portulaca oleracea* seeds were found to have about 20–30 times the recommended daily requirement (Brand & Cherikoff 1985).

Many seeds are almost twice as high in protein as the common cereals and often many times higher in fat. The fruits have higher protein, fat and carbohydrate levels than cultivated fruits. The rootstocks have compositions similar to those of the potato or carrot, although mineral content may be higher (Brand & Cherikoff 1985).

Meat, fish and seafood

Australia has important native fish and crustacean harvesting industries (DEST 1993). The composition of some of these local products is shown in Table 3.2.2, and the harvesting of these products, for both local consumption and export, is discussed in Section 6.2.

The macropods — kangaroos and wallabies — used to be the largest source of terrestrial prey available to Aboriginals. In certain areas of Australia they are still hunted for food and fibre as they were traditionally (Meek & O'Brien 1992). Kangaroos and wallabies were also a welcome source of food for early European settlers, but once agricultural enterprises expanded they were perceived as a threat to production because they compete for fodder (Ramsay 1994).

Today, however, they are also harvested by professional shooters on a much larger scale to provide meat and skins to more recently developed markets (i.e. meat for pet food, human consumption, and hides; see Section 6.3 Wildlife).

Table 3.2.2 presents nutritional data for some other Australian animals eaten primarily by the Aboriginals. These include muttonbirds, crocodiles, emus and magpie geese. Crocodile meat, and eggs, were used as a food source by Aborigines for some 20–40,000 years prior to European contact. The annual harvest for crocodile meat by Aboriginals today is thought to be about 150 animals (Meek & O'Brien 1992). In addition, sales of crocodile meat to the restaurant trade in Australia have flourished since the late 1980s (see Section 6.4 Agricultural plants and animals) (Ramsay 1994).

Magpie geese found on Aboriginal lands in the Northern Territory and Cape York are a continuing important subsistence food for Aboriginals, who harvest both the geese and their eggs (Meek & O'Brien 1992).

A few muttonbirds are sold through specialist meat distributors in mainland Australia, but most

3.2.2 Composition of selected Australian meat, fish and shellfish foods, per 100g edible portion, raw unless otherwise indicated

		Energy	*Water*	*Protein*	*Fat*	*Carbo-hydrate*	*Ash*	*Calcium*	*Iron*	*Vit C*
Species	*Description*	*kJ*	*g*	*g*	*g*	*g*	*g*	*mg*	*mg*	*mg*
Anseranus semipalmata (Magpie Goose)	Flesh of bird	614	68.5	24.2	4.6	2.0	na	7.0	3.5	2.0
Anseranus semipalmata (Magpie Goose)	Egg	878	70.3	8.5	19.1	1.7	na	80.0	2.3	2.0
Emu	Thigh	460	74.0	23.3	1.7	0.0	na	0.3	5.0	0.0
Crocodylus porosus and C. johnstoni (Crocodile)		436	75.9	21.1	1.9	0.0	1.0	0.0	na	na
Puffinus tenuirostris (Muttonbird)	Cooked skinless flesh	1100	55.1	23.9	18.7	0.0	1.0	46.0	4.5	0.0
Macropus robustus (Common walleroo)	Flesh	374	77.8	19.5	0.4	1.7	na	10.0	12.7	2.0
Macropus sp. (Kangaroo)	Flesh (flap)	nd	71.6	25.8	2.7	na	1.1	2.0	12.8	na
Nerita lineata (Shellfish)		465	71.3	17.4	2.7	4.3	4.3	360.0	23.8	na
Pinctada margaretifera (Black Lip Oyster)		215	86.8	7.4	1.3	2.5	na	50.0	32.3	2.0
Scylla sp. (Mud crab)		372	76.9	18.0	1.1	1.7	2.1	90.0	1.6	na
Telescopium telescopium (Shellfish, marine)		464	66.9	16.8	1.2	8.5	5.1	802.0	20.4	5.0
Velesunio ambiguus (Freshwater mussel)		303	64.4	5.4	1.4	8.7	1.4	124.0	16.6	na
Fish		621	66.4	20.0	7.3	0.9	5.7	140.0	na	na
Rock oysters		409	80.2	8.6	5.2	4.4	1.6	160.0	7.5	na
Cossidae sp. (Witchetty grub)		1027	61.3	16.2	28.6	4.6	na	9.0	3.1	3.0

Source: Brand Miller, James & Maggiore 1993.

3.2.3 Persons involved in hunting, fishing or gathering bush food

Usual weekly hours	Hunting, fishing or gathering bush food	All voluntary work (a)
	%	%
Less than 1	6.3	8.8
1–5	40.2	46.7
6–10	27.0	20.9
11–15	10.0	6.7
16–24	9.2	6.2
25–34	2.9	2.7
35 +	2.7	4.4
Not stated	1.8	3.6
Total	**100.0**	**100.0**
	'000	'000
Total	**19.2**	**49.5**

(a) 15 years and over.
(b) Hunting, fishing or gathering bush food .Refers to voluntary work.
Source: ABS 1995 (4190.0).

birds are sold to retail outlets in Tasmania as a fresh, salted or cooked product (Ramsay 1994, p67).

Although hunting, fishing and gathering are still practised by Aboriginals, nomadism and the utilisation of wild animals are less prevalent than they used to be. According to the National Aboriginal and Torres Strait Islander Survey 11%, or just over 19,000 people, reportedly engaged in hunting, fishing and gathering (Table 3.2.3). This was the predominant activity of persons engaged in voluntary work.

Medicine

Traditional use

Although Australia's first colonists did experiment with native plants in the treatment of some conditions such as Native Currants for relief from scurvy, and ruby-red resin from eucalypts for the relief of dysentery, native plants have been used mostly by the Aboriginals for therapeutic purposes. Table 3.2.4 lists a number of native plants used by Aboriginals to treat some common medical complaints.

This table presents only a subset of plants used medicinally. For example, at least 70 native plants were used by central Australian Aboriginal people for medicinal purposes (DEST 1993, p18).

Furthermore, a lot of information on medicinal plants may already have been lost, especially as

3.2.4 Native plants used for medicinal purposes by Aboriginals, historically & currently

Medicinal use	*Species*	*Description*
Tonics; vitamin deficiencies; blood purifiers	*Alstonia constricta* (Quinine bush); *Centipeda cunninghamii* (Sneezeweed); *Centaurium spicatum* (Spike centaury); *Nauclea orientalis* (Leichardt tree); *Smilax glyciphylla* (Native sarsaparilla); *Nauclea orientalis* (Leichardt tree).	Bark of Quinine bush and Spike centaury popular tonics. Infusion of leaves of Native sarsaparilla are drunk as tea is reported as a tonic and general remedy. High vitamin C content prevents scurvy.
Toothache	*Buchanania obovata* (Wild plum); *Melaleuca cajuputi* (Small-leaved paperbark); *Ventilago viminalis* (Supplejack, Vine tree); *Casuarina equisetifolia* (Whistling tree);	Inner bark and sapwood of Wild plum and Whistling tree used for toothaches. Roots and bark of Supplejack mashed and soaked in water is good for toothache.
Headache	*Centaurium spicatum* (Spike centaury); *Melaleuca symphyocarpa* (Liniment tree); *Pterocaulon serrulatum* (Apple bush); *Tinospora smilacina* (Snake vine); *Eucalyptus microtheca* (Coolibah, Dwarf box).	Stem of Snake vine pounded and tied around head to relieve headaches.
Other analgesics; earache	*Litsea glutinosa;* *Melaleuca cajuputi* (Small-leaved paperbark); *Melaleuca symphyocarpa* (Liniment tree); *Tinospora smilacina* (Snake vine).	Leaves crumbled in hot water and liquid used as body wash for aches and pains; aroma inhaled for running nose or rubbed on chest for congestion.
Rheumatism; swellings; inflammations	*Centaurium spicatum* (Spike centaury); *Melaleuca cajuputi* (Small-leaved paperbark); *Melaleuca symphyocarpa* (Liniment tree); *Nauclea orientalis* (Leichardt tree); *Tinospora smilacina* (Snake vine); *Ventilago viminalis* (Supplejack, Vine tree); *Ficus opposita* (Sandpaper fig).	Decoction of Spike centaury applied for inflammation of genitals. Warmed leaves of Sandpaper fig placed over swollen areas of body. Roots and bark of Supplejack mashed and soaked in water is good for rheumatism and swellings.
Eye disease; treatment of sore eyes	*Buchanania obovata* (Wild plum); *Centipeda thespidioides* (Sneezeweed); *Litsea glutinosa;* *Ficus opposita* (Sandpaper fig).	Infusion of Wild plum and soaking inner bark of Sandpaper fig were popular eyewashes. Native 'Sneezeweed' infusions were reportedly used for Sandy blight, an eye inflammation.

3.2.4 Native plants used for medicinal purposes by Aboriginals, historically & currently *(Continued)*

Medicinal use	*Species*	*Description*
Coughs and colds	*Casuarina equisetifolia* (Whistling tree); *Centipeda thespidioides;* *Melaleuca cajuputi* (Small-leaved paperbark); *Melaleuca symphyocarpa* (Liniment tree); *Pterocaulon serrulatum* (Apple bush); *Smilax glyciphylla* (Native sarsaparilla).	Aromatic plants feature prominently amongst species used to treat colds, headaches and clear congested breathing passages. The medicinal activity of several of these species probably relates to their cineole-rich leaf oils. 1,8-cineole reduces swelling of mucous membranes and loosens phlegm, making breathing easier.
Treatment of fever; diaphoretics	*Alstonia constricta* (Quinine bush); *Melaleuca cajuputi* (Small-leaved paperbark); *Nauclea orientalis* (Leichardt tree); *Pterocaulon serrulatum* (Apple bush).	Bark of Quinine bush particularly effective in treating fevers.
Bactericides; wounds, sores, ulcerstypics	*Alstonia constricta* (Quinine bush); *Eucalyptus gummifera* (Bloodwood); *Ficus opposita* (Sandpaper fig); *Litsea glutinosa;* *Pterocaulon serrulatum* (Apple bush); *Ventilago viminalis* (Supplejack, Vine tree).	Latex of Quinine bush used to cure infectious sores. Bloodwood exudation used with leaves and mud on wounds to stop bleeding.
Skin diseases, complaints	*Centaurium spicatum* (Spike centaury); *Eucalyptus gummifera* (Bloodwood); *Ficus opposita* (Sandpaper fig); *Litsea glutinosa;* *Tinospora smilacina* (Snake vine).	Milky sap of Sandpaper fig and exudation of Bloodwood used with some success for treatment of fungal diseases such as ringworm. External application of a decoction of the alkaloid-rich *Litsea glutinosa* used to treat scabies.
Stomach disorders; emetics; diuretics	*Nauclea orientalis* (Leichardt tree); *lyciphylla* (Native sarsaparilla).	Native sarsparilla used as a diuretic.
Diarrhoea; dysentery	*Casuarina equisetifolia* (Whistling tree); *Eucalyptus gummifera* (Bloodwood); *Ficus opposita* (Sandpaper fig); *Grewia latifolia.*	Infusion of Sandpaper fig and decoction from roots of *Grewia latifolia* used to treat diarrhoea.
Anthelmintics; treatment of internal parasites	*Melaleuca cajuputi* (Small-leaved paperbark).	Cajuput oil thought to be responsible for anthelmintic properties.
Bites; stings	*Nauclea orientalis* (Leichardt tree); *Tinospora smilacina* (Snake vine); *Eucalyptus microtheca* (Coolibah, Dwarf box).	Coolibah inner beaten and applied as poultice for snake bite. Analgesic properties of Leichardt tree and Snake vine alleviate side effects of snake bite and marine stings.
Venereal disease	*Eucalyptus gummifera* (Bloodwood).	Gum taken internally or dusted locally in powder form for venereal sores.
Other	*Centipeda thespidioides;* *Melaleuca cajuputi* (Small-leaved paperbark); *Centipeda cunninghamii* (Sneezeweed).	*Centipeda thespioides* poultice applied to sprained and jarred limbs. Small-leaved paperbark liquid from steeped leaves used in treatment of constipation. Liquid from boiled Sneezeweed drunk for tuberculosis.

Source: Lassak & McCarthy 1990.

the older generation of Aboriginals diminishes in number. For example, with only a few exceptions, the northern Queensland Aboriginals already rely heavily on western medicine (Lassak & McCarthy 1990, p14).

Of the estimated 44% of people found to have taken some health action in the two weeks prior to the National Aboriginal and Torres Strait Islander Survey, only about 8%, or just over 11,000 individuals, reported using bush medicine (Table 3.2.5). This compares with an overwhelming 72% of Aboriginal and Torres Strait Islanders who used medication (ABS 1995, 4190.0).

3.2.5 Health related actions taken by Aboriginal and Torres Strait Islander people (a)

	Location			
	Capital city	*Other urban*	*Rural*	*Total*
Type of action taken	*'000*	*'000*	*'000*	*'000*
Visited emergency/ outpatients clinic	4.8	11.0	8.0	23.8
Admitted to hospital	1.5	3.2	2.8	7.5
Consulted doctor	21.7	23.2	11.9	56.9
Consulted Aboriginal health worker	2.2	6.2	9.6	18.1
Consulted nurse	2.9	5.3	7.8	16.0
Used medication	33.8	40.1	23.5	97.3
Used bush medicine	**2.5**	**3.2**	**5.6**	**11.3**
Reduced daily activities	13.9	15.9	8.4	38.2

(a) Reference period = two weeks prior to NATSI Survey.
Source: ABS 1995 (4190.0).

3.2.6 Native plants with potential for use in medicinal plant industry

Species	*Location*	*Active constituent*	*Potential use*
Acacia ixiophylla	Southern Qld, central & northern NSW, S-W Aust.	Lower polymeric tannins from the phyllodes and twigs.	Show antitumour activity.
Bauerella simplicifolia (Scrub ash)	Central coastal NSW to north Qld	Acronycine, and other alkaloids.	Shows activity against certain tumours.
Bursaria spinosa (Blackthorn, Native box, Box thorn, Native olive, Sweet bursaria)	Widespread in all States as a weed. Not in arid areas	Leaves contain coumarin aesculin.	Used in treatment of lupus (ulcerative condition of the skin). Aesculin has been used as an ultraviolet radiation screen in suntan lotions.
Callitris columellaris (White cypress pine, White pine)	All mainland States. More often drier inland	Number of diterpenoid acids in resinous exudate.	Used by pharmaceutical industry for the coating of pills.
Callitris endlicheri (Black cypress pine, Black pine, Red pine, Scrub pine, Murray pine)	N-W Vic. through NSW into S-E Qld	Number of diterpenoid acids in resinous exudate Leaves contain an essential oil rich in geranyl acetate.	Used by pharmaceutical industry for the coating of pills.
Casuarina decaisneana (Desert oak)	Arid inland and sandhill country of WA, NT & far north SA	May contain bacteriostatic compounds.	Moderate inhibition in the growth of Staphylococcus aureus.
Duboisia leichhardtii (Corkwood)	Southern central Qld, Far Western Plains district of NSW	Leaves contain variable mixture of alkaloids, including hyoscyamine and scopolamine.	Pharmaceutically used alkaloids.
Duboisia myoporoides (Corkwood, cork tree)	Extends from Sydney along coast and tablelands of NSW to Cape York Peninsula, Qld	Leaves contain alkaloids including scopolamine and hyoscyamine.	Used by Aboriginals as narcotic. Leaf extracts useful in ophthalmic surgery (pupil dilating properties). Presently used as a source of scopolamine (hyoscine), a drug useful in the prevention of air and sea-sickness, and in the treatment of stomach ulcers.
Eriostemon trachyphyllus (Rough eriostemon)	Southern coastal NSW and S-E Vic.	Leaves contain up to 1% of the coumarin bergapten.	Bergapten is a skin sensitizer and has been used in cases of insufficient skin pigmentation such as leucoderma.
Eucalyptus citriodora (Lemon-scented gum, Lemon-scented spotted gum, Boabo)	Coastal Qld	Citronellol and citronellal present in oil in leaves Kino contains citriodorol.	Bacteriostatic activity towards *Staphylococcus aureus* Antibiotic.
Eucalyptus dives (Broadleaf peppermint)	Northern Vic., southern coastal NSW and adjacent tablelands	Piperitone-rich strain. Cineole-rich strain.	Used in manufacture of menthol — used in liniments and mouth washes - and thymol — a fungicide. Medicinal eucalyptus oil (see *E. globulus* below).
Eucalyptus globulus subspecies globulus (Tasmanian blue gum, Blue gum)	Tas. and southern Vic.	Leaf oil rich in 1,8-cineole	Used extensively in manufacture of cough medicines, liniments and the like for the relief of colds, muscular pain, rheumatism.
Eucalyptus macrorhyncha subspecies macrorhyncha (Red stringybark)	Extends from SA (rare) through Victoria and to northern NSW	Leaves contain between 6 and 24% of the drug rutin.	Ability to strengthen the walls of small blood vessels and capillaries (prevent nose bleeds).
Eucalyptus polybractea (Blue mallee)	Semi-arid interior	1,8-cineole present in oil.	Medicinal eucalyptus oil. Liniments for the relief of headcolds, rheumatism, muscular pain. Expectorant in cases of bronchitis (added to cough syrups).
Eucalyptus smithii (Gully gum, Gully ash, White top, Blackbutt peppermint)	Deep soils in gullies and alluvial flats; volcanic hills	1,8-cineole, main component of oil.	Medicinal eucalyptus oil (as above).
Eucalyptus youmanii (Youman's stringybark)	New England district of NSW as far north as Stanthorpe, Qld	Leaves contain 7 to 11% rutin.	Used pharmaceutically (see *E. macroryncha).*
Melaleuca linariifolia	Coast and coastal plateaux of NSW & southern Qld	Terpinen-4-ol in essential oil of one chemical form 1,8-cineole in oil of other chemical form.	Production of a bactericidal oil. Relief of headache.
Ochrosia moorei	Coastal rainforests of far northern NSW & southern Qld	Bark contains alkaloids ellipticine and 9-methoxyellipticine.	Exhibits tumour inhibitory properties.

3.2.6 Native plants with potential for use in medicinal plant industry *(Continued)*

Species	*Location*	*Active constituent*	*Potential use*
Ochrosia moorei	Coastal rainforests of far northern NSW & southern Qld	Bark contains alkaloids ellipticine and 9-methoxyellipticine.	Exhibits tumour inhibitory properties.
Solanum sp. (*S. capsiciforme* (Native pepper); *S. aviculare; S. laciniatum* (Kangaroo apple); *S. linearifolium* (Mountain kangaroo apple); *S. simile; S. symonii; S. vescum*	Widespread	Berries are a source of steroidal alkaloid salasodine.	Starting material for the synthesis of steroidal hormones.
Strychnos lucida (Strychnine bush)	Rocky outcrops from Cape York Peninsula to northern WA	Seed contains alkaloids brucine and smaller amounts of strychnine.	Used by pharmaceutical industry.
Templetonia egena (Broombush)		Sparteine as major alkaloid of whole plant.	Sulphate form has been used in cardiac arhythmia and in early stages of labour.

Source: Lassak & McCarthy 1990.

Medicinal plant industry

Another group of plants includes species that are not necessarily used medicinally, but the pharmacologically active components of which could be extracted and used by the pharmaceutical industry.

Table 3.2.6 lists a number of Australian plants with potential (or current) pharmaceutical uses, along with their active constituent.

In particular, a product of the Australian corkwood species, hyoscine (scopolamine), has been used to treat the effects of cancer therapy, among other uses (Low 1987); the kangaroo apples *Solanum aviculare and S. laciniatum*, provide salasodine, which may be chemically converted to the medicinally valuable drug cortisone, and other steroidal drugs (Lassak & McCarthy 1990, p196).

In Australia, not more than thirty plant species have been exploited commercially. Of these, about twenty are various species of *Eucalyptus*, yielding very similar medicinal oils rich in 1,8-cineole (Lassak & McCarthy 1990, p194).

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3.3 Perceived value of the environment

In a survey conducted by the ABS in June 1994 on people's perceptions about certain environmental problems (discussed in Section 2.3), 71% of respondents ranked environmental protection and economic growth as of equal importance, and a further 18% ranked environmental protection as more important, as illustrated in Table 3.3.1.

When compared to the results of a similar survey conducted by the ABS in May 1992, the change in ranking of the two objectives was barely significant overall. There was a marginal shift away from priority for the environment in some States.

As the survey questions were necessarily cast in somewhat simplified terms, the responses can only be regarded as indicative of general attitudes rather than of fully formed views.

3.3.1 Ranking of environmental protection and economic growth

	Most important factor: Environmental protection or economic growth							
	Environment protection		*Equally important*		*Economic growth*		*Undecided /no opinion*	
	1992	*1994*	*1992*	*1994*	*1992*	*1994*	*1992*	*1994*
State	%	%	%	%	%	%	%	%
NSW	19.5	17.8	68.8	69.3	6.7	7.8	5.0	5.1
Vic.	17.5	16.5	69.7	71.4	7.6	7.6	5.2	4.5
Qld	18.2	19.0	71.0	71.3	6.8	6.5	3.9	3.2
SA	20.9	18.7	70.5	73.7	4.6	5.4	4.0	2.2
WA	19.3	19.9	73.4	72.4	4.9	4.5	2.4	3.2
Tas.	13.4	12.9	76.8	75.8	6.5	7.7	3.2	3.6
NT	19.4	20.1	71.9	73.1	*5.9	5.5	*2.8	*1.3
ACT	24.4	22.2	70.0	69.1	*3.6	6.8	*2	1.9
Australia	**18.8**	**17.9**	**70.3**	**71.0**	**6.6**	**7.0**	**4.4**	**4.1**

Source: ABS 1993 (4602.0); ABS 1995 (4602.0).

3.3.2 Public opinion — Environment protection vs economic growth trade-off

Country	*Year of survey*	*Number of interviews*	*Priority to environmental protection* %	*Both are possible* %	*Priority to economic growth* %	*Don't know* %
Australia	**1994**	**13 412**	**18**	**71**	**7**	**4**
Australia	**1992**	**14 425**	**19**	**70**	**7**	**4**
USA	1990	1 223	71	na	19	10
Japan	1990	3 753	36	43	8	13
Finland	1989	1 985	63	26	6	5
Iceland	1992	1 000	73	. .	20	7
Norway	1990	1 506	48	49	1	2
Belgium	1992	1 000	23	67	5	5
Denmark	1992	1 000	34	61	2	4
France	1992	1 000	13	79	5	4
Germany	1992	2 000	29	66	3	2
Greece	1992	1 000	21	71	6	3
Ireland	1992	1 000	15	59	12	14
Italy	1992	1 000	18	71	4	6
Luxembourg	1992	500	28	59	6	7
Netherlands	1992	1 000	31	65	2	2
Portugal	1992	1 000	18	62	9	11
Spain	1992	1 000	19	69	6	6
United Kingdom	1992	1 300	25	66	5	5

Source: ABS 1993 (4602.0); ABS 1995 (4602.0); OECD 1993, p. 287.

Table 3.3.2 presents the results of the surveys on environmental issues conducted by the ABS, focusing on people's attitudes to environmental protection and economic growth, compared with results from public opinion surveys on these issues carried out in Japan, the USA, Finland, Norway and other countries of the European Community, as compiled by the Organisation for Economic Co-operation and Development (OECD). As the survey design and the style and wording of questions varied from country to country, this comparison is indicative at best. The data are expressed in percentages of the total number of persons interviewed.

Ecologically Sustainable Development

Community awareness and understanding of Ecologically Sustainable Development (ESD) were examined in a survey by Australian National Opinion Polls (ANOP) in September 1993 (also referred to in Section 2.3). While there is no universally accepted definition of ESD, the Commonwealth Government has suggested the following definition for ESD in Australia:

"using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased."

3.3.3 Awareness of Ecologically Sustainable Development (ESD), September 1993

	Proportion of people
	%
Aware of ESD and able to define it	21
Aware of ESD but unable to define it	4
Not aware of ESD/unsure	75

Source: ANOP 1993, p. 101.

3.3.4 Perceived importance of the environment in 10 years time, September 1993

	%
More important in 10 years	77
No change — important now	9
No change — not important	2
Less important in 10 years	10
Unsure	2

Source: ANOP 1993, p. 12.

ESD has also been described as development which aims to meet the needs of Australians today, while conserving our ecosystems for the world in which future generations will live (Strategic Directions for ESD in Australia, 1992). To this end, Australia has a National Strategy for Ecologically Sustainable Development, the elements of which have been agreed by the Commonwealth and State governments.

The ANOP survey revealed (Table 3.3.3) that 21% of respondents were aware of ESD and were capable of defining what they understood it to mean. Four per cent indicated that they were aware of ESD but were unable to define it. A substantial majority of respondents (75%) indicated that they had not seen, heard or read any material about ESD.

Future importance of the environment

The survey also sought to gauge the perceived importance of the environment in 10 years' time. A large majority of respondents (77%) believed that the environment would become a more important issue in the future, while 10% considered that it would become less important. The survey results (Table 3.3.4) indicated a view by the majority of respondents that the effects of pollution and environmental degradation will become more apparent with time, and that population growth will lead to increased environmental problems (ANOP, 1993).

3.3.5 Main perceived issues facing Australia

	December 1991		*September 1993*	
	Most important issue	*All issues mentioned*	*Most important issue*	*All issues mentioned*
Issue	%	%	%	%
Unemployment	38	56	49	67
State of the economy	24	35	30	54
Environment	12	30	3	13

Source: ANOP 1993, p. 11.

3.3.6 Main issues facing Australia

	Unemployment	*State of the economy*	*Environment*
	%	%	%
State			
New South Wales	64	57	11
Victoria	74	50	19
Queensland	65	55	8
South Australia	73	49	11
Western Australia	59	56	12
Tasmania	75	45	9
Location			
Industrial/urban	70	53	13
All urban	70	54	15
Provincial/rural	62	53	8
Total	**67**	**54**	**13**

Source: ANOP 1993, p. 70.

When asked to nominate the main issues confronting Australia, respondents to the ANOP survey in September 1993 indicated most concern for economy-related issues, predominantly unemployment, as illustrated in Tables 3.3.5 and 3.3.6. Comparing the results of this survey with those of a similar ANOP survey in December 1991, out of all issues mentioned by respondents, the incidence of respondents mentioning the environment dropped from 30% in 1991 to 13% in 1993. The incidence of respondents considering the environment to be the most important issue facing Australia dropped from 12% in 1991 to 3% in 1993.

A slightly smaller proportion of respondents in rural areas considered unemployment and the state of the economy to be important than those living in urban areas. Eight per cent of rural respondents considered the environment to be important, compared with 15% of urban respondents.

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Chapter 4 — Impacts of Natural Events and Processes on the Economy

4.1 Impacts of natural events and processes

Each year, natural events result in millions of dollars in insurance payouts, and additional costs to businesses and individuals. The economy as a whole suffers considerable financial losses and thousands, sometimes millions of individuals are affected financially by natural disasters. The data in this section provide a broad picture of these costs.

The section focuses on the impact of natural events such as drought, bushfires, floods, cyclones, severe storms and earthquakes. The impacts of the natural processes of wind and water erosion, while also significant, were treated in Sections 1.1 and 1.3. Table 4.1.1 provides a summary of the risk of natural hazards occurring in Australia. In areas of population concentration along the eastern, south-eastern and south-western coastlines of Australia, meteorological and geological hazards are the most relevant. Rural centres throughout the remainder of Australia, with associated industries, are most likely to be affected by the meteorological hazards of flood and drought, and biological hazards. Figure 4.1.2 depicts Australia's hazard areas.

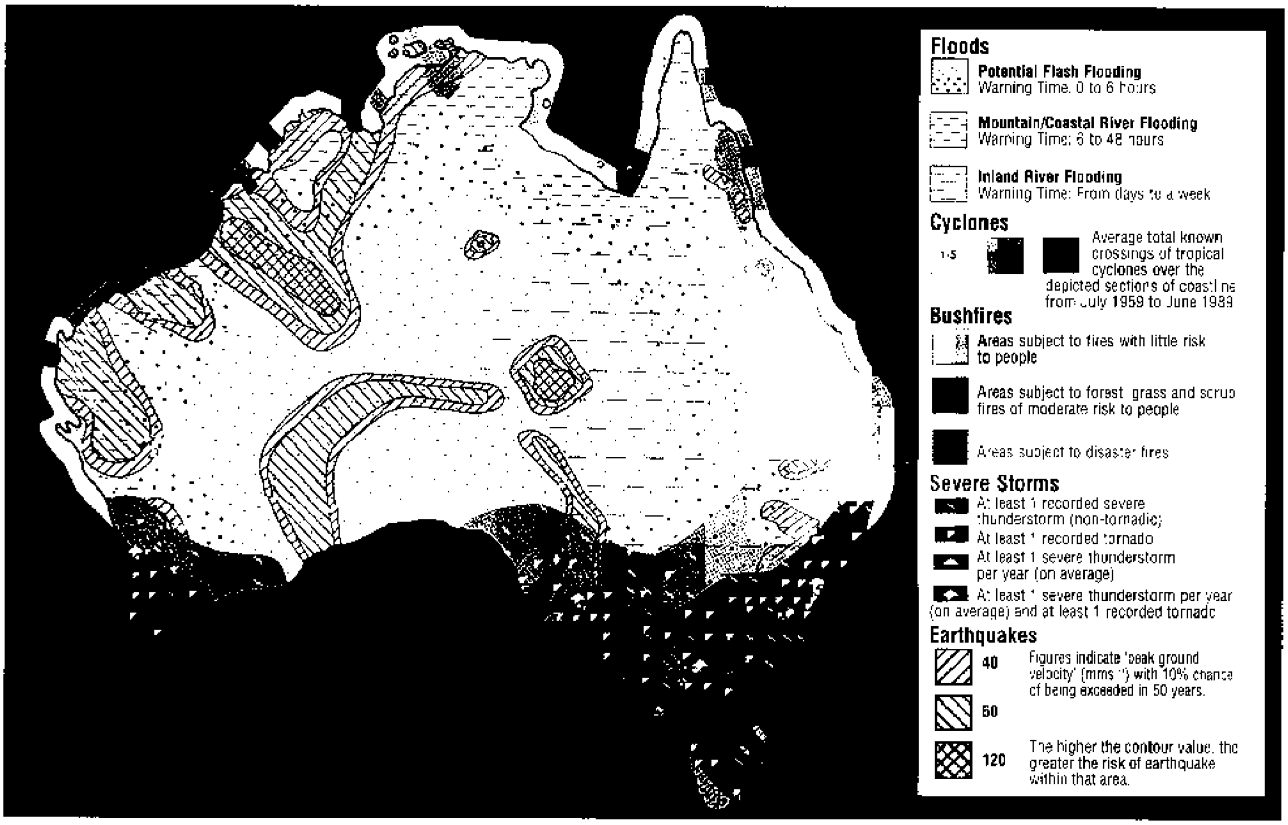
At the outset, it must be recognised that 'natural' events and processes interact with one another, and human influence is so universal that it can rarely be discounted. For example, the effects of strong winds are exacerbated by drought which has dried out the soil and killed off vegetation. Over-clearing of the land for agriculture accelerates the effects of wind and water. Bushfires often occur at the end of a drought, and leave land denuded of vegetation and therefore at greater risk of erosion (also see Section 1.3).

4.1.1 Risk of natural hazards in Australia

Natural Hazard	*Frequency of major damage impacts*	*Geographical Location*	*Population vulnerable* millions	*Socio-economic consequences*
Meteorological				
Cyclone	Few per year	Qld, WA, NT	3	Short term
Storm surge	Rare	East and west coasts	6	Short term
Severe storm	Many per year	All States & Territories	17	Short term
Tornado	Several per year	All States & Territories	5	Short term
Flood	Few per year	All States & Territories	15	Short term
Bushfire	Few per year	All States & Territories	5	Short term
Drought	Twice per decade	All States & Territories	17	Long term (a)
Heatwave	Several per decade	All States & Territories	17	Short term
Geological				
Earthquake	Once per decade	All States & Territories	17	Short & long term (a)
Tsunami	Rare	East and west coasts	3	Short term
Landslide	Occasional	Hilly urban and rural residential areas	3	Short term
Volcano	Never		0	
Biological				
Insect plague	Several per decade	All States & Territories		Short term (b)
Vermin plague	Twice per decade	All States & Territories		Short term (b)
Exotic animal diseases	Rare	All States & Territories		Short & long term (b)

(a) A disastrous event may have serious consequences for the national economy.
(b) Consequences would be mainly on agricultural and pastoral industries. Through these the event may have serious consequences to the national economy.
Source: Rynn et al. 1994, p. 12.

4.1.2 Australian hazard areas



Source: Emergency Management Australia 1993.

Meteorological hazards

Tropical cyclones

In the Australian region, tropical cyclones are most likely to occur from November to April. They form over tropical ocean waters and bring violent winds, intense, prolonged rain and storm surges to coastal areas of northern Australia. Occasionally, tropical cyclones may migrate further southwards, to New South Wales or the Perth-Geraldton area of Western Australia. The Bureau of Meteorology tracks about ten cyclones per year in the region, four or five of which cross the coastline. Figure 4.1.3 shows the paths of recent cyclones, revealing the unpredictable nature of a cyclone's path. The amount of damage depends on the strength of the winds, nearness to zone of maximum wind, building standards, vegetation type and resultant flooding.

The impact of tropical cyclones can be summarised as follows:

- Violent winds. Table 4.1.4 shows a system of categorising cyclones according to wind speed and associated likely damage. Violent winds often unroof houses, leading to damage to contents and weakening of the structure; damage to buildings and death or injury from flying debris; and rough seas leading to boating accidents. Not only are the winds violent, but they lull and then change direction as the eye of the cyclone passes. Because cyclones are so large, an area up to 60 km wide may be affected by the winds;
- Torrential rain. Rain may fall before, during and after a cyclone, extending over an area much greater than the cyclone itself and lasting for long periods. As soil becomes saturated, flooding is likely to follow, and is often a major source of cyclone damage; and

- Storm surges. A storm surge is a raised dome of water about 60–80 km across and typically about 2–5 m higher than the normal tide level. It is created by pressure differences within the cyclone. Although infrequent in Australia, storm surges are thought to cause about 90% of deaths from tropical cyclones world-wide. If associated with a high tide they pose a great threat of flooding to extensive coastal areas. They can wreck ships at sea, or boats moored in harbours.

Table 4.1.5 shows the costs of tropical cyclones since 1967. The large discrepancy between insurance costs and total estimated costs shows the inadequacy of insurance cover, and the magnitude of costs borne by individuals, businesses and governments. These costs, and the associated disruption to communications, business and agriculture, reflect the significant impact that cyclones have on the Australian economy.

Severe storms

Severe storms are very localised events, and their devastating impact is often underestimated. These storms can occur anywhere in Australia and do so much more frequently than any other major natural hazard. On average, each year severe storms are responsible for more damage (as measured by insurance costs) than tropical cyclones, earthquakes, floods or bushfires.

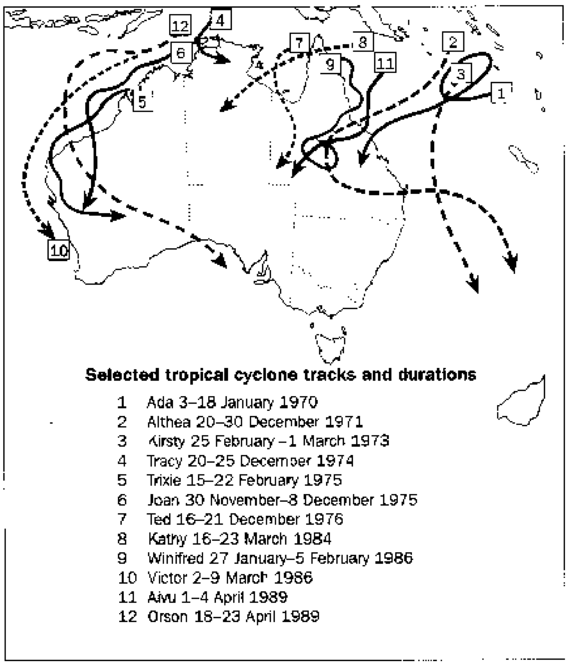
Severe thunderstorms

The Bureau of Meteorology defines severe thunderstorms as those which produce either hailstones with diameter of 2 cm or more, or wind gusts of 90 km/h or greater, or flash-floods, or tornadoes, or any combination of the above. Hail causes injury to people and damage to buildings and vehicles. The gusty winds associated with storms can also cause damage from falling trees and flying debris. Tornadoes, with winds up to 450 km/h, can cause severe damage in their path.

Severe thunderstorms can occur throughout the year, although they are very rare during the dry winter months in the north. Most strike from November to March when the supply of solar energy is greatest, but severe winter storms linked to cold fronts are common in the south-west of Western Australia.

Because of a lack of observations over much of the continent, not all storms are recorded. However, analysis of weather patterns suggests that severe thunderstorms are a threat throughout the country. The most damaging individual storms have hit the populous parts of the continent, in particular south-eastern Queensland and the central New South Wales coast (see Figure 4.1.6).

4.1.3 Cyclone paths in Australia



Source: Dolan 1994, p. 131.

4.1.4 Cyclone severity categories

Category	*Strongest gust (km/h)*	*Typical effects*
1	<125	Negligible house damage. Damage to some crops, trees and caravans. Boats may drag moorings.
2	125–170	Minor house damage. Significant damage to signs, trees and caravans. Heavy damage to some crops. Risk of power failure. Boats may break moorings.
3 (e.g. Winifred)	170–225	Some roof and structural damage. Some caravans destroyed. Power failure likely.
4 (e.g. Tracy)	225–280	Significant roofing loss and structural damage. Many caravans destroyed and blown away. Dangerous airborne debris. Widespread power failure.
5 (e.g. Orson)	>280	Extremely dangerous with widespread destruction.

Source: Dolan 1994.

4.1.5 Costs of tropical cyclones (a), 1967–95

Date	Cyclone	Location	Effects	Insurance loss (b) $m	Total cost (b) (c) $m
1970 Jan.	Ada	Whitsunday Islands, Qld	Day Dream Island resort destroyed.	71	355
1971 Dec.	Althea	Townsville Qld	Hundreds of homes damaged or destroyed.	133	665
1972 Feb.	Daisy	Bundaberg, Qld		11	55
1973 Mar.	Madge	Qld, NT and WA		136	680
1974 Jan.–Feb.	Wanda	Brisbane, Qld	Floods.	297	850
1974 Mar.	Zoe	Qld and northern NSW coasts		11	55
1974 Dec.	Tracy	Darwin, NT	80% of all buildings destroyed, none undamaged. Massive infrastructure damage and commercial/industrial losses.	760	3 800
1975 Dec.	Joan	Northern WA		67	270
1976 Feb.	Beth	Bundaberg, Qld		11	50
1976 Dec.	Ted	Qld		44	200
1978 Apr.	Alby	WA		35	175
1979 Mar.	Hazel	WA		37	100
1980 Feb.	Dean	Pilbara, WA	Mining infrastructure and production losses.	45	200
1980 Dec.		Brisbane, Qld	Widespread wind and flood damage.	15	75
1984 Jan.	Grace	Qld		10	50
1984 Mar.	Kathy	NT		11	35
1986 Jan.	Winifred	Cairns to Ingham, north Qld	50 homes destroyed, hundreds of houses and buildings damaged, heavy crop damage.	59	295
1988 May	Herbie	Carnarvon to Denham, WA	Moderate damage including shipwreck of Korean Star.	27	62
1989 Apr.	Aivu	Ayr, Home Hill, Clare, Qld		31	155
1989 Apr.	Orson	Dampier, Karratha, Panawonica, WA	Damage caused to oil and gas rigs offshore.	4	21
1990 Feb.	Nancy	Southern Qld and north NSW	Mainly flooding.	38	220
1990 Dec. to 1991 Jan.	Joy	Qld	Wind damage and extensive coastal flooding, including Rockhampton, caused large crop, livestock and coal production losses.	68	350
1991 Apr.	Fifi	WA	Bulk ore ship sank, 27 drowned.	na	35
1995 Feb.	Bobby	Onslow, WA	Many homes unroofed/damaged; 2 fishing trawlers sank (7 died); bulk ore carrier ran aground; extensive floods throughout central and south. Substantial agricultural and mining production losses resulted.	10	75

(a) Tropic cyclones which caused at least 3 deaths, or 20 injuries, or $10M insurance loss, or $30M total estimated cost to the community.
(b) 1995 prices.
(c) A conservative estimate taking into account the cost of all facets of the emergency response; all insurance losses; all uninsured losses including replacement costs of private property, public buildings and assets, damaged infrastructure (e.g. water, sewer, power, gas, roads, bridges, paths etc); material and production losses incurred by industry, commerce (including tourism), government and agriculture; community dislocation, rehabilitation/ recovery services etc.
Note: Information sources used by Emergency Management Australia in the compilation of these figures include the Insurance Council of Australia, the Centre for Resource and Environmental Studies — Australian National University, the Bureau of Meteorology, the Natural Hazards Research Centre — Macquarie University, reports by State and Territory emergency management and response agencies, historical and contemporary Australian disaster texts and validated press reports.
Source: Information provided courtesy of the Disaster Awareness Program, Emergency Management Australia 1995, unpub.

Land Gales

Land gales are gale force winds with speeds of 62 km/h or more. They usually affect a much wider area and last longer than thunderstorms. In the southern half of Australia extreme winds generally occur in winter and spring, while in the north they occur in summer and autumn. In this area strong winds may be also associated with tropical cyclones.

Land gales are often responsible for severe dust storms, which carry away tonnes of valuable topsoil, especially after a period of drought. This was the case in 1994 in Western Australia, South Australia and New South Wales when losses were estimated at $50 million. Land gales increase the risk and severity of bushfires. Some of the 'Ash Wednesday' fires of 1983 were started when gale force winds caused power lines to rub together, throwing out sparks.

Figure 4.1.7 shows the most likely time of year for maximum wind gusts. Table 4.1.8 details major severe storms since 1967 and the insured and total estimated costs resulting from them. There are two types of severe storms — severe thunderstorms and land gales.

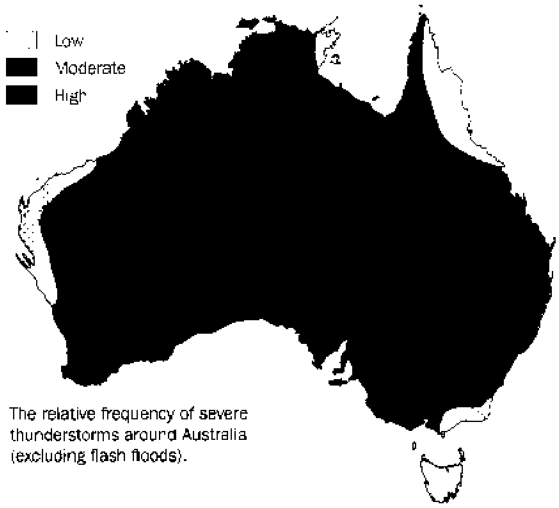
Floods

All capital cities, and many other settlements and farming areas, are at some risk of flooding, even though the pattern of flooding varies. Floods cost Australia about $300–$400 million each year.

Floodwaters have enormous potential for destruction because of their sheer weight and pressure. Currents and turbulent water can knock down and drown people and animals in relatively shallow depths. Debris carried by the water can also cause injury and destruction. Undermining the foundation of buildings causes damage. Saturation of soils may cause landslides or subsidence. Mud, oil and other pollutants carried by the water can ruin crops, damage building contents and contaminate water supplies. Sewerage systems may be destroyed and diseases may be spread by the floodwaters.

Floods are also capable of causing major disruption. Utilities such as power, gas and water supplies are at risk. Machinery and electronics may suffer damage resulting in communications failures and economic losses for industry. Fishing and other maritime industries may be particularly badly affected. Food stacks may be damaged by floodwaters and depleted by the losses of penned/confined livestock and damage to crops. Sites and artefacts of cultural and historical significance may also be damaged or lost (Dolan 1995, p. 31).

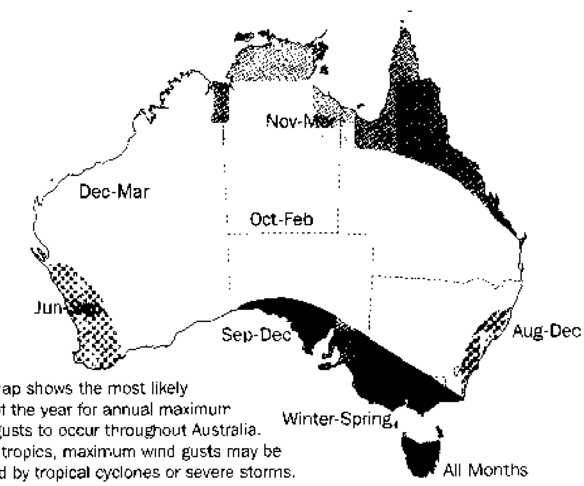
4.1.6 Relative frequency of severe thunderstorms



The relative frequency of severe thunderstorms around Australia (excluding flash floods).

Source: Natural Disasters Organisation & Bureau of Meteorology, 1991.

4.1.7 Most likely time of year for maximum wind gusts



This map shows the most likely time of the year for annual maximum wind gusts to occur throughout Australia. In the tropics, maximum wind gusts may be caused by tropical cyclones or severe storms.

Source: Natural Disasters Organisation & Bureau of Meteorology, 1991.

4.1.8 Costs of major severe storms (a) in Australia, 1967–95

Date	Details (a)	Insurance loss (b) $m	Total cost (b) (c) $m
1974 May	Sydney, NSW. Wind and hail.	89	240
1976 Jan.	Toowoomba, Qld. Hailstorm	45	72
1976 Nov.	NSW. Hailstorms.	119	200
1976 Nov.	Sandon/Castlemaine, Vic. Homes damaged and destroyed	11	32
1977 Jan.	NSW. Thunderstorms.	44	132
1977 Feb.	Tongala, Echuca, Vic.	12	36
1978 Feb.	Sydney, Newcastle and Wollongong, NSW. Damage and power failure to many homes.	40	120
1978 Mar.	North coast NSW.	14	42
1978 June	Sydney, NSW. Winds, flooding.	19	80
1979 Nov.	SA. Hail, wind.	22	50
1980 Dec.	Brighton, Qld. Heavy wind damage.	32	96
1982 Nov.	Melbourne and region, Vic.	17	51
1985 Jan.	Brisbane, Qld. Hailstorm and tornado, many homes, buildings and vehicles severely damaged or destroyed.	271	350
1985 Sep.	Melbourne, Vic. Hailstorm.	15	20
1986 Jan.	Orange, NSW. Hailstorm — homes and vehicles badly damaged.	37	48
1986 Aug.	Western suburbs, Sydney, NSW. Hail/rainstorms and flash-floods.	49	210
1986 Dec.	Adelaide, SA. 100 homes severely damaged.	14	42
1987 Nov.–Dec.	Melbourne, Vic. Rain and flood damage.	11	40
1988 Sep.	WA. Widespread storms.	11	33
1988 Nov.	Vic. Rainstorms and flash floods.	14	50
1989 Feb.	Melbourne, Vic. Rainstorms and flash floods.	21	70
1989 Nov.	Ballarat, Vic. Hailstorm — homes, cars, farm buildings and crops severely damaged.	22	40
1990 Feb.	Dubbo, NSW. Hailstorm — extensive damage to homes and vehicles.	11	16
1990 Feb.	Sydney, NSW. Hailstorm — serious damage to homes, businesses and vehicles.	11	16
1990 Mar.	Auburn, south-west Sydney, NSW. Severe hailstorm — damage to many homes, businesses and vehicles.	349	500
1990 Aug.	Sydney, NSW. Many homes seriously damaged.	14	41
1991 Jan.	Northern Sydney, NSW. Extreme wind/hail/rain storm — falling trees damaged over 7,000 houses, totally destroying 20; many businesses suffered extensive damage; 140 km of powerlines and 3 steel towers downed. Damage pattern suggested a tornado. At least 50,000 significant trees were felled or suffered long-term damage.	205	600
1991 Jan.	Adelaide, SA. Hailstorm — hundreds of vehicles and homes badly damaged.	27	80
1991 Jan.	Orbost, Vic. Hailstorm — extensive damage to homes and vehicles.	11	na
1991 June	South-eastern NSW. Storms and floods.	13	60
1992 Feb.	Sydney, NSW. Many homes and businesses damaged.	101	305
1993 Sep.	Mandurah, WA. Tornado — over 100 houses damaged, several totally destroyed; widespread damage to powerlines, trees etc.	2	8
1993 Dec.	Melbourne and Shepparton, Vic. Factories, houses, buildings, crops and orchards damaged.	11	33
1994 May	Perth, WA. Winds up to 140 km/h caused 600 homes to be damaged, powerlines downed — 60,000 homes blacked-out; large losses to commerce and industry.	35	100
1994 May	WA, SA, Vic. and south NSW. Dust storms — loss of millions of tons of topsoil (Estimated loss of $50m in agricultural production); high winds and dust caused damage to buildings and public utilities. (insurance loss figure only for WA).	24	85
1994 Nov.	Vic. Land gales. winds up to 145 km/h — worst in 10 years; houses damaged; homes blacked-out. ACT and NSW. Land gales. 1 house destroyed, hundreds of houses and cars damaged. Wollongong and Sydney areas — 20,000 homes blacked-out; boats and a ship damaged. Dust storms in Vic. and southern NSW from Riverina to east coast.	14	80
1994 Nov.	Sydney, NSW. Widespread damage to trees, powerlines, cars and houses.	13	40
1995 Apr.	Merimbula and Pambula, south coast, NSW. Tornado with winds over 150km/h cut a 100m wide swathe of damage for 10 km including sections of forest. 200 houses damaged; 12 destroyed; cars and caravans damaged; trees uprooted; black-outs.	6	20

See footnotes to table 4.1.5.

Source: Information provided courtesy of the Disaster Awareness Program, Emergency Management Australia 1995, unpub.

4.1.9 Costs of major floods (a) in Australia, 1967–95

Date	*Details*	*Insurance loss (b)* *$m*	*Total cost (b) (c)* *$m*
1970 Aug.	Deloraine and Latrobe, Tas. 100 homes flooded, 15 homes destroyed, many roads flooded, minor flooding Hobart.	28	220
1971 Jan.	Woden Valley, Canberra, ACT. FLASH flooding damaged roads and stormwater systems; several vehicles destroyed.	6	30
1971 Feb.	Gippsland, Vic. Heavy agricultural losses.	11	100
1974 Jan.–Feb.	Brisbane, Qld. Result of TC Wanda.	297	850
1974 Apr.	Sydney, NSW.	89	380
1974 May	Vic. Widespread agricultural losses.	18	180
1974 June	Seymour, Vic.	11	100
1975 Mar.	Sydney, NSW.	57	270
1977 Mar.	NSW.	21	200
1978 Feb.–Mar.	Sydney and Penrith, NSW.	na	120
1981 Feb.	Dalby, Qld. Caused by severe storms; heavy crop damage.	45	180
1984 Nov.	NSW, including western Sydney.	271	350
1988 Mar.–Apr.	Alice Springs and region, NT.	13	50
1988 Apr.	Southern Qld and northern NSW.	10	70
1988 Apr.	Sydney, NSW.	32	200
1989 Apr.	Southern Qld and northern NSW (mainly coastal).	na	110
1990 Apr.–May	Qld/NSW/Vic. Great Floods. Southern Qld, including Charleville; northern and western NSW, including Nyngan; north-eastern Vic., Bairnsdale, Gippsland — worst for 35 years; 5,000 evacuated. At their peak, floodwaters covered 1 million km^2. Large crop losses. More than 1 million stock perished. Road and rail links cut for long periods.	35	380
1991 Feb.–Mar.	Monsoonal flooding affected the Gulf country, central and southern (coastal) Qld and the north of NT.	na	120
1991 Dec.	Melbourne and Ballarat, Vic. Floods and water damage to homes and businesses.	20	90
1992 Aug.–Sep.	Adelaide region including Adelaide Hills, SA. Flash floods. Severe flooding at Two Wells, Mallala and Langhorne Creek.	na	145
1992 Dec.	Kanmantoo (near Adelaide) and Adelaide Hills, SA. Market gardens, orchards, crops destroyed and homes damaged.	na	250
1993 Oct.	North-east Vic. 12 rivers in flood. Benalla — over 1500 were evacuated. Shepparton, Wangaratta and Euroa — over 4000 evacuated and over 4000 homes/shops damaged. Over 3500 sheep and over 1600 cattle died, crops, orchards and market gardens were destroyed resulting in huge dairy and other primary production losses.	11	400

See footnotes to table 4.1.5.

Source: Information provided courtesy of the Disaster Awareness Program, Emergency Management Australia 1995, unpub.

Flash Floods

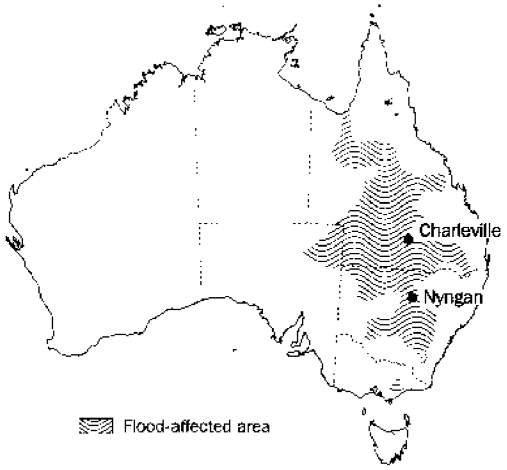
While flooding usually only lasts for one or two days, these floods often cause more damage and pose a greater threat to life and property, since there is less time to take preventative action.

Flash floods result from relatively short bursts of rainfall, commonly from thunderstorms. They can occur in almost all parts of Australia. Because of the speed with which it occurs, this type of flooding poses the greatest threat of loss of life and can result in significant damage to property as well as causing major social disruption. It is a serious problem in built-up areas where drainage systems are unable to cope.

Table 4.1.9 shows the estimated total costs to the economy of floods in Australia since 1967. In the case of floods, insurance payouts are much lower than total costs. This is because many businesses and individuals did not have special flood insurance to cover the costs. There are substantial costs involved in repairing railways, roads and stormwater systems which are damaged by floods. Finally there are significant costs involved in protection and rescue work, welfare and use of the Army and State Emergency Services.

The other notable feature of this table is the high costs that are caused by floods in city areas, such as the 1974 floods in Brisbane (see Section 2.2) and the 1975 and 1988 floods in Sydney.

The 'Great Floods' of 1990



Source: Dolan 1994

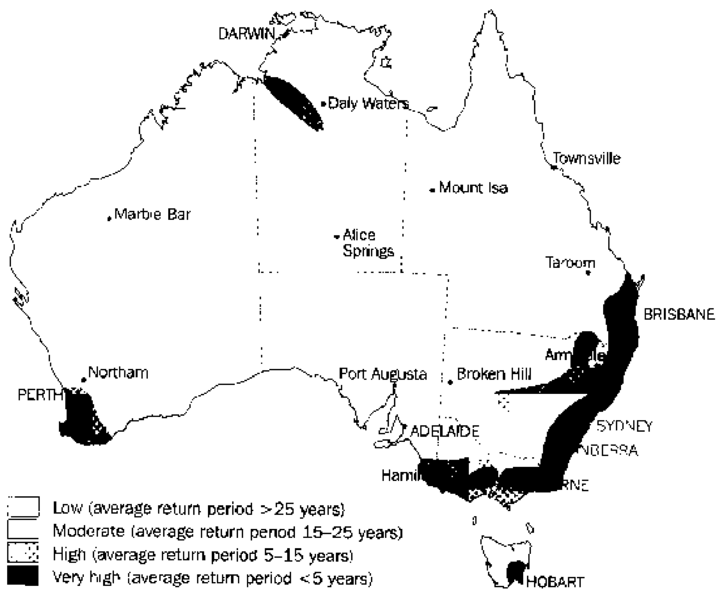
Source: Disaster Awareness Program, Emergency Management Australia.

Bushfires

Australia experiences many bushfires, and these have the potential to be one of the most destructive forces in nature. Even a small fire can quickly get out of control, threatening human life, property, crops, livestock, forests and wildlife. Tasmania, South Australia, Victoria and New South Wales have all experienced disastrous bushfires, in which many lives have been lost and millions of dollars worth of damage done. Figure 4.1.10 shows the areas of Australia where damaging bushfires are most frequent. It can be seen that these areas correspond with areas where the population is more concentrated.

Table 4.1.11 gives details of major fires since 1967. As well as causing loss of life, homes and buildings, fencing and infrastructure, fires may destroy huge areas of farm land, forests and national parks. They have the potential for broad-ranging impact on the economy.

4.1.10 Frequency of damaging bushfires



Source: Dolan 1994, p.157.

4.1.11 Costs of major bushfires (a) in Australia, 1967–95

Date	Details	Insurance loss (b) $m	Total cost (b) (c) $m
1967 Feb.	Hobart, Tas. (Black Tuesday) — 1,446 buildings destroyed and 265,000 ha burnt.	91	270
1968 Nov.	Blue Mountains, Illawarra and north coast regions, NSW. Over 200 buildings destroyed. Over 1 million ha burnt.	na	100
1969 Jan.	Southern Vic. 230 homes and 21 other buildings destroyed. 250,000 ha burnt.	na	198
1977 Feb.	Western Districts, Vic.	27	81
1977 Dec.	Blue Mountains, NSW. 49 buildings, including 15 homes destroyed and 54,000 ha burnt.	3	12
1980 Feb.	Adelaide Hills, SA. 35 homes destroyed and orchards and market gardens ravaged.	30	90
1979 Dec.–1980 Feb.	NSW. Fires widespread, burning more than 1 million ha. 14 homes lost. 5 firemen died at Gray's Point, Sutherland Shire, Feb. 1980.	5	15
1982 Feb.	Broadmarsh, Tas.	10	30
1982 Dec.–1983 Jan.	Blue Mountains and southern NSW. Major fires — 60,000 ha burnt including a pine forest worth $12M.	5	17
1983 Feb.	Ash Wednesday, Vic. and SA. 2450 homes destroyed, plus hundreds of other buildings. over 360,000 livestock died while 20,000 km of fencing and 1.5 million hay bales burnt. more than 1 million ha burnt in Vic. and SA during the 1982/83 summer.	294	882
1984 Sep.–1985 Feb.	Central and southern NSW — worst fire season for 10 years. 3.5 million ha burnt in 6,000 fires. 40,000 livestock lost.	41	123
1985 Jan.	Vic.	5	15
1987 Feb.	Southern Tas.	11	33
1987 Dec.–1988 Jan.	Bethungra, NSW. 3 died, 180,000 ha burnt across State.	na	5
1990 Nov.–Dec.	Hay district, Sydney to Newcastle, NSW. 176,000 sheep and 200 cattle died; 280,000 ha grazing land, hundreds of kilometres of fencing burnt; 8 homes destroyed.	1	30
1990 Dec.–1991 Jan.	Strathbogie Ranges, Vic. Extensive livestock/property loss.	11	33
1991 Oct.–1992 Jan.	Western Sydney, central coast and many other areas across NSW. 21 homes destroyed.	11	33
1994 Jan.	Eastern seaboard, NSW. Over 800 fires for over 3 weeks —206 homes and 20 other buildings destroyed; 800,000 ha burnt; 20,000 firefighters deployed.	51	153
1994 Sep.–Nov.	Eastern seaboard, Qld. 23 houses and a sawmill destroyed; stock and fencing losses occurred.	2	15

See footnotes to table 4.1.5.
Source: Information provided courtesy of the Disaster Awareness Program, Emergency Management Australia 1995, unpub.

Two disastrous fires

'Ash Wednesday' 1983	*New South Wales 1994*
76 died (including 11 volunteer firefighters); 1,100 injured.	4 died (including 2 volunteer firefighters); 120 injured.
Over 2,450 homes destroyed and hundreds of other buildings.	206 homes and 20 other buildings destroyed.
552,000 ha burnt, including large areas of forest and grazing lands.	8,000,000 ha burnt, rural, forest and metropolitan areas— 40 national parks were affected.
340,000 sheep and 18,000 cattle either died in the fires or had to be destroyed afterwards.	200 head of livestock died in fires.
Hundreds of native animals — kangaroos, wallabies, possums and koalas — were killed.	Large losses of native wildlife — up to 90% of populations in some national parks.
20,000km of fencing were destroyed.	600km of fencing were destroyed.
4,540 insurance claims, totalling $294 million (1995 prices) were made.	Insurance claims totalling $51 million (1995 prices) were made.
Total estimated cost was $882 million (1995 prices).	Total estimated cost was $153 million (1995 prices).

Source: Information provided courtesy of the Disaster Awareness Program, Emergency Management Australia 1995, unpub.

4.1.12 Cost of droughts (a) in Australia, 1967–95

Date	Details	Total cost (b) (c) $m
1958–68	Affected most of Australia, second only to 1895–1903 drought in severity.	>600 (d)
1981–83	South-eastern Australia. Massive crop and livestock losses. Dust storms caused loss of millions of dollars worth of topsoil.	3 500
1992–95	Affected most of Australia, particularly northern NSW and southern Qld (worst on record). Huge crop and livestock losses.	4 000 (e)

(a) to (c) See table 4.1.5.
(d) Agricultural losses only for 1967–68
(e) Only estimated cost to September 1995. Drought in large areas of NSW and Qld persisted into the latter part of 1995.
Source: Information provided courtesy of the Disaster Awareness Program. Emergency Management Australia 1995, unpub.

Drought

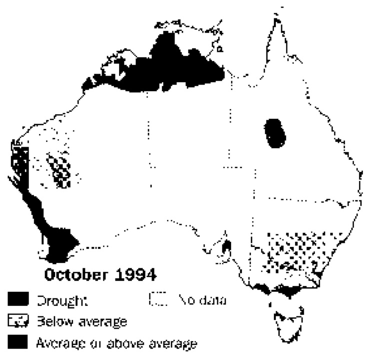
Drought has had a significant influence on the development of Australia. Major droughts have affected large parts of the continent at least every twenty years, lasting months and sometimes years. Yet, of all natural events, drought is perhaps the most difficult to define. Both its onset and end can be hard to pinpoint. It is related to people's perceptions of 'normal' conditions. Drought results not only from lack of rainfall but may also depend on the storage, use and management of water supplies. Thus, drought could be defined as "lack of sufficient water to meet essential needs for an unusually long time" (Dolan 1994, p. 103).

In Australia, early farming practices that involved total clearing of the land have exacerbated the effects of drought, wind, water and soil erosion. Farmers now recognise that drought is a recurrent event in the Australian environment, rather than an aberration. This changed perspective is leading to the development of appropriate farm management practices that will minimise the impact of drought. These include self-reliant land management, and strategic planning of long term stocking rates and feeding strategies, based on medium to long range forecasting, modelling soil moisture levels and remote sensing (White & Howden 1992).

Droughts have serious long-term economic consequences. Australia's rural population suffers dramatic loss of income as cropping programs are disrupted and breeding stocks are reduced. Grasses, shrubs and trees die, the land is denuded of vegetation, and soils and soil nutrients are carried away by wind. Associated with the decline in productivity are marked increases in costs, such as buying water, feed and extra fertiliser (White & Howden, 1992). Table 4.1.12 shows the total estimated cost of major

Economic impacts of the 1994–95 drought

Australia farmers perceptions of seasonal conditions



Source: ABARE 1995.

The 1994–95 drought affected large areas of Queensland, New South Wales and Victoria as well as some areas in South Australia and Western Australia. (See map). Large falls in farm production, exports and income in the farm economy resulted. the cropping sector was particularly affected, with winter crop production in 1994–95 reduced by almost 50% relative to the previous year. in consequence, more than 500,000 tonnes of foodstuffs had to be imported. these aggregate numbers mask the differences in farm performance across those farmers affected by drought and those not affected.

Although agriculture now comprises less than 3% of national income in Australia, the drought has also had a significant impact on economic growth via the direct and indirect linkages between rural and other industries. The drought is estimated to have reduced Australia's economic growth rate in 1994–95 by 0.75 percentage points on the potential level it would have otherwise achieved. The livestock sector was affected through higher slaughtering and deaths, lower wool production and higher feed input costs.

Source: ABARE 1995.

Impacts on economic sectors

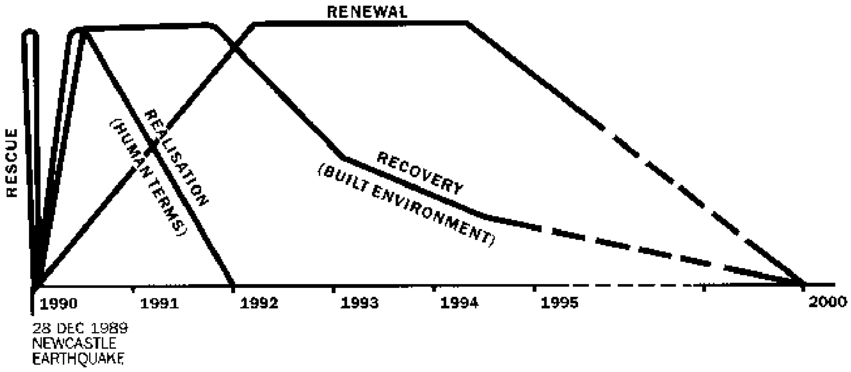
	Impact $ billion	Impact %
Farm Sector		
Gross value of production	−2.0	−8.0
Net value of production	−1.8	−47.0
Net rural exports	−1.6	−8.7
Economy		
Gross domestic product	−3.3	−0.8
Consumer price index	. .	0.2

Source: ABARE 1995.

The Newcastle Earthquake, 1989

Geology	The earthquake struck without warning, in an area that was considered low-risk, causing more damage than any previous earthquake. It measured only 5.6 on the Richter scale. The extent of damage can be explained by the shallowness of the quake (between 1km and 5km below the surface), the location of the epicentre close to the centre of the built up area with many older buildings, and the thin layer of alluvium under the city, which magnified the shock waves.
Affected Area	The quake was felt over more than 250,000km^2, as far as Liverpool, Sydney, (138 km south); Scone (145km north-west); and Gladstone (320km north). Damage extended over an area of about 20,000km^2.
Costs	13 deaths; 150 injuries; about 1,000 people left homeless; 300,000 people affected; Insurance losses were over $1 billion; total estimated costs over $4 billion.

Long term effects: Process of recovery from effects of the quake



Source: Rynn et al. 1994, p. 13.

droughts in Australia during the second half of this century. Such losses have a significant impact on Australia's economy. For example, ABS data show that the value of agricultural production in 1994–95 fell by 1.3% to $23.2 billion as a result of the drought in eastern Australia. However, the effect was cushioned by higher prices received for agricultural products, especially wheat and wool. The nation's grain farmers absorbed the brunt of the drought, with the value of crops cut by 6.4% to $10.8 billion. The wheat crop, cut by 45% to nine millions tonnes, decreased in value by 32.8% to $1.9 billion. With about 70% of the crop exported in an average year, the loss in value was also evident in the balance of payments. New South Wales, Australia's biggest agricultural State, was hardest hit by the drought, with the value of its farm sector production cut by 11% to $5.6 billion. Victoria's production dropped 3.6% to $5.3 billion (ABS 1995, 7501.0).

The Australian Bureau of Agricultural and Resource Economics (ABARE) attempted to quantify the impact of the drought on the farm sector, by isolating the effects of the drought from other international and domestic factors which influence yearly changes in production and prices. ABARE estimated production and prices which would have occurred in 1994–95 in the absence of drought. The results are shown in the case study 'Economic Impacts of the 1994–95 Drought'.

Geological hazards

Earthquakes

Earthquakes in Australia are infrequent. This is because Australia is located away from the margins of the plates of the Earth's crust, where 95% of earthquakes occur. As can be seen from Figure 4.1.13, the western and central parts of Australia are the most active earthquake zones. Many of the stronger earthquakes that have occurred in Australia have been in unpopulated regions where little damage has resulted. In contrast, earthquakes in built up areas such as Meckering and Newcastle have caused significant damage and disruption. Table 4.1.13 also shows the costs of major earthquakes since 1967. As with floods, there was significant damage that was not covered by insurance.The Newcastle earthquake in 1989 revealed that, although Australia is a low risk country for earthquakes, a lethal earthquake can occur, and that there is a strong correlation between geological conditions and potential for damage. This can be expected to result in improved building codes and practices, and more intensive monitoring of seismic activity. More detailed understanding of geological conditions beneath population centres would provide more accurate indication of the seismic risks. There is also the need to include long-term consequences in emergency management planning.

4.1.13 Costs of earthquakes in Australia, 1967–95

Date	Details	Richter scale magnitude	Insurance loss (b) $m	Total cost (b) (c) $m
1968 Oct.	Meckering, WA. Most buildings in the town destroyed. Of the 800 buildings with some damage 70% were in Perth.	7	11	44
1979 Jun.	Cadoux, WA. Many homes and buildings damaged or destroyed.	6	11	42
1989 Dec.	Newcastle, NSW. Over 30,000 homes and buildings seriously damaged, including commercial and schools; an estimated 70,000 buildings (including 147 schools) in the Hunter region sustained some damage. high infrastructure and commercial/industrial losses also resulted.	6	1 020	4 080
1994 Aug.	Cessnock and Hunter Valley, NSW. Several homes and buildings and hotels badly damaged; up to 1,000 homes partly damaged; infrastructure damage; commercial and industrial losses.	5	34	136

See footnotes to table 4.1.5.

Source: Information provided courtesy of the Disaster Awareness Program, Emergency Management Australia 1995, unpub.

Biological hazards

Locust plagues

Locust plagues are the main form of insect plague in Australia. They occur about every two years and have been recorded since 1844. There have been six major plagues in the last 50 years. Outbreaks and plagues are therefore frequent but also short-lived. Even so, large areas of crops and pasture can be lost before the plague declines. For example, the cost of damage in New South Wales alone in 1934 has been estimated to be $63 million in 1986 figures (Wright 1986, p. 294).

Table 4.1.14 shows estimates of the reduction in yield and of the overall monetary losses associated with the crop damage caused by the locusts. Estimation was highly complex, owing to the many types of crop attacked, the variation in plant response and the great variety of farm enterprises involved.

4.1.14 Final losses of crops attacked by locusts in the 1984 plague in New South Wales

Class/crop	Crop no.	Yield loss(a) %	Comment	Loss $
Wheat	45 (b)	10		2 429 029
Other cereals	9	. .		104 208
Barley	7	40		84 618
Oats	1	59		3 590
Triticale	1	85		16 000
Summer crops	12	. .		658 141
Rice	6	38	Some resowing, some regeneration.	269 623
Maize	4	19	Some regeneration.	259 768
Sorghum	1	25	Resown.	32 950
Millet	1	25	Resown.	2 650
Sunflower				
seed	1	25		5 000
oil	3	38	One resown, some regeneration in one crop.	31 990
Soya	2	25	Resown.	56 160
Market garden & vines	6	. .		357 977
Grapes	2	71		106 200
Melons	3	43	Resown several times before assessment.	67 277
Tomatoes	1	50	Too late to resow damaged sector.	184 500
Irrigated pasture	2	. .		30 387
Lucerne	2	50	Some regrowth.	30 387
Total	**80**	. .		**3 579 742**

(a) Final percentage loss in yield assessed from harvest.
(b) Value of lass includes a sample of 3 crops outside the main area.
Source: Wright 1986, pp. 303–304.

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Chapter 5 — Environmental Benefits to the Economy

This chapter presents statistics which reflect the flow in the PEP model from Natural Assets and Processes to the Economy. The focus is on the direct benefits generated through the input of environmental (or natural) resources into various economic sectors. Chapter 6 will then explore the use and consumption of a number of natural resources.

Chapter 5 explores the employment, output and economic wealth which are generated in the economy from the use of environmental resources. This contrasts with the statistics presented in Chapter 4, where the adverse impacts of the environment on the economy were explored.

5.1.1 Input intensities (a) — resource inputs into selected industries, 1989–90

	Resource Inputs		
	Raw	*Processed*	*Services*
ASIC Division	%	%	%
Agriculture, forestry, fishing and hunting	9.4	13.1	14.4
Mining	7.5	11.5	15.8
Manufacturing	12.1	33.6	15.5
Communication	0.0	10.2	20.7
Public administration and defence	0.2	14.6	39.2
Total industry	**4.0**	**17.1**	**20.8**

(a) Input intensities represent the value of inputs as a percentage of total value of outputs for the industry.
Source: ABS, unpub.

5.1 Jobs and economic wealth from environmental resources

Environmental resources provide a variety of benefits to the population. At the micro level, individuals benefit from recreation (discussed in Section 3.1), general health (Section 3.2), and enjoying and valuing the environment itself (Section 3.3). On a larger scale, the economy can be viewed as a tool for society to increase individuals' satisfaction from the trade in goods and services (see Section 11.1).

This chapter deals with the flows from natural assets directly to the economy. In studying and comparing the benefits flowing from environmental resources to the economy, it is impossible to measure the value of the resource until it joins the economic process. Therefore, in the absence of any other data, it is necessary to measure the benefits of environmental resources in dollar terms.

The use of natural assets in primary industries and ecotourism provides a relatively direct flow into the economy. The importance of natural resources to the primary industries is apparent from Table 5.1.1, but raw materials are also vital for other industry divisions, such as manufacturing. The inclusion in this section of the primary industries, but not the manufacturing industries, is a function of the framework under which this publication was developed. The manufacturing process

5.1.2 Contribution to GDP(P) at average 1989–90 prices

	Agriculture		Forestry, fishing and hunting		Mining		Services to Mining		Total GDP
	$m	%	$m	%	$m	%	$m	%	$m
1985–86	12 652	4.04	1 089	0.35	12 601	4.02	739	0.24	313 090
1986–87	13 196	4.14	1 090	0.34	11 959	3.75	504	0.16	318 988
1987–88	12 541	3.71	1 129	0.33	13 501	4.00	650	0.19	337 901
1988–89	12 502	3.49	1 187	0.33	13 977	3.90	667	0.19	358 098
1989–90	13 665	3.68	1 161	0.31	15 263	4.11	565	0.15	371 050
1990–91	14 637	3.99	1 251	0.34	15 984	4.36	520	0.14	366 494
1991–92	13 808	3.78	1 300	0.36	16 319	4.47	452	0.12	365 426
1992–93	14 630	3.88	1 309	0.35	16 429	4.36	510	0.14	376 875
1993–94	14 979	3.82	1 235	0.31	16 691	4.25	514	0.13	392 298
1994–95	12 016	2.90	1 276	0.31	17 389	4.19	628	0.15	415 024

Note: GDP(P) is the approach to measuring Gross Domestic Product by summing the value added (or gross product) of all industries.
Source: ABS 1995 (5206.0).

5.1.3 Employed persons by industry division and subdivision 1989–95, yearly average

	Number of employed persons				Proportion of total labour force			
	1989	1991	1993	1995	1989	1991	1993	1995
Industry, division and subdivision	'000	'000	'000	'000	%	%	%	%
Agriculture, forestry, fishing and hunting	428.5	422.0	408.8	411.1	5.6	5.5	5.3	5.0
Agriculture	376.8	375.7	363.4	364.4	4.9	4.9	4.7	4.4
Services to agriculture; hunting and trapping	21.7	20.2	19.7	19.0	0.3	0.3	0.3	0.2
Forestry and logging	12.4	10.9	10.8	11.0	0.2	0.1	0.1	0.1
Commercial fishing	17.6	15.2	15.0	16.7	0.2	0.2	0.2	0.2
Mining	103.1	92.2	88.9	85.0	1.3	1.2	1.2	1.0
Coal mining	30.5	29.6	28.0	24.4	0.4	0.4	0.4	0.3
Oil and gas extraction	2.9	4.7	4.5	4.0	0.0	0.1	0.1	0.1
Metal ore mining	41.6	36.0	31.2	32.3	0.5	0.5	0.4	0.4
Other mining	13.0	8.6	10.9	11.3	0.2	0.1	0.1	0.1
Services to mining	15.1	13.4	14.5	13.1	0.2	0.2	0.2	0.2
Total	**531.6**	**514.2**	**497.7**	**496.1**	**6.9**	**6.7**	**6.5**	**6.0**

Source: ABS (6203.0), various years.

eventually provides benefits from natural assets to the economy, but it is a far less direct process, and is accompanied by a large amount of value-adding.

The chapter covers the following 5 sectors — Agriculture, Fisheries, Forestry, Mining and Ecotourism, each of which can be measured in terms of contribution to Gross Domestic Product (GDP), contribution to the total labour force, and value of assets (wealth).

GDP can be measured in three broad ways. For the purposes of this discussion it is calculated as the value of production of all goods and services — so-called GDP (P). When comparing the contributions to GDP by various industries over time, changing values may represent a number of things. If the size of the GDP 'pie' remains the same, a change in the size of the 'slice' contributed by each sector will indicate a real change in its contribution. However, if the rate of change in GDP is similar to that of the component industries, no real change has occurred in their contribution. This should be borne in mind when viewing the contribution to GDP of agriculture, forestry and fishing, which fell between 1985 and 1995 (see Table 5.1.2). Mining increased its share of GDP slightly during the same period, from 4% to 4.2%. Attempts to measure ecotourism's contribution to GDP are still in progress. However, if the industry's turnover is of the order of $250 million as estimated (Econsult, unpub.), its contribution to GDP in 1995 would have been about 0.06%.

Combined employment in the primary industries of agriculture, forestry, fishing and mining fell

5.1.4 Contribution to Australian merchandise exports

	Farm (a)	Forest (b)	Fisheries (c)	Resource sector (d)	Other (e)	Total merchandise (f)
	%	%	%	%	%	$m
1969–70	52.7	0.5	1.0	31.7	14.6	3 998
1974–75	44.8	1.0	0.8	40.2	13.5	8 512
1979–80	45.2	1.1	1.3	39.8	12.5	18 589
1984–85	35.2	1.0	1.3	50.3	12.2	29 730
1989–90	29.8	1.2	1.6	51.1	17.0	48 564
1994–95p	26.7	1.5	2.1	45.6	25.0	66 418

(a) Includes exports of wine.
(b) Includes paper and paperboard.
(c) Includes tuna trans-shipped at sea or captured under joint venture agreements, which are not included in ABS exports data.
(d) Prior to 1990–91 includes ABARE estimates for items such as bauxite, manganese and diamonds which were excluded from ABS estimates for confidentiality reasons. From July 1990 ABS estimates contain details for such items.
(e) Excludes exports of wine and paper and paperboard, which ABARE includes in farm and forests exports respectively.
(f) Balance of payments basis.
Source: ABARE 1995.

5.1.5 National balance sheet for Australia at 30 June 1991 and 1992

Assets, liabilities and net worth	*Opening balance sheet*	*Net capital formation*	*Financial trans-actions*	*Other changes in volume of assets*	*Re-valuation*	*Closing balance sheet*	*Change from opening balance sheet*
	$ billion	*$ billion*	*$ billion*	*$ billion*	*$ billion*	*$ billion*	*%*
Non-financial assets	**1 876.2**	**14.9**		**6.4**	**– 28.0**	**1 869.5**	**– 0.4**
Produced assets	**1 186.9**	**14.9**		0.0	**4.8**	**1 206.6**	**1.7**
Fixed assets	1 108.6	16.4		0.0	5.0	1 130.0	1.9
Tangible fixed assets	1 108.6	16.4		0.0	5.0	1 130.0	1.9
Dwellings	370.2	8.2		0.0	0.4	378.8	2.3
Non-dwellings construction	452.0	6.8		0.0	– 3.2	455.6	0.8
Machinery and equipment	225.8	0.7		0.0	7.3	233.8	3.5
Livestock — fixed assets	19.4	– 0.1		0.0	0.5	19.8	2.1
Real estate transfer expenses (a)	41.2	0.8		0.0	0.0	42.0	1.9
Intangible fixed assets	na	na		na	na	na	na
Inventories	78.3	– 1.5		0.0	– 0.2	76.6	– 2.2
Private non-farm stocks	56.3	– 1.6		0.0	0.4	55.1	– 2.1
Farm stocks	1.2	0.1		0.0	0.0	1.3	8.3
Public marketing authorities	3.9	– 0.4		0.0	0.1	3.6	– 7.7
Other public authorities	2.1	0.1		0.0	– 0.1	2.1	0.0
Livestock — inventories	8.6	0.3		0.0	– 0.8	8.1	– 5.8
Plantation forests	6.2	0.0		0.0	0.2	6.4	3.2
Valuables	na	na		na	na	na	na
Non-produced assets	**689.3**	na		**6.4**	**– 32.8**	**662.9**	**– 3.8**
Tangible non-produced assets	689.3	na		6.4	– 32.8	662.9	– 3.8
Land	544.8	na		na	– 36.1	508.7	– 6.6
Subsoil assets	135.5	na		6.6	3.1	145.2	7.2
Non-cultivated assets							
Native forests	8.8	na		– 0.2	0.2	8.8	0.0
Wild animals	0.2	0.0		0.0	0.0	0.2	0.0
Water resources	na	na		na	na	na	na
Intangible non-produced assets	na	na		na	na	na	na
Financial assets with rest of the world (b)	**111.6**		**-0.1**		**8.3**	**119.8**	**7.3**
International reserves	24.0		-3.9		2.1	22.2	– 7.5
Foreign deposits	4.2		-1.1		– 0.3	2.8	– 33.3
Securities other than shares	4.4		1.4		1.0	6.8	54.5
Loans	15.3		1.8		0.6	17.7	15.7
Shares and other equity	54.8		2.8		5.5	63.1	15.1
Other claims	8.9		-1.1		– 0.6	7.2	– 19.1
***less* Liabilities to rest of the world (b)**	**300.8**		**16.2**		**2.9**	**319.9**	**6.3**
Cash and deposits	7.3		0.0		0.6	7.9	8.2
Securities other than shares	128.0		8.9		1.3	138.2	8.0
Loans	62.8		3.6		-0.6	65.8	4.8
Shares and other equity	102.3		3.7		1.6	107.6	5.2
Other claims	0.4		0.0		0.0	0.4	0.0
Net worth	**1 687.0**	**14.9**	**– 16.3**	**6.4**	**– 22.6**	**1 669.4**	**– 1.0**
Memorandum items —							
Consumer durables	87.9	2.1		0.0	0.0	90.0	2.4
Direct foreign investment							
in Australia	287.5	0.8	14.7		1.8	304.8	6.0
Australian investment abroad	73.8	0.6	2.4		6.2	83.0	12.5

(a) The SNA recommends that these expenses should be allocated between dwellings, non-dwelling construction and land. However, there are insufficient data available for this to be done in these balance sheets.

(b) Amounts shown in the Revaluation Account column for Financial assets and liabilities include values for "other changes in volume of assets", as well as revaluations, see Australian National Accounts — Financial Accounts (5232.0) for a description of this reconciliation.

Source: ABS 1995 (5241.0).

between 1989 and 1995 from 531,600 to 496,100. This represented a decrease in the share of the total labour force from 6.9% to 6.2% (see Table 5.1.3). Employment in ecotourism has been estimated at about 6,500 in 1994–95, which would be less than 0.1% of the total labour force (Econsult, unpub.).

Australia's economy is dependent on strong export earnings, and the resource sector provides a large proportion of this income. Table 5.1.4 indicates the contribution of some primary industry sectors to total merchandise exports.

When measuring the wealth of a nation, it has been customary to only include assets produced within the economy. Recent developments in national accounting have encouraged the inclusion of natural assets in national balance sheets. Guided by the recommendations of the 1993 System of National Accounts (SNA93), the recent publication 'National Balance Sheets for Australia: Issues and Experimental Estimates' (ABS 1995, 5241.0) has included natural resources in the balance sheets, in addition to produced and financial assets. Table 5.1.5 presents the national balance sheet at 30 June 1991 and 1992, which classifies total Australian assets into produced assets (housing, machinery, livestock, farm stocks), non-produced assets (forests, land, and subsoil assets), and financial assets. The value of produced assets was estimated at $1,206.6 billion at the close of the 1991–92 financial year, while the value of selected non-produced assets was estimated at $662.9 billion. As noted in this publication, "Care should be taken when interpreting the experimental results of Australia's natural resources because of the difficulties of valuation, and the size of the resource stock being valued" (ABS 1995, 5241.0, p. 5).

5.1.6 Contribution of gross farm product to GDP

Year	*Gross farm product* $m	*GDP* $m	*Proportion of GDP* %
1951–52	1 225	7 590	16.1
1956–57	1 664	11 785	14.1
1961–62	1 611	15 593	10.3
1966–67	2 326	23 838	9.8
1971–72	2 218	39 288	5.6
1976–77	4 046	87 594	4.6
1981–82	7 066	158 722	4.5
1986–87	9 268	265 029	3.5
1991–92	10 380	386 958	2.7
1992–93	11 449	404 007	2.8
1993–94	12 101	428 589	2.8

Source: ABS 1995 (5204.0).

Agriculture

Agriculture has been a significant contributor to the Australian economy. While the value of agriculture to the economy is currently decreasing in terms of its contribution to GDP and employment, agriculture has played an important part in the growth of the economy, and continues to do so through its contribution to export earnings and to the growth of processed foods in the manufacturing sector. Table 5.1.6 shows the contribution of the farm sector to GDP(I) over time. Although the data are not in constant prices, the fall in the contribution of the farm sector to GDP is still evident, from 16.1% of GDP(I) in 1951–52 to 2.8% in 1993–94.

Table 5.1.7 indicates the value and volume of agricultural production between 1954–55 and 1994–95 in constant prices. The volume of agricultural production presented in Table 5.1.7 is in index form. This is not a measure of absolute volume, but rather an indication of the change in volume, using 1989-90 as the base year. The total volume of agricultural production

5.1.7 Value and volume of Australian farm production

	Gross value of production				*Indexes of volume of production (a)*			
	Crops	*Livestock slaughtering*	*Livestock products*	*Total*	*Crops*	*Livestock slaughtering*	*Livestock products*	*Total*
Year	*$m*	*$m*	*$m*	*$m*	*No.*	*No.*	*No.*	*No.*
1954–55	679	385	1 143	2 208	30.6	na	na	41.6
1964–65	1 320	733	1 369	3 422	53.4	56.9	82.3	61.2
1974–75	3 205	1 020	1 617	5 841	69.2	81.2	81.4	74.8
1984–85	7 880	3 808	3 785	15 473	112.1	82.6	80.7	94.3
1994–95p	11 030	6 308	6 110	23 448	90.9	107.6	81.6	92.2

(a) Base 1989–90=100
Source: ABARE 1995.

5.1.8 Value of Australia's livestock at 30 June

Year	Fixed assets (a)	Inventories (b)	Wild animals	Total
	$ billion	$ billion	$ billion	$ billion
1989	24.7	9.1	0.2	34.0
1990	20.5	8.9	0.2	29.6
1991	19.4	8.6	0.2	28.2
1992	19.8	8.1	0.2	28.1

(a) Animals raised for wool, dairy products, breeding, transport etc.
(b) Animals raised for slaughter.
Source: ABS 1995 (5241.0).

5.1.9 Value of land in Australia at 30 June

	Type of land use			
	Residential	Commercial	Rural	Total
	$ billion	$ billion	$ billion	$ billion
1989	368.0	111.4	62.3	541.7
1990	366.7	101.9	64.5	533.1
1991	387.4	90.7	66.7	544.8
1992	376.2	75.4	57.1	508.7

Source: ABS 1995 (5241.0).

increased over 100% from 1954–55 to 1994–95, but has fallen slightly in recent years. The severe drought of the early 1990s caused a fall in volume of several key agricultural commodities, most noticeably grain production and wool. Total grain production fell from 27.5 million tonnes in 1993–94 to 15.4 million tonnes in 1994–95.

The estimated value of land and livestock used in agricultural production, as measured in the 'National Balance Sheets for Australia: Issues and Experimental Estimates' (ABS 1995, 5241.0), is detailed in Tables 5.1.8 and 5.1.9.

The rural sector has traditionally accounted for a large part of Australia's export earnings. In 1951–52, for example, farm exports were about 81% of total merchandise exports and 74% of total exports. The farm sector's contribution has fallen, however, from 52.7% of merchandise exports in 1969–70 to 26.7% in 1994–95. The decrease in the relative size of farm sector exports can be attributed to the rapid expansion in Australia's mineral sector in the 1960s, and some growth in the manufacturing and service industries.

Employment in the agriculture sub-division fell from 376,800 persons in 1989 to 364,400 persons in 1995 (excluding services to agriculture). This represents a fall in agriculture's share of the total labour force from 4.9% to 4.4% (see Table 5.1.3).

Fisheries

Fisheries play a role in the economic wellbeing of Australia, providing job opportunities away from major capital cities. Together, forestry and fisheries contributed $1,276 million to GDP in 1994–95, or about 0.3% of total GDP.

Table 5.1.10 indicates the value of production (catches) of the major Australian fisheries, during the period 1979–80 to 1994–95. It should be noted that the values are presented in current prices. The increase in value of prawns, for example, from $101 million in 1979–80 to $329 million, may indicate an increase in actual catch,

5.1.10 Value of production of major Australian fisheries

	1979–80	1984–85 (a)	1989–90 (a)	1994–95p (a)	1979–80	1984–85 (a)	1989–90 (a)	1994–95p (a)
Fishery	$m	$m	$m	$m	%	%	%	%
Prawns	101	164	226	329	34	31	21	19
Rock lobster	83	172	245	435	28	33	22	25
Abalone	17	35	90	148	6	7	8	8
Scallops	10(b)	20	25	51	3(b)	4	2	3
Oysters	14(c)	29	36	42	5(c)	6	3	2
Fish (d)	61	88	278	363	20	17	25	21
Tuna	12	14	66(e)	116(e)	4	3	6(e)	7(e)
Total	**299**	**522**	**1 092**(f)	**1 745**(f)	**100**	**100**	**100**(f)	**100** (f)

Note: These figures have been adjusted, and therefore do not necessarily correspond to unadjusted figures in section 6.2
(a) ABARE estimate; the values of production are based on values to fishermen (ABS estimates of gross value of production include certain marketing costs in some cases).
(b) Excludes production in the Northern Territory.
(c) Excludes production in Victoria and Queensland.
(d) Excludes tuna, freshwater catches and fish not for human consumption.
(e) Includes an estimate of the tuna production from joint venture agreements. Excludes Commonwealth SBT as an input to South Australian farms.
(f) Includes pearls, aquaculture and other products.
Source: ABARE 1995.

or an increase in the unit price of prawns, or a combination of the two.

The table also indicates the percentage contribution of each species to the value of the total catch over the period 1979–80 to 1994–95. The contributions of prawns and oysters have fallen by 12% and 2% respectively. Rock lobster, abalone, fish and tuna have all increased their contribution to the value of total catch, while the contribution of scallops has remained relatively constant.

Recreational fishing could also be considered as a contribution to the economy from natural resources, in both the employment the industry provides and the wealth it generates. Data on the economic benefits of recreational fishing are scarce, reflecting the difficulty of collecting and measuring such data. Not only are data subject to differing concepts and collection methods in the various States and Territories, but there are significant problems in collecting such data from recreational fishers.

At the State level, the ABS ran a recreational fishery survey in Western Australia in 1987. The Northern Territory Department of Primary Industry has commissioned a 'Fishcount 95' survey, which will provide a broad range of statistics on recreational fishing in the Northern Territory. In Western Australia, the Recreational Fishing Research Section is overseeing several research projects along the coastline, as well as establishing a recreational catch and effort database. The Queensland Fish Management Authority (QFMA) and the Queensland Department of Primary Industries (QDPI) are co-developing an Australia-wide recreational fishing database, with information gained from several surveys and research projects throughout the State. In South Australia, spatial surveys are being conducted, and preliminary results show the recreational harvest to be significant. Recreational fishing in Victoria is monitored by the Bays and Inlets Fisheries Assessment Program at the Victoria Fisheries Research Institute (VFRI), and various surveys have been undertaken at a State level. A survey in NSW, initiated by the NSW Game Fishing Association (NSW GFA), estimated total expenditure on items involved in game and sport fishing off eastern Australia at $209 million in 1993 (Pepperell 1995).

5.1.11 Estimated gross value of forestry production 1992–93 to 1994–95

Product	*Average annual gross value* $m
Hardwood sawlogs	238.0
Softwood sawlogs (a)	312.4
Cypress sawlogs	15.5
Plywood and veneer logs	13.1
Wood panels pulplogs	34.4
Export woodchip hardwood pulplogs	217.6
Export woodchip softwood pulplogs	25.2
Paper pulplogs	110.8
Total	**967.1**

(a) Excludes Cypress sawlogs.
Source: ABARE 1996.

Forestry

The use of forests as a marketable resource has been a growing point of contention among industry groups, environmental groups, local communities and government organisations. The economic value alone of forests is estimated to be quite substantial (see table 5.1.5).

Unfortunately, there is very little data available on the value of forest products in their raw state, rather than as an export or saleable commodity. Table 5.1.11 presents the estimated gross value of forestry production. The average annual value of forest products over the three years 1992–93 to 1994–95 was $967.1 million. Because estimates for periods prior to this are not available, it is impossible to compare these data over time and so form any conclusions relating to the changing value of forest production.

Employment in the forestry sector (see Table 5.1.3) has fallen from 12,400 persons employed in 1989 to 11,000 persons in 1995. This represented a small decrease in forestry's share of the total workforce, from 0.2% to 0.15%.

The ABS publication *National Balance Sheets for Australia: Issues and Experimental Estimates* (ABS 1995, 5241.0) proposed an asset value of $15.2 billion for forests in 1992, including plantation forests, and native forests available for exploitation under current economic and technological conditions. Table 5.1.12 focuses on the value of forests as an asset for future use rather than the value of their current production (the subject of Table 5.1.11).

5.1.12 Value of Australia's forests at 30 June

	Native Forest	*Coniferous plantations*	*Broadleaf plantations*	*Total*
	$ billion	*$ billion*	*$ billion*	*$ billion*
1989	8.3	4.6	0.1	13.0
1990	8.7	5.2	0.2	14.1
1991	8.8	6.0	0.2	15.0
1992	8.8	6.2	0.2	15.2

Source: ABS 1995 (5241.0).

Mining

The value of the resource sector to the Australian economy could be perceived as relatively minor if the level of employment (see Table 5.1.3) and contribution to GDP (see Table 5.1.1) were taken as the only indicators. In 1994–95 mining, including services to mining, contributed about 4.2% to GDP(P), equal to $17,389 million at 1989–90 prices (see Table 5.1.2). Some other sectors, over the same time, nearly doubled their contributions to GDP. Communication services, for example, contributed 1.9% to GDP in 1985–86 — a total of $6,042 million — and increased to 3.25% of GDP — equal to $13,456 million — in 1994–95. Mining, including services to mining, accounts for 1% of Australia's employed persons, employing a total of 85,000 people in 1995 (see Table 5.1.3). Compared with a major employment sector such as retail trade, employing over 1,220,000 persons, the mining industry appears relatively small. However it is not only the size of the employment in industry which is important to Australia's economy, but also the location of that employment. Employment in mining contributes significantly to regional development.

Table 5.1.4 indicates the growth in the mining sector's contribution to total merchandise exports, from 31.7% in 1969–70 to 45.6% in 1994–95. Australia is a leading world producer of several minerals, including bauxite, diamonds, and selected mineral sands (see Table 5.1.13). For a more detailed discussion of minerals see Section 6.6 Minerals.

5.1.14 Net present value of Australia's subsoil assets (a), at 30 June

Year	*$ billion*	*Annual increase*
1989	109.1	na
1990	115.6	6.0
1991	135.5	17.2
1992	145.2	7.2

(a) Using a 7.5% discount rate.
Source: ABS 1995b, (5241.0).

Subsoil assets, as presented in Table 5.1.14, are defined as "proven and probable reserves of mineral deposits located on or below the earth's surface that are economically exploitable given current technology and relative prices" (ABS 1995, 5241.0). The estimated net present value of economic demonstrated subsoil assets increased from $109.1 billion in 1989 to $145.2 billion in 1992.

5.1.13 Quantity of selected minerals, Australian and estimated world production, 1992

		Estimated world production	*Australian production*		*World's leading producer*	
				% of world production	*Country*	*Production*
Mineral	*Unit*	*Units*	*Units*	*%*		*Units*
Bauxite	Mt	105	40	38	Australia	40
Black coal — saleable	Mt	3 499	180	5	China	1 095
Copper in ores and concentrates	kt	8 900	330	4	Chile	1 870
Diamonds	Mct	110	40	36	Australia	40
Gold in ores and concentrates	t	2 170	240	11	South Africa	600
Iron ore	Mt	845	118	14	Former USSR	200
lead in ores and concentrates	kt	3 200	525	16	Australia	525
Manganese ore	kt	18 800	1 000	5	Former USSR	6 800
Mineral sands						
Ilmenite concentrate	kt	3 200	1 772	55	Australia	1 772
Rutile concentrate	kt	410	180	44	Australia	180
Zircon concentrate	kt	765	300	39	Australia	300
Nickel in ores and concentrates	kt	916	70	8	Former USSR	225
Salt	Mt	205	9	4	USA	40
Silver in ores and concentrates	t	13 700	1 218	9	Mexico	2 000
Tin in ores and concentrates	kt	200	6	3	China	45
Tungsten in concentrates	kt	39 800	200	1	China	25 000
Uranium in concentrates	t	20 416	2 334	11	Canada	9 307
Zinc in ores and concentrates	kt	7 365	1 000	14	Canada	1 290

Source: ABS 1994 (8405.0).

Ecotourism

The term 'Ecotourism' was originally used by Hector Ceballos-Lascurain in 1983, and was further defined in 1988 as:

"travelling to relatively undisturbed or uncontaminated areas with the specific object of studying, admiring, and enjoying the scenery, its wild plants and animals, as well as any existing cultural manifestations found in these areas" (DEST 1995, p. 9).

Since then there have been numerous attempts to redefine ecotourism, including the following:

- "Nature-based tourism that involves education and interpretation of the natural environment and is managed to be ecologically sustainable" (Commonwealth Department of Tourism 1994, p. 3); and
- "Ecologically sustainable tourism that fosters environmental and cultural understanding, appreciation and conservation" (Commonwealth Department of Tourism 1994, p. 15).

Definitions have emphasised the boundaries rather than identified the components of ecotourism. "Although questions of how ecotourism as a concept is to be defined have begun to subside, the question of how a given definition might be operationalised for marketing and market research purposes remains" (Blamey 1995, p. 1).

It can be seen that attempts to measure the ecotourism industry and market have been confounded by the question of what to measure. It should be noted that ecotourism has also been defined as a small section of nature-based tourism (NBT). The latter is a more general term, and is perhaps even less documented and defined that ecotourism. This section, while concentrating on ecotourism, recognises that it is only a portion of the total NBT market.

Tourism overall is a major contributor to the Australian economy, directly accounting for 6.6% of GDP and 6.6% of persons employed in 1993–94 (BTR 1995, p. 1).

"A strong and viable tourism industry will remain a major contributor to continued employment growth. The industry's relatively high ratio of labour to capital and capacity to employ those most affected by structural unemployment, such as low skilled and part-time workers, are important factors" (ACF, ACTU, DEET 1994, p. 175). Ecotourism, as a growing part of that market, harnesses the human desire to experience nature, and converts it into income and employment generation. In this way ecotourism uses environmental resources, but does not visibly consume them. The National Ecotourism Strategy (Commonwealth Department of Tourism 1994, p. 20) notes several authors who have identified the economic benefits from ecotourism as the following:

- "additional foreign exchange earnings;
- economic development, diversification and long term stability, particularly in regional areas;
- the distribution of income directly into regional and local economies through demand for local goods and services (this income may then be re-spent within the community, providing indirect benefits);
- the tendency for greater expenditure and length of stay by ecotourists (compared to tourists generally);
- the generation of income for the conservation and management of national parks and other public land;
- additional skilled employment opportunities, utilising local knowledge and facilities; and
- local infrastructure development" (Commonwealth Department of Tourism 1994, p. 21).

In order to profile the ecotourism industry, several studies have attempted to measure the size and nature of those operators who provide ecotourism services. From a study undertaken by Econsult (Australia) in July 1995, the *National Ecotourism Strategy Business Development Program Report* identified a number of difficulties in developing a list of ecotourism operators. The report went on to estimate that around 6,500 people were employed in the ecotourism industry in Australia, about 4,500 of those being full time. These estimates were derived from a survey of ecotourism operators in Australia compiled by Econsult (Australia) (see Table 5.1.15). The Econsult survey acknowledges that the estimates do not relate to a narrowly defined ecotourism market. Based on the estimate of 4,500 full time staff, an average full time wage of $25,000 per annum, and a turnover of $50,000 per year per staff member, Econsult estimated the turnover of the ecotourism industry in 1994–95 to have been about $250 million, with a yearly payroll of $115 million.

5.1.15 Estimated number of ecotourism operators, 1995

State / Territory	*Number*	*%*
New South Wales	110	18.4
Victoria	130	21.7
Queensland	105	17.6
South Australia	109	18.2
Western Australia	81	13.5
Tasmania	19	3.2
Northern Territory	35	5.9
Australian Capital Territory	9	1.5
Australia	**598**	100.0

Source: Econsult (Australia), unpub.

The 'Green Jobs in Ecotourism Survey', conducted by the Green Jobs Unit in late 1993 and early 1994, identified a possible group of 440 ecotourism operators in Australia. Seventy-two questionnaires were returned, a 16% response rate (ACF, ACTU & DEET 1994). The survey indicated that, depending on the definition of ecotourism used, the industry size could vary from the 440 operators the Green Jobs Unit identified, to 1500–2000 operators engaged in broader nature based operations. Absolute employment levels in the ecotourism market were not given in the *Green Jobs in Industry Research Report*, given the small size of the survey sample.

Data on the expenditure of participants in the ecotourism market, and therefore wealth generated from the industry, are limited. A report to the Great Barrier Reef Marine Park Authority (Driml 1994) investigated the economic and financial returns to various protected areas throughout Australia — a summary of the findings is presented in Table 5.1.16. Although this does not present the total expenditure by ecotourists throughout Australia, it indicates expenditure in major ecotourism destinations. Gross expenditure just on tourism and recreation in these areas amounted to $1.9 billion over 1991–92. With the inclusion of other expenditures, such as on commercial fishing, recreational fishing and boating, the gross expenditure was $2.1 billion.

A study by the Bureau of Tourism Research (Blamey 1996), has attempted to gauge the economic impact of nature-based tourists, by measuring the per trip expenditure of inbound tourists visiting Australian National Parks or undertaking one or more of the nature based activities listed in the findings. Table 5.1.17 presents the average expenditure of tourists undertaking selected activities. The problem with data of this type is that they do not highlight expenditure made purely on eco-tourism activities. Rather, they measure total expenditure of tourists undertaking one or more nature-based activities, which may include a large portion of non-nature-based activities. The average expenditure for all visitors to Australia was just

5.1.16 Major ecotourist destinations — gross financial values, management budgets and revenue from users, 1991–1992

	Tourism and recreation (a)	*Other uses measured value (b)*	*Total measured value (c)*	*Management budget*	*Revenue from users*
	$m	*$m*	*$m*	*$m*	*$m*
Great Barrier Reef WHA	776	147	923	18.1	0.8
Wet Tropics WHA	377	25	402	12.1	0.3
Kakadu National Park	122	na	122	10.8	1.0
Uluru National Park	38	na	38	2.9	1.9
Tasmanian WHA	59	0	59	4.8	0.2
Kosciusko National Park	640	na	640	11.4	10.9
Ningaloo Marine Park	na	na	na	0.5	0.0
Solitary Islands Marine Reserve	na	na	na	<0.5	0.0
Total	**1 918**	**262**	**2 174**	**61.0**	**15.0**

(a) Gross Expenditure by tourists and recreational visitors.
(b) Gross Revenue. These include only values able to be measured.
(c) These include only values able to be measured.
Source: Driml 1994.

5.1.17 Average expenditure (a) of overseas visitors who undertook selected activities in Australia, 1993

Country of residence	Bush-walking $	Scuba diving/ snorkelling $	Rock-climbing/ mountaineering $	Horse/Trail Riding $	Outback safari tours $	Wildflower viewing $	National Park $	All Visitors $
United States	2 483	2 370	2 300	3 932	3 284	2 334	2 098	2 004
Canada	2 580	2 551	2 778	3 292	3 012	2 279	2 211	2 284
UK and Ireland	2 873	3 258	3 429	3 668	4 266	2 754	2 129	1 915
Germany	3 288	3 565	3 071	3 677	3 876	3 723	2 997	2 776
Scandinavia	3 166	3 788	4 230	5 173	4 310	2 935	2 829	2 533
Switzerland	4 080	5 020	4 509	6 103	5 557	3 830	4 010	1 388
Other Europe	2 928	3 548	3 749	3 331	3 278	2 883	2 555	2 303
Japan	1 926	1 513	2 582	1 729	1 881	1 417	1 464	1 388
Other Asia	4 555	2 208	2 431	4 687	2 831	2 837	2 392	2 093
New Zealand	1 344	1 813	2 549	2 241	1 829	1 712	1 509	1 120
Other Countries	3 293	2 941	4 993	5 333	2 783	3 146	2 781	1 843

(a) Includes expenditures on all activities while in Australia, not just selected activities.
Source: Blamey 1996.

5.1.18 Total expenditure (a) of overseas visitors who undertook selected activities in Australia, 1993

Country of residence	Bushwalking $m	Scuba-diving, snorkelling $m	Rock climbing/ mountaineering $m	Horse/ Trail riding $m	Outback safari tours $m	Wildflower viewing $m	National Park $m	All Visitors $m
United States	155	139	41	32	29	43	324	535
Canada	48	40	17	8	14	16	70	109
UK and Ireland	199	180	66	51	63	69	379	578
Germany	143	114	54	18	43	39	210	284
Scandinavia	45	40	18	10	11	6	68	93
Switzerland	59	62	16	12	25	11	88	110
Other Europe	117	92	48	16	29	23	206	307
Japan	56	185	14	14	10	9	380	890
Other Asia	156	33	10	56	10	52	562	1 273
New Zealand	59	18	4	8	2	10	183	519
Other Countries	47	22	6	8	6	4	167	281
Total	**1 084**	**926**	**295**	**232**	**241**	**281**	**2 637**	**4 978**

(a) Includes expenditures on all activities while in Australia, not just selected activities.
Source: Blamey 1996.

under $1,800, while the average expenditure by all those visitors undertaking nature-based activities ranged from just over $2,000 to well over $3,000. The highest expenditure per visitor per trip was by those tourists undertaking horse or trail riding activities, while the lowest expenditure was by the tourists visiting National Parks.

Table 5.1.18 indicates the total expenditure for each visitor group. The lowest total expenditure was for those visitors undertaking horse or trail riding — $232 million — while the total expenditure by tourists visiting National Parks — $2,637 million — was the highest. This range reflects the volume of visitors undertaking each activity.

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Chapter 6 — Resource Consumption and Use

This chapter focuses on the consumption and use of a number of natural resources. Some of these resources have already been covered in Chapter 1 (such as water and soils), although there the statistics were providing an overview of the resources in their capacity as life support conditions. The resources dealt with in Chapter 6 are:

- Forests (Section 6.1);
- Fish and other aquatic resources (Section 6.2);
- Wildlife (Section 6.3);
- Agricultural plants and animals (Section 6.4);
- Water consumption (Section 6.5);
- Minerals (Section 6.6);
- Soil conditions (Section 6.7); and
- Energy (Section 6.8).

6.1 Forests

Forest is defined in terms of tree coverage and height of trees. Australia's National Forest Inventory defines forest as an ecosystem, including all living and non-living components, which is dominated by trees with an existing or potential height greater than two metres and a projected crown area of 20–100%. Due to the difficulties of estimation, Australia's total forest area is not known exactly, but there are 40–43 million hectares of native forest in a total continental area of 768 million hectares (see Tables 6.1.1 and 6.1.2 for estimates of forest cover from different sources). This is a little over 5% of the continent. Before European settlement this figure stood at about 70 million hectares, or about 9% of the total land area. Australia's forests occur in an arc across all of the north of the continent, extending in a broad band down the whole of the east coast and around the south to the Eyre Peninsula in South Australia. There are significant outliers in the south-west of Western Australia. Eucalypts dominate most native forest types (see Table 6.1.3).

6.1.1 Extent of Native Forest and Woodland

	Area	*Proportion forested*
State/Territory	*'000 ha*	*%*
NSW	14 416	18.0
Vic.	4 365	19.8
Qld	9 946	5.8
SA	27	0.0
WA	2 405	1.0
Tas.	2 887	42.6
NT	9 041	6.7
ACT	98	40.8
Australia	**43 185**	**5.6**

Source: RAC 1992a, pp. 2 -12.

6.1.2 Australian forest area, at 30 June 1994

	Native forest	*Woodland*	*Plantation*	*Total*
State	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*
NSW	14 722	3 300	295	18 317
Vic.	5 433	2 500	234	8 167
Qld	11 796	28 200	190	40 186
WA	2 352	20 470	128	22 950
SA	0	900	109	1 009
Tas.	2 934	1 051	131	4 116
NT	3 431	7 000	4	10 435
ACT	51	5	15	71
Aust.	**40 719**	**63 426**	**1 105**	**105 250**

Source: ABARE 1995, p. 115.

Australian forests can be grouped into fifteen broad classes. The coverage of each is listed in Table 6.1.3. Figure 6.1.4 shows a rough distribution of forest and woodland in Australia.

The main defining influences on tree growth and forest type are climate, situation, soil nutrients and hydrology. Fire is a natural part of the forest cycle. All the major forest types are periodically burnt by bushfire, except tropical rainforests where factors such as the moisture and density of vegetation prevent fire taking hold. Many forest trees need fire to regenerate, either to encourage new shoots, to disperse seeds or to crack open their seedpods.

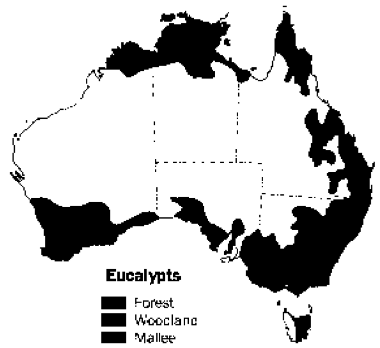
Forest trees are essential for many animals. Australia's flora and fauna have evolved together and many species have developed an interdependence (ESD Working Groups 1991, p. 18). Old growth does not necessarily provide more diverse habitat than a forest with varied ages of vegetation, but it can have greater

6.1.3 Area in each forest group

Forest group	Area '000 ha	Proportion of total %
Eucalypt forest	*25 589*	*59.3*
South-east wet eucalypt forest	4 064	9.4
South-east ash forest	1 482	3.4
South-east coastal eucalypt forest	3 775	8.7
South-west dry eucalypt forest	2 220	5.1
South-west wet eucalypt forest	184	0.4
South-east dry forest and woodland	6 429	14.9
North-east coastal eucalypt forest	2 738	6.3
Central coastal eucalypt forest	4 241	9.8
River red gum forest	456	1.1
Rainforest	*2 544*	*5.9*
Temperate rainforest	1 002	2.3
Tropical rainforest	1 146	2.7
Sub tropical rainforest	396	0.9
Mixed forest and woodland	*14 137*	*32.7*
Northern dry forest and woodland	10 119	23.4
Native pine forest and woodland	4 018	9.3
Mangrove and swamp forest	*913*	*2.1*
Total	**43 185**	**100.0**

Source: RAC 1992a, pp.13-15.

6.1.4 The distribution of forest, mallee and woodland in Australia



Source: AUSLIG 1992, p. 58.

structural diversity and is particularly important for some specific habitat requirements. For example, it provides more nest and shelter hollows for birds and animals than does younger forest (ESD Working Groups 1991, p. 93). It also has particular intrinsic value because of its naturalness.

Several factors threaten the ecological viability of Australia's native forests, including clearing, indiscriminate logging, feral animals, disease and dieback. Dieback is a wider term that actually describes several causes of tree decline. The root rotting cinnamon fungus *Phytophthora*

6.1.5 Tenure over Australia's native forests and plantations, 30 June 1994

Responsibility	Area million ha	Proportion %
Crown land	30.2	72.0
Private land	11.6	28.0

Source: ABARE 1995, p. 115.

cinnamoni spreads when soil is moved from an infected area to an uninfected area.

Responsibility for forests

Table 6.1.5 indicates tenure over native forests in Australia. Private ownership is low compared with countries such as Japan, USA and Germany (ESD Working Groups 1991, p. 23). Of the 11.5 million hectares in State forest, 7.1 million hectares are actually available for sustained wood production. It is difficult to get an accurate estimate of the total area of commercial forest harvested. One estimate is that about 200,000 hectares per year are harvested, and regenerated, in all tenures in Australia (Department of Environment and Land Management 1993, p. 19).

6.1.6 Value of forests

Natural values
Endangered species habitat
Habitat conservation
Wilderness
Preservation of genetic stocks
Soil retention
Climatic regulator
Catchment protection
Economic values
Logging for timber and woodchip
Grazing
Fuelwood
Honey
New economic plants
Potential medicinal uses
Source of biological control agents
Secondary products such as leaf oil, tannin, flowers and fruits, seeds
Other values
Recreation
Education
Scientific research
Spiritual and cultural value
Aesthetic value
Historic and archaeological value

Source: ESD Working Groups 1991, pp. 18-21.

6.1.7 Perceived importance of forest management factors

Factor	Considered 'very important' and 'somewhat important' %
Protect water quality	98
Prevent soil erosion	97
Protect wildlife and plants	97
Counter Greenhouse effect	93
Provide wilderness	85
Provide employment	79
Allow large old trees to grow	78
Reduce imports of timber	75
Areas for bushwalking and camping	72
Maintain forest industries	72
Tourism	64
House and furniture timber	63
Protect Aboriginal values	59
Produce timber for export	44
Produce woodchips for export	33

Source: Dargavel 1995, p. 157.

Changing role of forests

A long term average of 500,000 hectares of forest was cleared annually from the European settlement to the 1980s. Forests were viewed largely from an economic perspective. However, although there was significant clearing for agriculture, the need to protect forests was recognised in legislation from the late nineteenth century. Today, about 18% of remaining eucalypt forests are unlogged, although not necessarily undisturbed (RAC 1992a, p. 27). Attitudes towards the values of forests have diversified in recent times. About 20,000 hectares of plantation are established annually (National Forest Inventory). Some of the many values of forests are listed in Table 6.1.6.

6.1.9 Imports and exports of forest products

Year	Exports (a) '$m	Imports $m	Net imports $m
1988–89	573.3	2 289.1	1 715.8
1989–90	566.3	2 289.7	1 723.4
1990–91	660.2	1 990.2	1 330.0
1991–92	708.6	2 212.8	1 504.2
1992–93	780.4	2 450.8	1 670.4
1993–94	854.2	2 642.0	1 787.8
1994-95p	1 004.4	2 998.8	1 994.4

(a) Includes sawnwood, roundwood, pulpwood, other wood products, paper and paperboard.

Source: ABARE 1995, pp. 121-122.

The wider range of forest values was reflected in the results of a survey of public attitudes to forests (for a list of forest management factors considered by respondents to be 'very important' and 'somewhat important', see Table 6.1.7).

The variety of forest activities necessitates multiple use plans, an example of which is outlined in Table 6.1.8.

Forestry and changes to forests

Logging is one of the major activities undertaken in forests. Table 6.1.9 shows that Australia imports considerably more timber than it exports.

Most of the wood harvested in Australia is used within Australia. Table 6.1.10 compares production with exports for some categories of wood products.

Methods of logging include selective logging and clear felling. Clear felling removes most of the trees in a specified cutting area, with the exception of certain sensitive adjacent areas where all the vegetation is retained for conservation purposes. These areas include stream banks, steep slopes and areas of high

6.1.8 River red gum forest multiple use plan

Use of the forest	Description
Timber	timber for housing, sleepers etc to balance of growth of forest against harvest levels.
Wildlife	forest provides nesting, shelter and feeding habitat for range of wildlife dependent on cycles of flood and drought. Identified nesting sites and habitats are protected.
Catchment	forests have role in deposition of sediment in floods and in flood mitigation by providing water storage.
Recreation	some parts of the forest designated special areas for recreation, preventing over-use and degradation.
Archaeological and historical	Aboriginal canoe trees, middens, sacred places, burial grounds occur through the forest; historic sites and relics from the early use of the Murray River also preserved.
Nature conservation	Central Murray river red gum forests — 12.6% reserves and parks, 4.6% by designation as special emphasis for nature conservation, riverside protection and recreation and as undeveloped forest.
Other values	beekeeping; controlled grazing; education and research.
Employment	forest management and harvesting of products.

Source: ESD Working Groups 1991, p. 48.

6.1.10 Production and export of wood products

	Sawnwood			Other wood products (a)			Paper and paperboard		
	Production	Exports	Exports	Production	Exports	Exports	Production	Exports	Exports
Year	'000m^3	'000m^3	%	'000m^3	'000m^3	%	kt	kt	%
1990–91	2 774	16	0.6	960	86	9.0	2 000	202	10.1
1991–92	2 941	27	0.9	952	161	16.9	2 070	247	11.9
1992–93	3 100	23	0.7	1 253	152	12.1	2 131	284	13.3
1993–94	3 431	41	1.2	1 470	212	14.4	2 237	272	12.1
1994–95	3 691	51	1.4	1 531	207	13.5	2 294	246	10.7

(a) Railway sleepers, veneers, plywood, particleboard, hardboard, medium density fibreboard, softboard and other fibreboards.
Source: ABARE 1995, p. 7.

habitat significance. Trees acting as nesting sites are also left. Planning for clear felling also takes account of landscape values and areas clear felled are dispersed throughout a forest in a mosaic pattern.

By contrast, selective logging removes certain trees of identified economic value. As a rule, less than half the wood harvested in native forest is suitable for saw logs. The choice of selective logging or clearfelling varies between regions and forest types.

Timber production activities influence the environment in various ways: construction and maintenance of roads and tracks, felling, removing and regeneration, control burning, control of pests and diseases, and culling less desirable trees. Effects vary according to the intensity, timing and extent of operations, the structure and condition of the forest, the nature of terrain and soils, climate, and the type of forestry activity undertaken (EPA NSW 1993, p.156). There is scientific dispute about the impact of forestry operations on soil nutrition and compaction. Conservation values are protected and any adverse environmental impacts minimised by adherence to sustainable forest management practices. All State Governments are committed to these practices under the National Forest Policy Statement. Codes of forest practice are currently being reviewed as part of the Comprehensive Regional Assessment (CRA) process to develop Regional Forest Agreements (RFAs).

Logging regimes can cause less disturbance if they fit into the natural cycle of growth and regrowth. Failure to approximate natural fire cycles can favour exotic animals at the expense of native animals.

Measures to reduce the impact of forestry operations include:

- Longer rotations to allow regeneration of mature and varied habitat;
- Retention of seed trees in logged area;
- Planting and aerial spraying of seeds; and
- Codes of forest practice relating to wildlife, soil, water and landscape values.

Hardwoods are necessary for good quality printing and writing paper and for structural applications. From about 18 years of age it is possible to harvest the thinnings for pulpwood, thereby obtaining a financial return as well as encouraging tree growth (Beckman 1991, pp. 25–27). The sources of woodchips are:

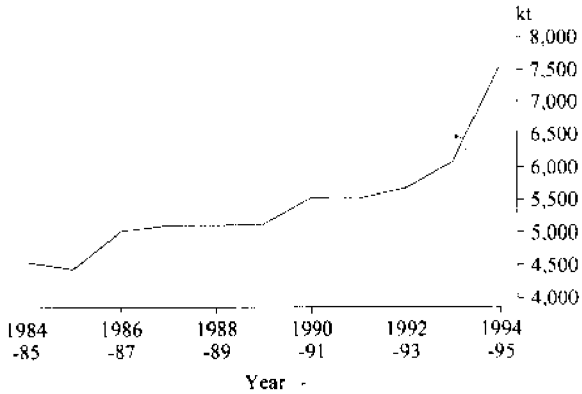
- Native pulplogs from trees, removed as part of integrated harvesting;
- Pulplogs from thinnings in sawlog plantations;
- Short rotation hardwoods grown specifically for pulp;
- Forest residues: branches and other waste left after forest harvesting; and
- Sawmill residues.

Figure 6.1.11 shows the growth in export woodchipping that has occurred since the mid 1980s.

Looking after forests

There are various effects of clearing forest. Pests and insects may more easily overrun the remaining areas of forests, and driving out birds by clearing habitats could also lead to a jump in the numbers of defoliating insects. There is also the possibility of isolating populations of

6.1.11 Australian woodchip exports



Note 1992–93 and 1993–94 data refer to bone dry tonnes. These are equivalent units.
Source: ABARE 1995, p. 123.

animals. Slight changes in habitat may bring in other species which compete successfully with established species (EPA NSW 1993, p. 79). The effects of logging are minimised in forestry programs by continuous regeneration of the harvested areas and by following sustainable forest management practices.

Essentially, forest use must not impair underlying ecological processes. Regeneration from a conservation perspective would try to use seeds from trees on the site, or at least to retain the same mix of species that were originally present, since these are the species best adapted to the conditions and to which the existing flora and fauna have adapted. However, from a wood production perspective it can be advantageous to encourage certain species, and this can conflict with conservation objectives. Regrowth forests can provide habitat for animals which do not use older forests. Forests with a mix of growth stages, including retained old growth, can sustain a wide range of forest life.

6.1.12 Australian forest areas, by year

	Native forest	*Woodland*	*Plantation*	*Total*
	'000 ha	*'000 ha*	*'000 ha*	*'000 ha*
1987–88	40 828	63 986	942	105 756
1988–89	40 972	63 466	974	105 412
1989–90	40 819	63 456	1 023	105 298
1990–91	40 818	63 446	1 046	105 310
1991–92	41 057	63 436	1 073	105 566
1992–93	40 719	63 426	1 083	105 228
1993–94	40 719	63 426	1 105	105 250

Source: ABARE 1995, p. 116.

Table 6.1.12 shows the forest cover in Australia over recent years. The regeneration of harvested areas means that the total forested area remains fairly steady.

Australian governments regulate the use of native forests for social and environmental objectives, according to the requirements of the National Forest Policy Statement. One of the initiatives flowing from the statement is the development of a National Forest Reserve System on public lands, to protect nature conservation values of forests. These reserves will be defined according to the CAR (comprehensive, adequate and representative) concepts and will redress imbalances in protection between various forest types. Criteria for the reserve system are being developed and include a 15% reservation benchmark for each forest type existing before European settlement. In support of this is the National Forest Inventory which collects data and maps forest attributes. This allows gaps in forest information reserves system to be identified. A continental inventory was completed in 1991, and revised in 1996.

The Resource Assessment Commission concluded that although forestry may decrease genetic diversity through tree selection and unnatural fire use and rotations, it is still possible to maintain diversity of species in forests which are being managed for timber harvesting. Table

6.1.13 Goals for ecologically sustainable forest use

Goal	*Objective*
Maintaining ecological processes	Soil base, water, carbon, nutrient and energy cycles protected; forest management strategies for sustainable yields; research into ecological processes.
Maintaining biodiversity	Understanding of conservation needs; valuing biological assets appropriately; conservation and management of biodiversity for future generations.
Optimising benefits to the community	Allocating land to achieve the highest community value.
Optimising economic benefits within ecological constraints	Maximise community returns; competitive wood processing industry; availability of wood resources for industry.
Optimising intangible forest benefits and safeguarding future	Optimise intangible values and non-commercial uses; maintaining options for future generations.
Removing impediments	Institutional arrangements to optimise conservation and economic benefits; remove cultural and policy barriers; nationally co-ordinated forest research.

Source: ESD Working Groups 1991, p. xix.

6.1.14 Forests on national estate listing, 1990

State/Territory	Proportion listed in National Estate %
New South Wales	14
Victoria	25
Queensland	42
South Australia	100
Western Australia	26
Tasmania	25
Northern Territory	18
Australian Capital Territory	41

Source: RAC 1992b, p. 16.

6.1.13 outlines a set of Ecologically Sustainable Development goals prepared for forests.

Regional Forest Assessments are being conducted by the Commonwealth and States. Six million hectares of forest have been set aside as Deferred Forest Areas where logging is prohibited until final decisions are made on reserve boundaries. Woodchipping quotas are contingent on State co-operation with the Regional Forest Assessment and the protection of areas under the forest reserves system. However, the Commonwealth Government has expressed an intention to remove export restrictions on woodchips from plantations. This could encourage more hardwood (eucalypt) plantations.

State policy varies within the national policy framework. The New South Wales government is proposing to cut logging by almost one third, to shift all logging from old growth areas and identify high conservation and old growth areas in a special assessment. Logging is also to be stopped in some regrowth areas pending their evaluation as reserves systems. The Queensland government is proposing guidelines for 90% of trees to be retained across the State. In Victoria the percentage of old growth forests protected has risen from 74% to 83%, an increase of about 20,000 hectares, but at the same time logging

6.1.15 World heritage properties with significant areas of forest

Property	Year proclaimed	State	Area '000 ha
Tasmanian wilderness (a)	1982	Tas.	1 374.0
Central Eastern Rainforest Reserves (Australia)	1986	NSW	203.6
Wet Tropics of Queensland	1988	Qld	890.0
Fraser Island	1992	Qld	166.3

(a) The Lemonthyme and Southern forests were added to the Tasmanian wilderness in 1989, to take total area to 1,374,000 ha.
Source: Dargavel 1995, p. 177.

6.1.16 Plantation areas, at 31 March 1994

State/ Territory	Coniferous (pinus, araucaria, other) '000 ha	Broadleaved (eucalypt, populus, other) '000 ha
NSW	266	29
Vic	215	18
Qld	189	2
SA	107	2
WA	89	39
Tas	76	55
NT	2	2
ACT	15	0
Australia	**959**	**146**

Source: ABARE 1995, p. 115.

quotas for the East Gippsland region have been maintained by the Victorian Government at 174,000 m^3 per year until 2003 and 178,000m^3 for 30 years after that. In terms of the recognition of natural forest values, Table 6.1.14 shows the percentage of forest listed on the National Estate, while Table 6.1.15 lists World Heritage properties in which forest is significant. National Estate listing does not confer any particular protection on a site, but does influence the actions of Commonwealth bodies with regard to the types of activities which are allowed on that site. Significant other areas of forest are protected under various State jurisdictions.

Table 6.1.3 showed the broad forest groups. Some of these groups have received more attention and protection than others. For example, the majority of tropical forest is protected. The Queensland Wet Tropics World Heritage Area covers 890,000 ha, or 78% of all tropical rainforest in Australia (ABS 1994, 1301.0).

Plantations

In addition to the native forest, there are about 1 million hectares of plantation. The majority is exotic softwood (see Table 6.1.16). Plantations were first established in South Australia, the State with the smallest area of forest. Pine plantations have certain soil and water requirements and are sometimes established on land cleared of native forest. Some advantages and problems associated with pine plantations are listed in Table 6.1.17.

A number of species of pine are fast-growing and adaptable to Australia's relatively poor soils, chiefly *Pinus radiata.* Native hardwood in plantations, mainly grown for pulpwood, is grown on much shorter rotation (15–25 years) than in native forests. Plantations are concentrated along the east coast and in the south-west of Western Australia. Of plantations, 339,000 ha are privately owned , with the remainder owned by State and Territory governments (ABARE 1995a, p. 115). A significant percentage of Australia's timber is produced from these plantations (CSIRO 1986, p. 16).

Comparatively few native trees are grown in plantations, although the number is increasing. There is further potential for expansion if farm forestry becomes more common.

6.1.17 Advantages and management problems of pine plantations

Advantages of plantations

- Increased wood per unit area, which reduces pressure on native forest.
- Plant breeding possible.
- Good nutrition, including fertilising.
- Control of pests, diseases and fire.

Management problems

- Disease can be particularly devastating to a monoculture of genetically similar trees.
- Pines can escape and invade surrounding native forest, out-competing natives.
- Native plants and animals cannot survive permanently in pine forest.
- Wood wasp (Sirex).
- Bark beetles.

Source: ECOS 80 1994, p. 11.

Farm forestry

The Farm Forestry Program, a Commonwealth initiative, defines farm forestry as "the incorporation of commercial tree growing into farming systems". A possible impediment to farm forestry is that the best land for both hardwood and softwood plantations is generally also the best for agriculture, and agriculture offers returns much faster than forestry. However, the CSIRO has estimated that much of the land used for grazing and cropping needs treatment for land degradation and that revegetation is an important component of this, since plantations impose smaller drains on soil than intensive

6.1.18 Research into forest products

Technique	*Advantages*
Genetic engineering	cross-pollination; genetic engineering to create trees which are more tolerant of extremes in growing conditions and which outperform hardwoods in yield, hardness, reliability and speed of growth[1].
Processed wood	structural material produced form crushed tree stems[2].
Seed banks	CSIRO has maintained a seed bank for 25 years; grows miniature eucalypts which produce seeds rather than vegetative growth; 25–30 tonnes of native seeds exported annually, worth $9 million[3].
X-Rays	use X-Rays to assess trees for their timber quality before they are felled[4].
Inoculation	inoculation of trees with fungi which help the trees extract phosphorous and other nutrients from infertile soil. Up to 30% growth increase, reduced rotation periods[5].
Charcoal	pelletised charcoal from timber cutting residues, used for fuelling sawmills — important as up to 65% of a sawlog ends up as residue after cutting, and up to 25% more lost during machining of the wood[6].
Board, pulp	particle board, hardboard and craft wood form sawmill residues, also some pulp[7].
Resistance	certain trees resist certain types of insect that decimate other trees — example, Christmas beetles completely defoliate manna gums but do not touch silver-topped ash[8].
Conditioning stock	stock can be conditioned not to eat eucalypt seedlings planted on farms[9].
Timing of fertilisation	Irrigation and fertilisation at certain times and combinations for maximum effect — for example, nitrogen uptake is affected by soil moisture.
Other	planting legumes amongst plantation trees to increase their uptake of nitrogen[10].
	plantations to act as sewage treatment.
	medicinal uses of forest products.
	climate variation plays a role in the outbreak of forest diseases and insect pests, and also influences when and where plantations are established[11].
	Tredat is a database developed by CSIRO, storing results of field trials; environment of the site, management practices used plus info on use of trees for fuelwood, in horticulture, as industrial crops, and for countering land degradation[12].
	Young eucalypt Program (YEP) a CSIRO research program which "investigated the growth, harvesting and use of intensively managed young (<30) eucalypts in SE Australia.
	Acacia seeds have outstanding protein, fat and energy values. Potential increased market for eucalyptus oil to replace trichloroethane as an industrial degreaser and solvent. Trich. is being withdrawn from use in the mid 1990s due to ozone depletion controls. Replacing whole market would take an estimated 10 million hectares of eucalypts[13].
	Macadamia is the only native food plant that is cultivated commercially. However, potential has been identified for various nuts, seeds, fruits, vegetables, herbs, spices and oils. This will require research and propagation techniques.

Source: [1]Environmental Update August 1994, p. 20; [2]CSIRO 1986, p.16; [3]Department of Prime Minister and Cabinet 1994, p 45.; [4]Environmental Update February 1995, p. 11; [5] ECOS 85 1995, p. 5; [6,7] ECOS 65 1990, p. 26; [8] ECOS 70 1991/92, p. 23; [9] Trees and Natural Resources Vol 37 No 3 Sept 1995; [10]CSIRO 1986, p. 23 [11] ECOS 84 1995, p. 21; [12] ECOS 66 1990/91, p. 3; [13] ECOS 82 1994/95, p. 6.

agriculture (CSIRO 1986, p. 18). CSIRO research classified land according to suitability for agricultural use and tree growing. Of 18.5 million hectares, 5.6% or about 1 million hectares had high plantation capability and low agricultural intensity. 400,000 hectares (2.1%) had medium capability and low agricultural intensity (Lehane 1993, p. 35).

Some of the advantages Fitzpatrick noted with farm forestry are that:

- trees protect the land from salinity and erosion;
- trees can increase soil fertility and lower soil acidity;
- trees help water retention in the soil, increasing growing seasons; and
- shelter reduces stress on crops and animals.

As well as these benefits, Fitzpatrick also noted various products might be derived from farm forestry. These include:

- timber;
- teatree oil, eucalyptus oil;
- sandalwood;
- honey;
- cut flowers and foliage;
- seed; and
- fodder.

From an agricultural perspective, trees can also harbour insects and birds useful to the crops. Trees may return more per unit area than the primary products originally grown on the land (Fitzpatrick 1994, p. 35). Trees were cleared in the past not only for direct use of the land, but because tree clearing was thought to improve pasture grasses.

Along similar lines to farm forestry is the North Queensland Community Rainforest Reforestation Programme, under which private landholders have planted thousands of hectares with rainforest and native eucalypt species. These will be harvested in the future.

Forest Research

A great deal more attention has been given to selection and breeding technology in agricultural plants than forest trees. This is chiefly due to the long regeneration times of trees (Department of Prime Minister and Cabinet 1994, p. 46). Table 6.1.18 summarises some aspects of research that has been conducted into forest products.

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6.2 Fish and other aquatic resources

Aquatic ecosystems contain resources that cfontribute significantly to the economic wellbeing of Australia in addition to providing an important food stock for the population. Australia's fisheries rank fifth among rural industries in terms of contribution to the economy after wool, beef, wheat and dairy products (ABARE 1995a). However, there are concerns about the ability of aquatic ecosystems to sustain the rate of harvesting of stocks that makes this economic contribution possible.

Because the marine ecosystems in areas adjacent to Australia have limited productivity, fishing activity and catches are relatively modest when compared to those of other fishing areas (see Table 6.2.1). Australia itself is a reasonably small player among fishing nations in terms of total catch by weight (see Table 6.2.2). Many of our near neighbours take larger amounts of fish than Australia. Nevertheless, substantial pressure has been exerted on existing fish stocks in the waters near Australia through harvesting and the effects of other activities. While direct harvesting is the greatest influence on the numbers of fish in most established fisheries, the process of fishing can also influence regeneration of the stock. Factors may include:

- the size and age class of the individuals taken;
- enough fish must be left to serve as the future breeding stock;
- through bycatch, i.e. fish unintentionally caught and returned to the sea, usually with a very low rate of survival;
- certain types of harvesting can damage environments and make it more difficult for the fish that escape to find food and shelter from predators. Trawling, for example, can drastically change the bottom of the ocean area over which the nets are towed;
- other human activities can also have major impacts on the ability of stocks to regenerate;
- land use change in estuaries and other coastal breeding areas; and
- runoff of contaminants and sediments from land based activities can damage or destroy fish breeding habitats.

Part of the difficulty in managing stocks of fish is that the estimation of fish populations and assessment of resource state and sustainability is subject to significant sources of uncertainty. Population numbers are usually difficult to assess. In the absence of a direct method of measuring stocks, information on catches of fish is usually used as one of the parameters in models to estimate stocks. However, because catch is only one of the factors affecting the total population and its ability to regenerate its numbers, catch statistics are rather poor measures for evaluating fish stocks and their sustainability.

6.2.1 World catches in seas adjacent to Australia and elsewhere, 1987 and 1993

Marine Fishing Areas (a)	*1987* Kt	*1993* Kt
Zones adjacent to Australia (b)	10 259	12 598
Other Indian Ocean	2 765	3 843
Other Pacific Ocean	41 958	44 418
Atlantic Ocean	24 586	21 720
Mediterranean & Black Seas	1 971	1 670
Arctic Sea	0	0
All Marine Fishing Areas	**81 539**	**84 249**

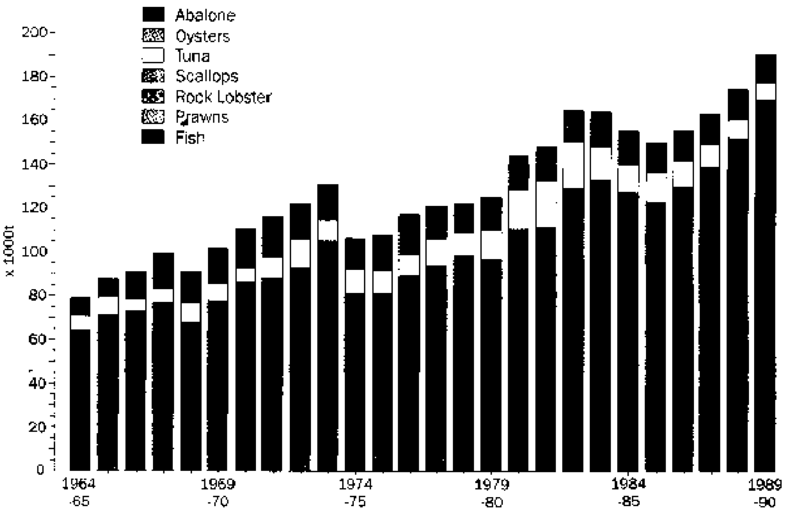
(a) UN FAO Marine Fisheries Zones for Statistical Purposes. The FAO divides the seas of the world into 19 major fishing areas. Three of these zones touch Australian shores.
(b) Eastern Indian Ocean (zone 57). Western Central Pacific (zone 71), and South-west Pacific (zone 81).
Source: FAO 1995, p 91.

6.2.2 Catch for selected fishing nations, 1993

Country	*Annual catch* '000 tonnes	*Proportion of world catch* %
China	17 567.9	17.3
Peru	8 450.6	8.3
Japan	8 128.1	8.0
Chile	6 038.0	6.0
USA	5 939.3	5.9
Russia	4 461.4	4.4
India (a)	4 324.2	4.3
Indonesia (a)	3 637.7	3.6
Thailand (a)	3 348.1	3.3
South Korea	2 649.0	2.6
Philippines (a)	2 263.8	2.2
Vietnam (a)	1 100.0	1.1
Bangladesh (a)	1 047.2	1.0
Myanmar (a)	836.9	0.8
Malaysia (a)	680.0	0.7
New Zealand (a)	470.4	0.5
Australia	**218.3**	0.2
Other countries	30256.6	29.8
Total	**101417.5**	**100.0**

(a) Indicates a nation with coastline in an FAO fishing zone also adjacent to Australian coastline (see Table 6.2.1).
Source: FAO 1995, p 89.

6.2.3 Australian Fisheries Production 1964–65 to 1989–90



Source: BRS 1993, p 3.

Australian fisheries

Figure 6.2.3 presents a time series of catch statistics by major groups, while Table 6.2.4 presents recent statistics on the amount and value of catch in the Australian fishery. The Bureau of Resource Sciences reports that Australia's fishery catch, in terms of total landed weight, is not expected to expand much beyond its present level (BRS 1993, p. 2). Since 1992–93, total catch has been lower (see Table 6.2.4), although the value of the catch has increased (ABARE 1995b).

As Figure 6.2.5 illustrates, the Bureau of Resource Sciences suggests that many of the currently harvested stocks within Commonwealth waters are either fished to, or over, their capacity to be self sustaining. Many State fisheries are also fully exploited or over-exploited A number of species in certain areas have been subjected to fishing pressures that have contributed to serious declines in catches, indications that stocks of these species have also been reduced. Among these species are the southern bluefin tuna, the orange roughy and the gemfish.

6.2.4 Australian fisheries production (a)

	Quantity			*Value*		
	1992–93	*1993–94*	*1994–95p*	*1992–93*	*1993–94*	*1994–95p*
	tonnes	*tonnes*	*tonnes*	*$'000*	*$'000*	*$'000*
Fish						
Tuna (b)	10 220	7 703	7 937	116 150	107 802	115 492
Other	134 958	123 573	129 259	322 022	354 763	362 517
Total	145 178	131 276	137 197	438 172	462 565	478 009
Crustaceans						
Prawns	24 805	22 766	25 259	287 329	315 963	329 135
Rock lobster	18 434	16 770	16 329	348 770	429 571	435 075
Other	5 562	7 543	7 606	29 480	38 361	37 006
Total	48800	47080	49 194	665579	783895	801 215
Molluscs						
Abalone	4 668	4 673	5 101	127 512	178 393	148 408
Scallops	33 630	24 141	12 199	88 084	71 712	51 398
Oysters	8 561	8 707	8 434	41 159	42 437	42 204
Other	4 940	5 136	6 148	132 172	146 923	223 281
Total	51798	42657	31 882	388927	439465	465 290
Australian Total (b)	**245 778**	**221 012**	**218 273**	**1 492 678**	**1 685 925**	**1 744 514**

(a) Totals include estimates of aquacultural production but exclude hatchery and inland commercial fishery production.
(b) Total has been adjusted to allow for southern bluefin tuna caught in the Commonwealth southern bluefin tuna fishery, as an input to farms in South Australia.
Source: ABARE 1995b.

For management purposes, Australian fisheries are subdivided by area and by species or method of fishing. The States traditionally have managed waters out to the three mile limit. The Commonwealth in turn has dealt with activities between three and 200 miles from shore. Major fisheries within Commonwealth waters are: northern prawn, Torres Strait prawn, south-east trawl, southern shark, Great Australian Bight trawl, east coast tuna, east coast purse seine, southern bluefin tuna, the north-west slope trawl and the western deepwater trawl. In all, about 70 State and Commonwealth fisheries have been recognised. This changed in June 1995 when new arrangements came into effect whereby a number of State managed inshore fisheries are managed as part of Commonwealth fisheries.

Fish catches are a function of fishing effort and the methods and equipment used by the fishers as well as the size of the stock present in the area fished. Fisheries managers regulate the methods, equipment and effort in order to limit catches and thus support the regeneration of stocks.

The nature of the control in a particular area depends on the species being pursued, the characteristics of the fleet and the aquatic environment. The methods used in the Australian fishery include the setting of total allowable catches for individual species in an area and the allocation of transferable quotas to operators (south-east fishery), restrictions on the numbers of operators and entry limitation (northern prawn fishery), as well as gear restrictions to, in effect, allow more of a pursued stock to escape (Southern Bight fishery). Limiting the catch season and closing particular areas are also methods at the manager's disposal.

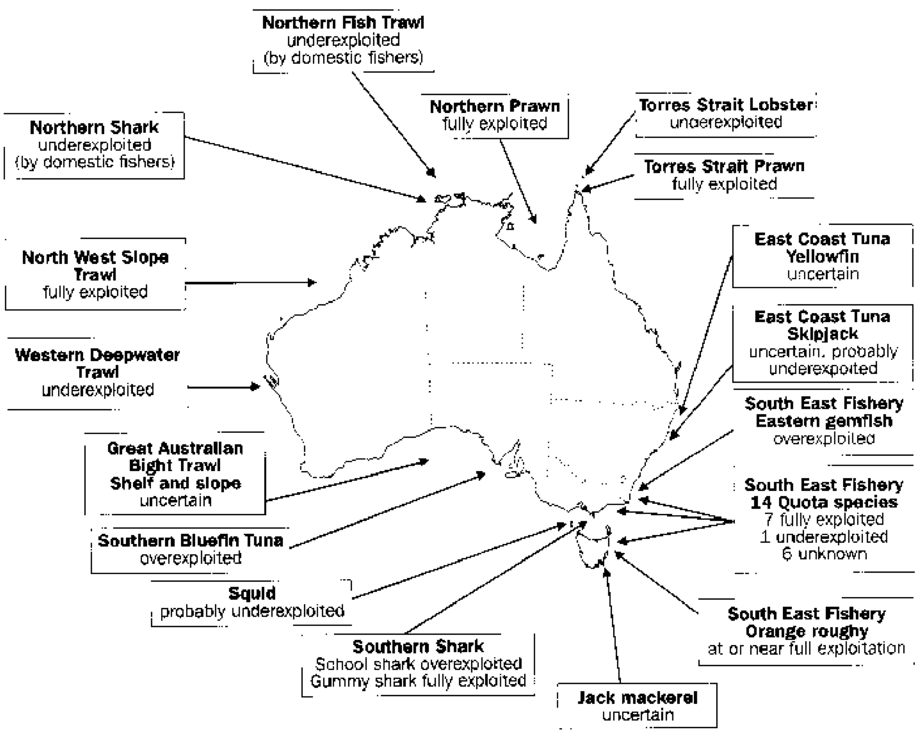
Regional fisheries

A number of tables that follow present more detailed information on catches by regional groupings.

Table 6.2.6 presents information on Commonwealth administered fisheries in the north. Prawn catches varied considerably from year to year for the period presented in the table. A number of management controls are in place in the northern prawn fishery because of past concerns about species numbers. Tiger prawns, for example, were considered over-exploited in the 1980s. Continued fluctuations in prawn numbers are thought to be at least partly the result of environmental factors.

Since most prawns have a life span of 1 to 2 years, environmental conditions during spawning can have a major influence on the size

6.2.5 Status of Commonwealth or jointly managed fisheries resources



Source: BRS 1995.

6.2.6 Commonwealth fisheries production — northern fisheries (a)

Fishery and species	1990–91 tonnes	1991–92 tonnes	1992–93 tonnes	1993–94 tonnes	1994–95p tonnes
Northern prawn					
Tiger prawn	3 364	4 142	2 891	2 806	3 520
Banana prawn	6 987	2 508	4 058	2 433	4 095
Endeavour prawn	727	1 054	813	794	756
King prawn	109	78	49	40	70
Total	**11 187**	**7 782**	**7 811**	**6 073**	**8 441**
Torres Strait					
Prawn					
Tiger prawn	674	764	586	533	568
Endeavour prawn	933	989	988	1 087	1 051
King prawn	57	58	44	48	32
Other prawn	9	6	5	8	4
Prawn Total	1 673	1 817	1 623	1 676	1 655
Tropical rock lobster	171	147	174	185	180
Spanish mackerel	106	100	102	102	70
Total	**1 950**	**2 064**	**1 899**	**1 963**	**1 905**

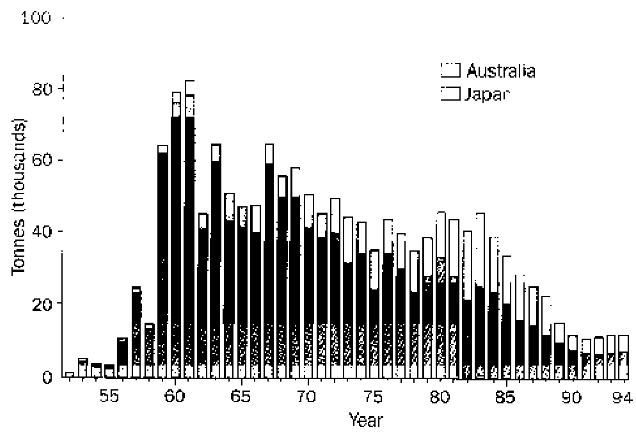
(a) Estimates.
Source: ABARE 1993; 1994; 1995b.

of stocks. Heavy rains and extensive flooding, for example, are thought to contribute to large populations of banana prawns in the summer that follow these events. The large catch for 1990–91 illustrates this.

Table 6.2.7 presents information on catches of tuna and related species. Despite controls on catches of many of these species, concerns about population sizes persist. Because tuna are highly mobile, the catches of fish by other nations outside Australian waters must also be taken into consideration when establishing plans to manage the Australian fishery.

The southern bluefin tuna, for example, is a highly valued species that is now found in relatively small numbers as a result of serious overfishing on the part of several nations in the past. Table 6.2.7 shows that Australian catches in recent years, controlled by the quotas in place, have been in the order of 5,000 tonnes. Added to Japanese and New Zealand catches the total

6.2.8 Southern bluefin tuna catch, 1952–1994



Source: BRS 1995, p 50.

6.2.7 Commonwealth fisheries production — pelagic fisheries

Species	1990–91 tonnes	1991–92 tonnes	1992–93 tonnes	1993–94 tonnes	1994–95p tonnes
East coast tuna					
Yellowfin	569	702	752	679	820
Skipjack	0	208	397	327	12
Albacore	86	203	156	261	349
Bigeye	14	37	23	45	128
Other	36	94	52	110	116
Skipjack — east coast purse seine	6 000	6 633	3 855	1 815	1 182
Southern bluefin tuna (a)	4 343	5 135	4 895	4 697	5 201

(a) Excludes any other tuna species caught in southern bluefin tuna fishery.
Source: ABARE 1993; 1994; 1995b.

6.2.9 Commonwealth fisheries production south-east trawl fishery (a)

Species	1992–93 tonnes	1993–94 tonnes	1994–95p tonnes
Orange roughy	12 023	9 965	6 527
Blue grenadier	3 039	3 048	3 240
Tiger flathead	1 549	1 483	1 585
Redfish	839	608	1 016
Blue warehou	968	865	673
Silver warehou	1 274	1 738	1 891
School whiting	900	1 169	993
Morwong	848	780	808
Ling	805	959	1 023
Gemfish	717	406	260
Silver trevally	194	175	174
Mirror dory	260	302	292
Royal red prawn	174	355	192
Ocean perch	262	286	255
John dory	104	123	122
Blue eye	78	97	53
Other	5 507	3 773	4 672
Total	**29 541**	**26 132**	**23 776**

(a) Estimates.
Source: ABARE 1995b.

annual take is about 13,500 tonnes. This contrasts with catches in the order of 80,000 tonnes in the early 1960s (see Figure 6.2.8).

The Southern Shark fishery in Commonwealth waters off Tasmania, Victoria and South Australia has also been the subject of concern regarding over-exploited stocks.

The south-east trawl fishery provides most of the fresh fish found in markets along the east coast of Australia. Here too limits on catch have been imposed because concerns exist about the size of a number of the stocks. Catch quotas are used as a means of control. Table 6.2.9 presents recent catches in the fishery while Table 6.2.10 presents an assessment of the status of many of the species. As the table indicates, many of the species are fully exploited while a few, such as the eastern gemfish, are over-exploited. The eastern gemfish stock bycatch (including discards) of about 250 tonnes in 1994 was considerably lower than the 1993 total of about 600 tonnes (see Figure 6.2.11) (BRS 1995 p73).

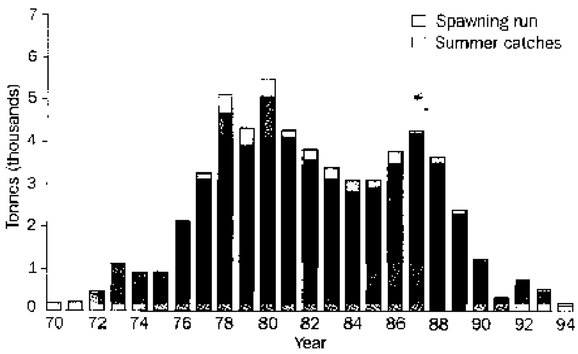
The orange roughy fishery off eastern Australia has developed in the last 13 years. Population concentrations of this long lived, slow growing fish in deep water off Tasmania and in the Great Australian Bight were located and these were heavily fished. TACs are now used to manage

6.2.10 Status of south-east fishery quota fisheries

Fishery	Information base	Sustainable yield estimate	Able to sustain 1993 catch level	Status
Orange roughy, east	moderate	yes	no (a)	fully exploited
Orange roughy, south	moderate	yes	probably not (a)	fully exploited
Orange roughy, west	poor	no	probably not	fully exploited
Gemfish, east	adequate	yes	no	over exploited
Gemfish, west	moderate	no	yes	fully exploited
Tiger flathead	adequate	yes	yes	fully exploited
Blue grenadier	moderate	yes	probably	under exploited
Redfish	moderate	yes	no	over exploited
School whiting	moderate	no	uncertain	fully exploited (b)
Jackass morwong	adequate (c)	yes	yes	fully exploited and under exploited (d)
Silver warehou	moderate	no	uncertain	uncertain
Blue warehou	moderate	no	uncertain	uncertain
Ling	poor	no	uncertain	uncertain
Mirror dory	poor	no	uncertain	fully exploited
John dory	poor	no	probably	fully exploited
Silver trevally	poor	no	uncertain	uncertain
Ocean perch (d)	moderate	no	uncertain	fully exploited and under exploited
Blue-eye trevalla	moderate	no	probably	uncertain
Royal red prawns	moderate	no	probably	uncertain

(a) 1995 Total Allowable Catch to be at estimated sustainable yield level under strategy fishing plan.
(b) Jervis Bay — Portland stock only.
(c) Subject to adoption of revised age/growth parameters.
(d) Fully exploited in the eastern sectors; under exploited in the south-west sector.
Source: Tilzey 1994.

6.2.11 Eastern Gemfish catch, 1970–94



Note: This is landed catch as recorded in logbooks and not necessarily total catch. This is important in recent years for eastern gemfish because of the proportionally larger amount of discards.

Source: BRS 1995

stocks in the south-east fishery. However, the lifehistory of this species makes the status of this resource difficult to assess (BRS 1993). It is estimated that the current biomass of roughy is now only about 35% of what it was when fishing for this species started in 1972. While this initial removal of biomass may not prevent a sustainable fishery at lower catch levels to be established, uncertainty exists about the correct levels of catch to allow, and so TACs are set to be intentionally conservative (BRS 1994).

6.2.12 Orange Roughy catch, 1986–1995

Year	*tonnes*
1986	4 226
1987	6 600
1988	11 200
1989	29 500
1990	45 000
1991	22 600
1992	300 000
1993	11 400
1994	7 600
1995	5 173

Source: BRS 1995.

Aquaculture

Aquaculture is an important contributor to fisheries production in Australia. In addition to farmed fish, much of Australia's shellfish are produced through aquaculture.

6.2.13 Aquaculture production, 1994–95 (a)

	NSW		*Victoria*		*Queensland*		*WA*		*SA*		*Tasmania*		*Australia (b)*	
	$000	*tonnes*	*$000*	*tonnes*	*$000*	*tonnes*	*$000*	*tonnes*	*$000*	*tonnes*	*$000*	*tonnes*	*$000*	*tonnes*
Fish														
Salmon	0	0	0	0	0	0	0	0	0	0	67 000	6 000	67 000	6 000
Trout	1 587	281	5 712	1 400	0	0	0	0	473	65	30 820	2 680	38 592	4 426
Tuna	0	0	0	0	0	0	0	0	24 225	1 275	0	0	24 225	1 275
Other (c)	452	39	2 107	208	2 400	235	0	0	299	27	0	0	5 259	509
Total	2 040	320	7 819	1 608	2 400	235	0	0	24 997	1 367	97 820	8 680	135 076	12 210
Crustaceans														
Prawns	3 736	248	0	0	24 000	1 400	0	0	0	0	0	0	27 736	1 648
Yabbies	452	30	51	5	0	0	2 610	290	293	26	0	0	3 406	350
Marron	7	0	0	0	0	0	440	18	85	3	0	0	532	21
Other (d)	20	2	357	4	586	39	0	0	0	0	0	0	963	45
Total	4 215	280	408	9	24 586	1 439	3 050	308	378	29	0	0	32 638	2 064
Molluscs														
Edible oysters	28 571	5 618	18	5	670	150	0	0	1 945	486	11 000	2 175	42 204	8 434
Pearl oysters	0	0	0	0	0	0	160 000	na	0	0	0	0	206 215	na
Other (e)	162	34	500	140	0	0	890	325	0	0	1 050	300	2 601	799
Total	28 732	5 652	518	145	670	150	160 890	325	1 945	486	12 050	2 475	251 020	9 233
Total	**34 987**	**6 252**	**8 745**	**1 761**	**27 656**	**1 824**	**163 940**	**633**	**27 320**	**1 882**	**109 870**	**11 155**	**418 733**	**23 507**

(a) Excludes aquarium fish, hatcheries production, crocodiles, microalgae, and aquarium worms.
(b) Australian total includes Northern Territories.
(c) Includes eels and other native fishes.
(d) Includes crabs and brine shrimp.
(e) An estimate based on previous years figures.
Note: National and Pearl oyster totals includes $46 million of pearl oysters produced in the NT.
Some figures included in this table are assumed to be unchanged from previous years, please refer to original publication for more details.
Source: ABARE 1995b.

As Table 6.2.13 illustrates, Atlantic salmon and bluefin tuna are the most important farmed fish in terms of value. The salmon industry is centred in Tasmania and accounts for 54% of that State's aquaculture production, while tuna are farmed in South Australia and comprise 89% of that State's total value of aquaculture production.

The largest overall contributor by value is the pearl oyster, comprising over 49% of the nation's aquaculture production. Edible oysters are also very significant. In New South Wales, for example, they account for 82% of the value of the State's aquaculture production. In Tasmania and Victoria, trout are important aquaculture species, while Queensland has a major prawn farming industry.

Recreational fishing

The contribution of recreational fishing to total fish catch and the overall impact on stocks are largely unquantified (BRS 1993). It is known that there are relatively large catches of some species, particularly close to populated areas.

Recreational fishing is a popular leisure activity. A 1984 survey found that one third of the population over the age of 10 went fishing at least once a year (BRS 1993). Further information on recreational fishing can be found in Section 9.4.

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6.3 Wildlife

Introduction

The term 'wildlife' denotes plant and animal species that are not under cultivation or domestication. In an Australian context this includes both native and introduced species.

This section is concerned with the current commercial and non-commercial use of wildlife in Australia, which includes the hunting and trapping of wild animal species and the harvesting of wild plant species. It also looks at the control of pest animals, the illegal export of native species and the use of wildlife for scientific and zoological purposes. The use of fish and other aquatic resources is discussed in Section 6.2.

As described in Section 1.4 (State of flora and fauna), Australia has a rich diversity of native species, many of which are unique to this continent. Aboriginal peoples have harvested wildlife as hunter-gatherers since their arrival on the continent over 40,000 years ago. It is probable that they harvested all available forms of animal life (Cairns & Kingsford 1995, p. 260). European settlers also harvested wildlife for recreation, subsistence, commercial gain and pest mitigation (Frith 1973 cited in Cairns & Kingsford 1995, p. 260). The native species harvested historically are listed in Table 6.3.1.

Since the arrival of Europeans a wide range of exotic species have also been introduced (see Section 9.3). As the human population of Australia has grown, its impact on the wildlife population has increased. This impact has favoured some species and severely disadvantaged others (Recher & Lim 1990).

Several species of wildlife are captive bred to supply products for the export market. These include emus, various insects (e.g. butterflies), and crocodiles (Australian Nature Conservation Agency (ANCA) 1994, p. 57; see Section 6.4 Agricultural plants and animals). Native birds and snakes are also bred for the domestic market.

Use and management of wildlife resources in Australia

The size and structure of the wildlife industry in Australia is determined by a combination of legislation, species ecology, economics and public attitudes.

The legislation which relates to the use of wildlife in Australia is listed in Table 6.3.2. Domestically

6.3.1 Australian species harvested historically

Species	*Purpose*	*Period of harvest*
Reptiles		
Marine Turtles	food and shell	1920–72
Saltwater Crocodile	skins	1940–72
Freshwater Crocodile	skins	1960–72
Other reptiles (lizard, snakes and turtles)	pet trade and collections	pre 1960s
Birds		
Emu	pest mitigation, meat, leather and oil	pre 1960
Albatross	feathers	1890–1910
Egrets	feathers	1890–1910
Cape Barren Geese	pest mitigation, food and recreation	pre 1965
Pigeons	food and recreation	pre 1920
Lyrebirds	feathers	pre 1920
Bowerbirds	feathers	pre 1920
Riflebirds	feathers	pre 1920
Mammals		
Thylacine	pest mitigation	pre 1930
Koala	skins	pre 1927
Dugong	food and oil	pre 1977
Fur Seals	skins	1790–1820
Australian Sea-lion	skins	1790–1820
Southern Elephant Seal	oil	1790–1820
Whales (Humpback, Southern Right)	oil	1790–1962
Whales (Sperm)	oil	1790–1978

Source: Cairns & Kingsford 1995, p. 261; Commonwealth Bureau of Census and Statistics (ABS) 1972–1979.

6.3.2 Legislation relevant to the Australian wildlife industry

Type of legislation	*Specific legislation*
International agreement aimed at regulating and monitoring trade in wildlife.	*Convention on International Trade in Endangered Species of Wild Flora and Fauna* (CITES) effective since 1975.
Legislation by individual countries to restrict imports of wildlife species which they determine are threatened by commercial use.	*Endangered Species Act 1973* (USA).
Legislation by individual countries to set minimum standards for import of products such as meat for human consumption.	Various.
Domestic legislation to conserve native species (and implement CITES).	*Wildlife Protection (Regulation of Exports and Imports) Act 1982; various* State and Territory legislation.
Domestic legislation to ensure minimum standards are met for the processing of wild animal products for domestic and export markets.	Various State and Territory legislation (domestic market); *Export Control Act 1982* (export market).
Pest control legislation.	Various State and Territory legislation.

Note: For a complete listing of legislation refer to Table 13.1.1.
Sources: Ramsay 1994; ANCA 1994.

the most powerful of these is the Wildlife Protection (Regulation of Exports and Imports) Act 1982, administered by the Australian Nature Conservation Agency (ANCA), which controls the export and import of wildlife and their products (ANCA 1994, p. 53). The Act provides the legislative base for meeting Australia's responsibilities under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Enforcement of the Act is primarily undertaken by the Australian Customs Service, with which the ANCA works in close cooperation (ANCA 1994, p. 53).

Management plans are required for all native species exported from Australia to ensure that harvesting is not detrimental to their continued survival. These plans are usually administered by State or Territory Government agencies (ANCA 1994 p. 54). The harvesting rates for native animals are controlled by quotas which are jointly determined by the conservation agencies of each State and Territory and the ANCA. These quotas are based on the estimated populations of the respective species.

The annual wholesale value of trade in wildlife and their products is conservatively estimated to be between $166 million and $190 million, of which the kangaroo and wallaby trade is the most important (see Table 6.3.3). The value of most commercially viable species is increasing.

6.3.3 Estimated annual wholesale value of trade in wildlife and their products

	Value	
Species	*$ million*	*Growth trend*
Kangaroos and wallabies	50–60	Increasing
Goats (a) (b)	27–28	Increasing
Horses (a)	22–25	Static
Wild boar	15–20	Increasing
Wild rabbits	8–9	Increasing
Feral buffalo	5–6	Decreasing
Wildflowers & wildplants	9	Increasing
Wild foods	25	Increasing
Crocodiles (c)	2–3	Increasing
Red fox	1–2	Decreasing
Others (d)	2–3	na
Total	166–190	Increasing

(a) Includes wild and domestic animals.
(b) Does not include value of the fibre trade.
(c) Includes captive bred stock.
(d) Includes brushtail possum, hare, cane toad, deer, and feral camel, cat and donkey.
Sources: Ramsay 1994; Graham, C 1996, pers.comm.; ABS 1996, unpub.

Hunting

At present only seven native species are commercially hunted in Australia (see Table 6.3.4). Red kangaroos and Wallaroos are hunted in Queensland, New South Wales, South Australia and Western Australia; Eastern Grey kangaroos are hunted in Queensland and New South Wales; Western Grey kangaroos in New South Wales, South Australia and Western Australia; Whiptail wallabies in Queensland and both Brushtail possums and Muttonbirds in Tasmania. Until 1986 the Bennett's and Rufous wallabies were also hunted in Tasmania.

Quotas are the usual method for regulating harvest, but have not always ensured that the harvesting of native animals has been sustainable. The Australian whaling industry, after its re-establishment in 1949, illustrates this. Quotas were set by the Minister for Primary Industry to conserve the stock of whales and thereby maintain industry stability. However, as Figure 6.3.5 shows, quotas for humpback whales were set at unrealistically high levels throughout the

6.3.4 Commercial hunting of native species

	Number harvested			Products and their export value, 1991–92 (a)				
	1985	1989	1992	Pet meat	Game meat	Skins/ leather	Other (b)	Total value of products
Species	'000	'000	'000	$'000	$'000	$'000	$'000	$'000
Kangaroos and Wallabies (c)	1 869.2	2 567.9	2 816.3(d)	220.1	499.0	27 691.4	..	28 410.4
Brushtail Possum	115.2	59.7	29.7	..	..	66.6	..	66.6
Muttonbirds	324.5	217.6	137	..	243.0(e)	..	17.3(e)	260.3

Note: where the harvest data were collected in a financial year they were converted to a calendar year to allow comparison across species (e.g. the 1985–86 financial year equates to the 1985 calendar year).

(a) Excepting Mutton bird which are 1990 figures.

(b) Includes oil and feathers.

(c) Includes the Red, Western and Eastern Grey Kangaroos, the Wallaroo or Euro, and the Whiptail, Bennett's and Rufous Wallabies. There has been no commercial hunting of the Bennett's and Rufous Wallabies since 1986.

(d) Excludes figures for the Whiptail Wallaby.

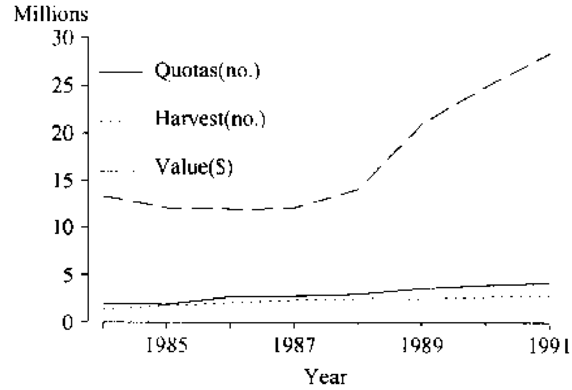
(e) Total value for domestic market and exports (breakdown not available).

Sources: Ramsay 1994; Hocking 1995, 3; Blackhall, S 1996, pers.comm.

1950s. The number of whales taken peaked in 1954 (at 2039) and again in 1956 (at 1990). A gradual decline followed, until the number of whales taken plummeted in 1962 to 718 due to whale scarcity. In July 1963 a complete prohibition was placed on the taking of Humpback whales by the International Whaling Commission (IWC). The falling stock of Humpback whales prompted whalers to switch to the taking of Sperm whales, which were not subject to quotas until 1972–73. These remained the focus of harvesting efforts until November 1978 when whaling ceased in Australia. Since then Australia has consistently voted against an international resumption of commercial whaling at IWC meetings (Alpin et al., 1995, p. 241).

The use of quotas for the commercial harvesting of kangaroos and wallabies has had greater success in balancing harvesting rates with population estimates. Figure 6.3.6 shows that the number of kangaroos and wallabies harvested has risen slowly, well within the set quotas, from 1984 to 1991. The value of products over the same period has more than doubled, from $13.2 million in 1984–85 to $28.4 million in 1991–92 (at 1991-92 prices).

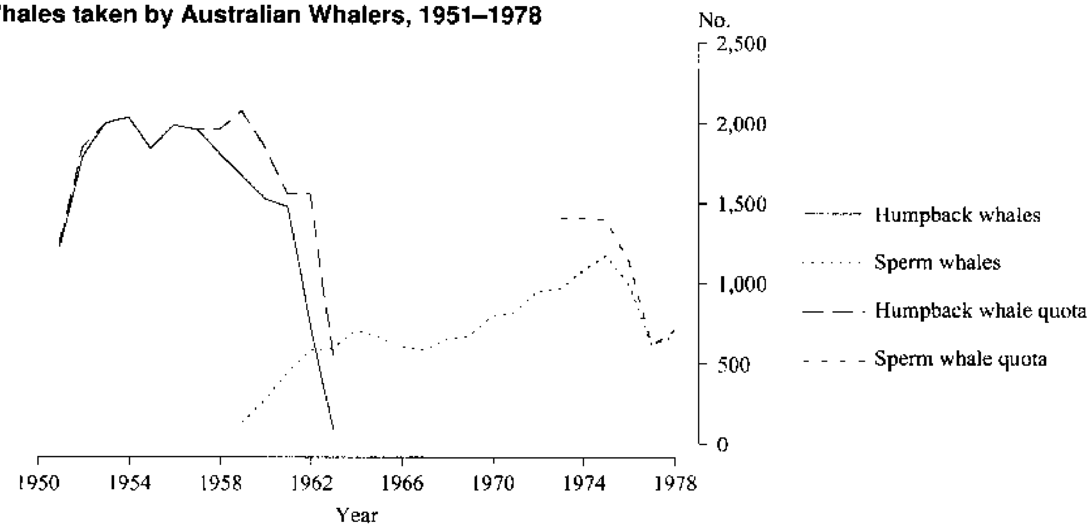
6.3.6 Kangaroo and wallaby quotas, harvests and value of products, 1984–91



Source: Ramsay 1994.

Unlike native species, introduced species are not subject to harvest quotas as they are regarded as

6.3.5 Whales taken by Australian Whalers, 1951–1978



Note: Whale catches include a small number of fin, blue and minke whales.

Source: Commonwealth Bureau of Census Statistics 1956–79; Inquiry into Whales and Whaling 1978.

6.3.7 Commercial hunting of introduced species

		Number harvested			Products and their value, 1991–92 (a)				
					Game meat		Skins/leather		Total value of products
		1985	1989	1992	Domestic	Export	Domestic	Export	
Species		'000	'000	'000	$'000	$'000	$'000	$'000	$'000
Wild pigs	Low est.	na	203.8	271.1	0	10 000	0	0	10 000.0
	High est.	. .	. .	. .	. .	20 000	. .	. .	20 000.0
Feral goats (b)		na	26.6	39.7	0	na	na	na	na
European wild rabbit (c)	Low est.	2 000	2 000	2 000	5 000	3 477	1 010	9 400	9 500
	High est.	3 000	3 000	3 000	5 600	. .	. .	. .	10 000
European red fox (d)		298.7	96.7	na	0	0	na	1 940.8	na

(a) Figures shown are for 1991–92 except where annual estimates are given and except for the domestic value of rabbit skins/leather which are for 1989–90.
(b) Slaughter of feral goats in the wild for export, primarily to the Caribbean.
(c) Harvest figures are annual estimates.
(d) Harvest figures calculated from fur skin export data.
Note: where the harvest data were collected in a financial year they were converted to a calendar year to allow comparison across species (e.g. the 1985–86 financial year equates to the 1985 calendar year).
Sources: Ramsay 1994.

agricultural and/or environmental pests. Table 6.3.7 shows the commercial hunting statistics for four introduced species. Of these, wild pigs and rabbits are the most commercially valuable species. Feral horses are also important contributors to the Australian horse industry, but quantitative figures are not available.

Many native and introduced wild animal species are also subject to non-commercial hunting and pest control. The numbers killed are largely unknown, especially for introduced species. The harvest figures for native species are shown in Table 6.3.8. It should be noted that these are conservative estimates based largely on permit figures and do not include illegal kills. In addition, the Conservation Commission of the Northern Territory shot 7,679 feral horses and 5,564 water buffalos between 1985 and 1990 as pest control measures (Ramsay 1994, p118 & 160). Other species harvested for pest mitigation include cormorants, parrots, honeyeaters, crows, ravens and flying foxes (Cairns & Kingsford 1995, p. 261).

Trapping

A number of native and introduced animal species are trapped or collected from the wild. The total harvest of both freshwater and saltwater crocodiles for the four years of the 1989 Management Plan is shown in Table 6.3.9. The eggs of saltwater crocodiles make up the largest number of total removals of either species (32,780 eggs). These have generally represented about 65% of the total number of saltwater

6.3.8 Non-commercial hunting and pest control of native species

	Number killed				
	1985	1989	1992	1993	
Species	'000	'000	'000	'000	Methods used
Kangaroos (a)	41 .5	18.6	na	na	Ground shooting; poisoning with 1080 (b), fertility control.
Wallabies (c)	561.2	4.9	na	na	Ground shooting; poisoning with 1080, fertility control.
Brushtail possums (d)	2.6	10.3	na	115.0	Ground shooting, live capture and release, poisoning with 1080.
Muttonbirds	300.0	300.0	300.0	na	Traditional hunting techniques.
Ducks (f)	2 310.1	1 151.0	658.0	760.2	Ground shooting.

(a) Figures based on permit issues include Wallaroos and Eastern Grey, Western Grey, and Red Kangaroos.
(b) The poison 1080 is sodium monofluoroacetate.
(c) Figures based on shooter questionnaires (1985) and Australian National Parks and Wildlife Service (ANPWS) estimates (1989). Includes Red-necked, Swamp, Whiptail, Bennett's, and Rufous Wallabies.
(d) 1985–1992 figures based on permit figures multiplied by the estimated numbers killed per permit (60); the number killed in 1993 is a Parks and Wildlife estimate for the 1993–94 financial year.
(e) Annual estimate.
(f) There are no estimates for New South Wales or the Northern Territory for this period or for South Australia later than 1988; Western Australia has banned recreational hunting since 1993 but duck shooting for pest mitigation is allowed and these figures are included.
Source: Skira 1987 cited in Ramsay 1994, p. 69; Hocking 1995; Report of the Task Force Enquiring into Duck Hunting in South Australia 1990, unpub.: Department of Conservation and Land Management, Western Australia 1996. unpub.; Department of Conservation and Natural Resources, Victoria 1996, unpub.

crocodile eggs harvested (Webb, Manolis & Ottley 1994, p. 172). The numbers of saltwater crocodile hatchlings, juveniles and adults taken from the wild have been relatively constant over the period. By contrast, the numbers of both viable freshwater crocodile eggs and hatchlings have declined dramatically since 1991.

As Table 6.3.10 shows, the trapping of feral goats, combined with the domestic goat populations, is an important wildlife industry. The actual value of feral goats to the goat industry is unknown. However, Ramsay (1994) has suggested that most goats slaughtered for export are of feral origin, and the export of live feral goats for slaughter at overseas abattoirs represents the largest volume of the live goat trade.

Harvesting of native plants

A wide variety of native plants and plant products are harvested from the wild for the domestic and export markets. Exports of native plants and plant products picked from the wild have risen both in terms of value and weight since 1988–89 (see Table 6.3.11). In particular, the exports of wildflowers have risen from about $1.5 million in 1988–89 to about $9.1 million in 1994–95 (see Figure 6.3.12). The majority of flower harvesting from the wild occurs in Western Australia, where in 1993 45% of the stems harvested came from

6.3.9 Freshwater and saltwater crocodiles taken from the wild (a), 1990–1993

	1990	*1991*	*1992*	*1993*	*Total*
	No.	*No.*	*No.*	*No.*	*No.*
Saltwater crocodiles					
Viable eggs	8953	5491	9838	8498	32780
Hatchlings	13	10	7	15	45
Juveniles	120	162	102	168	552
Adults	70	63	32	35	200
Freshwater crocodiles					
Viable eggs	2 071	953	49	0	3073
Hatchlings	1621	4579	0	0	6200
Juveniles	20	187	1	19	227
Adults	0	2	0	23	25

(a) Includes 'problem' crocodiles, crocodiles taken to supplement farm stocks, crocodiles found drowned and crocodiles which have attacked people or livestock.

Source: Webb, Manolis & Ottley 1994; Manolis, S.C 1996, pers.comm.

6.3.10 Commercial trapping and mustering of introduced species

	Number trapped/mustered			*Products and their value, 1990–91*			
	1987–88	*1989–90*	*1991–92*	*Abattoir meat*	*Live*	*Skins/ leather*	*Total value of products*
Species	*'000s*	*'000s*	*'000s*	*$'000*	*$'000*	*$'000*	*$'000*
Feral goats (a)	633.5	923.7	1 103.4	15 627.2	2 151.8(b)	2 997.6	20 776.6
Water buffalo (c)	39.4	24.6	na	4 415.0	975.0	198.0	5 588.0
Cane toads (d)	<30.0	<30.0	<30.0	na	na	na	<150.0

Note: where the harvest data was collected in a financial year it was converted to a calendar year to allow comparison across species (e.g. the 1985–86 financial year equates to the 1985 calendar year).

(a) Includes both feral and domestic goats (export values only).

(b) Excludes angora.

(c) Numbers trapped/mustered include all abattoir slaughtered water buffalo and live exports. Values shown are export figures except skins/leather for which domestic-export breakdowns are unavailable. Skins/leather also includes figures hunted buffalo.

(d) Number trapped are annual estimates. Products include live and preserved specimens and cane toad venom (bufotoxin) which is used for pharmaceutical purposes. Values include domestic and export markets.

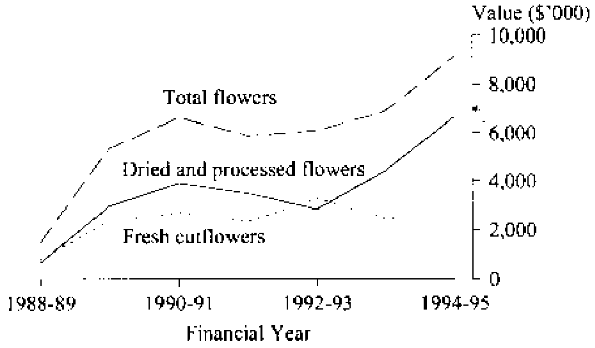
Source: Ramsay 1994.

6.3.11 Australian exports of wild plants and flowers picked from the wild

	Live plants		*Fresh cutflowers*		*Dried and processed flowers*		
Year	*tonnes*	*$ '000*	*tonnes*	*$ '000*	*tonnes*	*$ '000*	*$'000*
1988–89	0	18	153	807	117	681	1 506
1989–90	20	31	400	2 381	605	2 973	5 385
1990–91	1	6	417	2 724	627	3 920	6 650
1991–92	51	73	441	2 363	627	3 518	5 932
1992–93	173	157	646	3 277	519	2 848	6 282
1993–94	156	217	435	2 477	769	4 423	7 117
1994–95	8	107	395	2 446	1 073	6 672	9 225

Sources: ABS (5436.0), various years & unpub.

6.3.12 Wild picked flower exports, 1988–89 to 1994–95



Sources: ABS (5436.0), various years & unpub.

five flower species (see Table 6.3.13). The value of the domestic wild foods market is estimated to be in excess of $20 million per year Graham, C 1996, pers.comm.).

Trafficking of wildlife

The live export of Australian native wildlife is prohibited by the Wildlife Protection (Exports and Imports) Act 1982, except in the case of certain scientific and zoological transactions and household pets. The trade in Australian birds and other fauna is small and extremely variable, both in the number of animals exported each year and their export value. The total value of live fauna exports increased from $95,000 in 1988–89 to $325,000 in 1992–93, but fell to $58,000 in 1994–95 (see Table 6.3.14).

High prices overseas for Australian wildlife have encouraged its illegal trade. Prices for native birds have ranged from $1,500 for a sulphur-crested cockatoo to $50,000 for a glossy black cockatoo (Halstead 1992, p. 1). The eggs of native birds are smuggled by couriers wearing specially designed clothing (ibid; AAP 1995). Reptiles and other species have also been smuggled out of Australia through the postal service and by the illegal use

6.3.13 Five most heavily harvested native flower species in Western Australia 1993

Scientific name	*Quantity*
	000s
Stirlingia latifolia	4 345
Agonis parviceps	3 064
Podocarpus drouynianus	2920
Banksia hookeriana	2019
Banksia baxteri	1 490

Source: Department of Conservation and Land Management, Western Australia 1996, unpub.

of aircraft or vessels which bypass customs requirements (Halstead 1992, p. 1).

Between 1990 and 1996 the Australian Nature Conservation Agency has initiated investigations into 91 incidents of suspected breaches to the Wildlife Protection Act resulting in 70 prosecutions. Of these 70 prosecutions, 26 related to the export of birds, or bird eggs, 17 for the export of reptiles and 7 for the export of other specimens such as insects, fish and shells. There have also been 20 prosecutions relating to the illegal importation of species, 10 relating to birds, 3 to reptiles and 7 miscellaneous illegal importations including monkey and animal skins (ANCA 1996, unpub.).

Information needs

Currently the major gap in wildlife statistics is in the domestic trade of plant and animal species. In the case of wild animals and their products it has been suggested that such information is difficult to collate (Ramsay 1994, p. 21).

Another area for which data are lacking is non-commercial hunting and pest control for both native and introduced species. The statistics presented in Table 6.3.8 have been estimated using a number of different techniques and the

6.3.14 Live exports of Australian fauna

	Australian birds			*Australian fauna (excl. birds)*			*Total fauna*		
	Number	*Value*	*Average value*	*Number*	*Value*	*Average value*	*Number*	*Value*	*Average value*
Year	*No.*	*$'000*	*$*	*No.*	*$'000*	*$*	*No.*	*$'000*	*$*
1988–89	54	16	296	852	79	93	906	95	105
1989–90	6 598	69	10	1 274	113	89	7 872	182	23
1990–91	4 825	64	13	7 782	113	15	12 607	177	14
1991–92	933	52	56	10 320	212	21	11 253	264	23
1992–93	347	131	377	1 367	194	142	1 714	325	190
1993–94	6	8	1 333	10056	305	30	10062	313	31
1994–95	1 581	49	31	1203	9	7	2784	58	21

Source: ABS (5436.0), various years & unpub.

reliability of these estimates is questionable. For example, with a change in estimation technique (from shooter questionnaires to wildlife authority estimates) the estimated number of wallabies killed fell from 561,200 in 1985 to 4,900 in 1989.

It has also been found that discrepancies may exist in export statistics collected by different government agencies, even where they describe the same item. For example, the ABS estimates of the number of Brushtail possums exported from Australia are 43% less than the estimates of the Australian National Parks and Wildlife Service over the four years for which comparative data are available, and in no year do the figures match (Callister 1991 p. 53–54). Callister identifies a number of possible factors which may have acted together or alone to produce these differences. They include statistical errors/discrepancies, skin stockpiling and illegal trading of skins.

The reliability and availability of wildlife statistics presents a number of problems, both for industry groups and government agencies. In his discussion of Australia's wild animal industry, Ramsay (1994, p. 21) suggests that industry groups are hampered in their efforts to monitor trade characteristics, trends and opportunities, and that government agencies need reliable statistics on industry performance to develop policy and manage industry development. Such points are valid for the wildlife industry as a whole, and for the more general use and management of wildlife in Australia.

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6.4 Agricultural plants and animals

Agriculture is the most extensive form of land use in Australia, with about 469 million hectares (61% of the total land area) classified to agriculture. It is also the largest sectoral user of water, consuming more than 10,000 gigalitres, which represents 70% of Australia's use of stored water. This section focuses on agricultural plants and animals, and examines their management within the framework of sustainable development and Australia's environment.

Agriculture and the economy

In 1993–94, the gross value of agricultural production was $23,479 million, contributing about 3% to Gross Domestic Product. Agriculture is not only a valuable source of export income (27%), it also provides us with the bulk of our food requirements. 401,900 people (5% of the workforce) were employed in the agriculture, forestry and fishing division in 1995.

Agricultural land use

Agriculture has had a significant impact on the environment in the 200 years since Europeans first settled in Australia. Vast changes have been made to the natural vegetation: tracts of the country that once supported eucalypts and wattles now support wheat and other crops, whereas areas that were previously grasslands in 1788, now are covered with timber and scrub (SCA, 1991). The transformed landscape can be more susceptible than natural ecosystems to various kinds of land degradation, including erosion by water and wind, soil salinisation, soil acidification, and soil structure decline. This is not to overlook efforts that have been made to protect, maintain and even improve soils in many regions.

The economic and social importance of agriculture, coupled with the sector's dependence and impact on the environment, highlights the need to recognise the linkages between each of these elements in shaping the agricultural process in Australia.

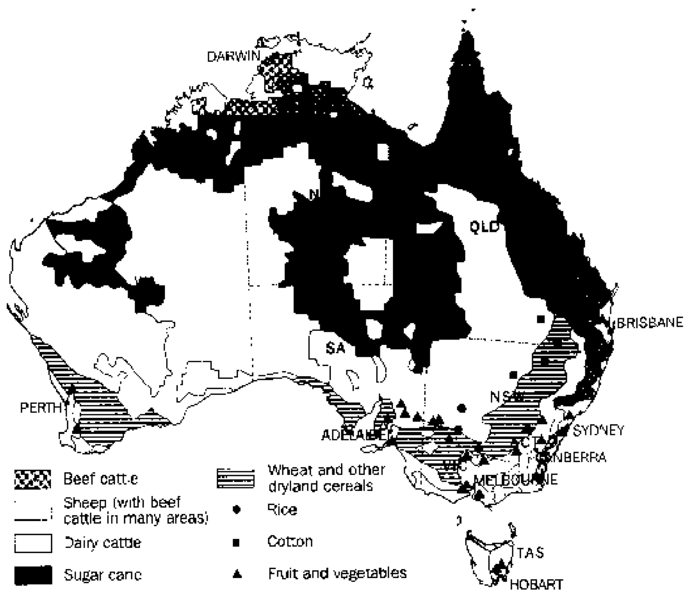
Map 6.4.1 shows the extent of grazing activity as well as other areas given over to the various agricultural activities.

Livestock grazing is the largest land user in Australian agriculture (see Tables 6.4.2 and 6.4.3). This grazing activity has led to the replacement of large areas of native vegetation with introduced pastures and grasses in the higher rainfall and irrigation areas. In the semi-arid and arid zones livestock graze on native grasses.

The estimated total area of agricultural establishments in Australia was 469 million hectares at 31 March 1994, representing 61% of the total land area (see Table 6.4.2).

In many regions of Australia, introduced crops and pastures have replaced the native vegetation. In 1993–94 almost 4% (18 million hectares) of Australia's agricultural land was cropped while another 6% (29.5 million hectares) was sown to pasture or grasses (see Table 6.4.2).

6.4.1 Pattern of agricultural activity



Source: ABS 1989 (1301.0).

6.4.2 Area of land cropped and sown to pasture or grasses

	Crops(a)		Sown pastures and grasses			
	Area	Proportion of total farm area	Area	Proportion of total farm area	Total area of farms (c)	Proportion of total land area of Australia
Year(b)	million ha	%	million ha	%	million ha	%
1960–61	11.0	2.3	14.4	3.1	468.3	61.0
1965–66	13.3	2.7	19.6	4.0	486.4	63.3
1970–71	13.4	2.7	28.0	5.6	497.9	64.8
1975–76	14.5	2.9	27.7	5.5	500.7	65.2
1980–81	18.3	3.7	24.9	5.0	495.4	64.5
1985–86	20.9	4.3	27.5	5.7	485.2	63.2
1990–91	17.4	3.8	28.3	6.1	462.8	60.2
1991–92	16.4	3.5	30.8	6.6	466.0	60.7
1992–93	17.3	3.8	29.0	6.3	460.1	59.9
1993–94	18.0	3.8	29.5	6.3	469.1	61.1

(a) Excludes pastures and grasses harvested for hay and seed which have been included in 'Sown pastures and grasses'.
(b) The ABS uses estimated value of agricultural output (EVAO) as a measure to determine those agricultural establishments within the scope of the Agricultural Census. Figures shown here for the period 1985–86 to 1992–93 relate to those establishments with an EVAO of $22,500 or more. The EVAO for those years prior to 1985–86 relates to establishments with an EVAO of $2,500 or more. For 1993–94, the EVAO cut-off was $5,000.
(c) At 31 March 1994.
Source: ABS (7221.0), various years; ABS (7330.0), various years; ABS 1996 (7113.0).

The area of land cropped or sown to pasture or grasses has been expanding. This expansion was facilitated by factors including "technological progress, increased use of fertilisers and reduction of rabbit populations by myxomatosis" (Hamblin 1993, pers. comm.).

Agro-ecological regions and regional analysis

In 1991 the Standing Committee on Agriculture (SCA) Working Group developed an agro-ecological regionalisation of Australia as a framework to address sustainable agriculture issues. Forty-six agro-ecological regions were identified "by aggregating Statistical Local Areas (SLAs) into groupings of common agricultural practice within relatively homogenous regions of climate and geography". A simplified version of this regionalisation was then developed for the Federal Government's National Strategy for Ecologically Sustainable Development. This divides Australia into eleven larger agro-ecological regions (Figure 6.4.4).

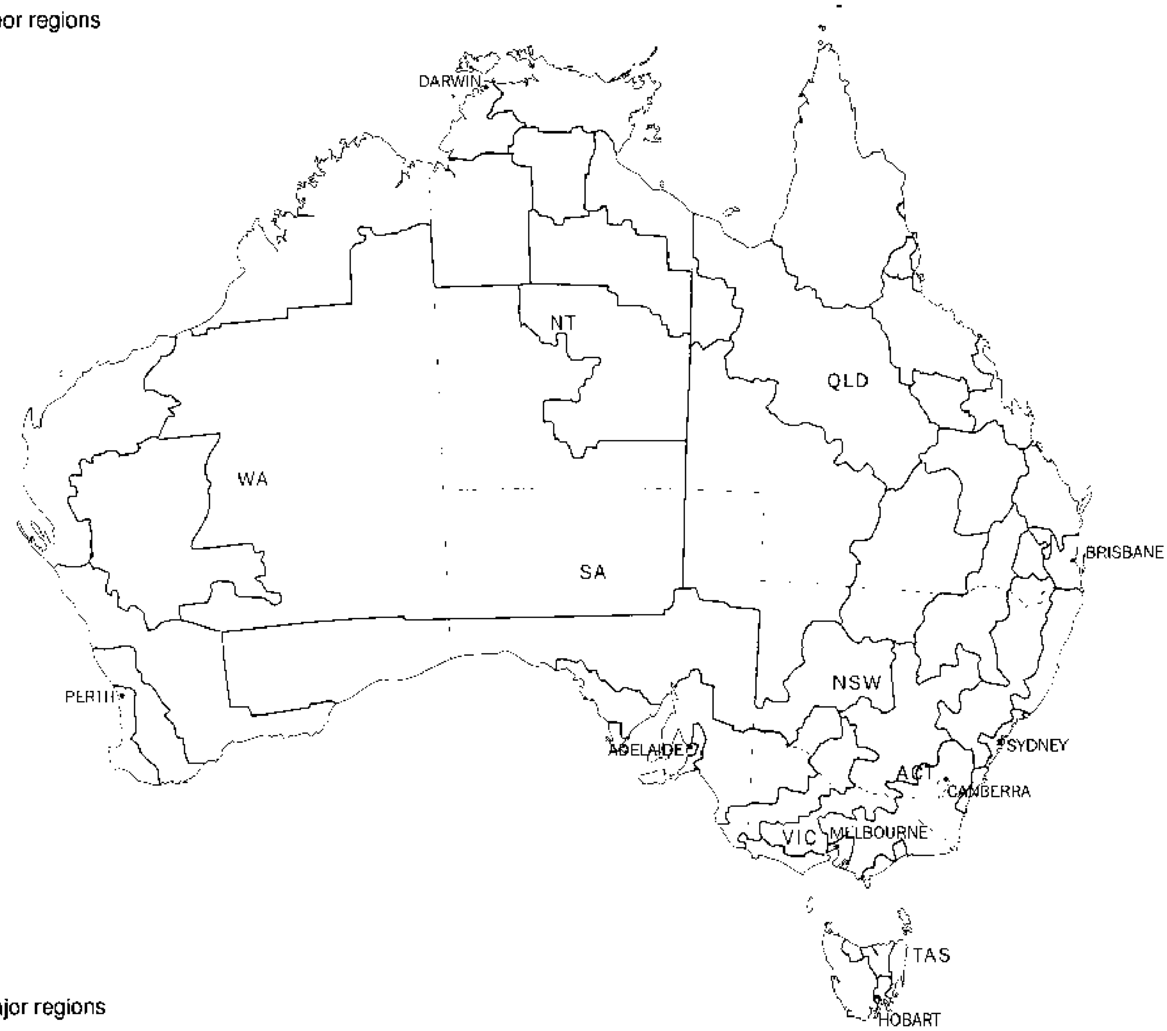
6.4.3 Total area of agricultural establishments

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Australia
Year(a)	million hectares	million hectares	million hectares	million hectares	million hectares	million hectares	million hectares	million hectares	million hectares
1960–61	69.9	15.4	151.4	63.3	100.3	2.6	65.2	0.2	468.3
1965–66	69.3	15.3	154.0	64.5	109.3	2.6	71.2	0.1	486.4
1970–71	69.3	15.8	154.8	65.8	114.6	2.6	74.9	0.1	497.9
1975–76	68.8	15.1	155.6	63.6	116.3	2.5	78.8	0.1	500.7
1980–81	65.2	14.7	157.5	62.4	115.8	2.2	79.6	0.1	495.4
1985–86	63.3	14.2	158.1	60.7	113.8	2.1	72.9	0.1	485.2
1990–91	60.7	12.7	150.8	57.0	110.9	1.9	68.8	0.1	462.8
1991–92	60.4	12.4	150.0	56.9	115.7	1.8	68.7	0.1	466.0
1992–93	59.4	12.3	149.5	56.6	110.6	1.8	69.9	0.1	460.1
1993–94	61.2	13.0	152.6	57.3	114.4	2.0	68.6	0.1	469.1
Total area of land	**80.1**	**22.8**	**172.7**	**98.4**	**252.6**	**6.8**	**134.6**	**0.2**	**768.3**

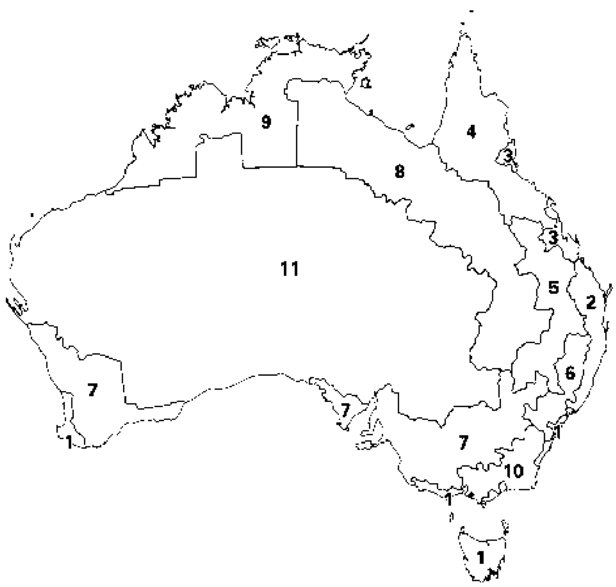
(a) The ABS uses estimated value of agricultural output (EVAO) as a measure to determine those agricultural establishments within the scope of the Agricultural Census. Figures shown here for those years prior to 1985–86 relates to establishments with an EVAO of $2,500 or more. The data for the period 1985–86 to 1992–93 relate to those establishments with an EVAO of $22,500 or more. For 1993–94, the EVAO cut-off was $5,000.
Source: ABS (7102.0), various years; ABS 1996 (7113.0).

6.4.4 Agro-ecological regions

Minor regions



Major regions



1 Wet Temperate Coasts

2 Wet Sub-Tropical Coast

3 Wet Tropical Coast and Tableland

4 North-East Wet/Dry Tropics

5 Sub-Tropical Slopes and Plains

6 Sub Tropical Highlands

7 Temperate Semi-Arid Slopes and Plains

8 Semi-Arid Tropical and Subtropical Plainlands

9 North-Western Wet/Dry Tropics

10 Temperate Highlands

11 Arid Interior

Source: SCA 1991.

Numbers of agricultural establishments

In March 1994 there were 150,000 establishments with agricultural activity above the $5,000 cut-off for estimated value of agricultural operations (Table 6.4.5). Nearly two thirds of these establishments were broadacre farms with activity classified to beef, sheep and grain growing, or some combination of these activities.

Volume of agricultural production

Soil and rainfall are vital determinants affecting the level of agricultural production. However, careful management of the soil resource is also important to optimise production. Sufficient and balanced use of fertilisers, lime and gypsum, and the use of legumes and pasture rotations, help replace soil nutrients lost during the production process. Tables 6.4.6 to 6.4.8 provide a summary of the respective levels of production for livestock products and livestock slaughterings, and areas cropped for 1993–94. While Table 6.4.7 shows the area planted to principal pastures and grasses for 1993–94.

Sheep and cattle account for most grazing activity in Australia; their numbers provide a good indicator of the dimension and regional importance of pastoral land use Australia-wide. At 31 March 1994, sheep numbers were just over 132.5 million while the estimated number of cattle was 25.8 million (with 23.1 million beef cattle and 2.7 million dairy cattle). During 1994, most sheep were found on properties in New South Wales (46.5 million), Western Australia (32 million) and Victoria (23.4 million).

The majority of beef cattle (68%) were concentrated in Queensland (9.7 million) and New South Wales (6.1 million). Dairy cattle dominated in the southern States, particularly Victoria (1.6 million).

6.4.5 Number of establishments with agricultural activity, year ending 31 March 1994

		Area of establishments (hectares)			
		0–499	*500–4 999*	*5 000 or more*	*Total establishments*
ANZSIC	*Main industry of establishment*	*Number*	*Number*	*Number*	*Number*
0111	Plant nurseries	2 065	23	3	2 091
0112	Cut flower and flower seed growing	903	31	1	935
0113	Vegetable growing	4 728	291	5	5 024
0114	Grape growing	4 231	53	2	4 286
0115	Apple and pear growing	1 356	22	0	1 378
0116	Stone fruit growing	1 342	15	1	1 358
0117	Kiwi fruit growing	50	0	0	50
0119	Fruit growing nes	5 708	102	6	5 816
0121	Grain growing	4 401	8 906	617	13 924
0122	Grain-sheep/beef cattle farming	5 095	12 174	796	18 065
0123	Sheep-beef cattle farming	5 370	5 503	1 409	12 282
0124	Sheep farming	7 980	5 946	1 626	15 552
0125	Beef cattle farming	25 546	8 050	2 886	36 482
0130	Dairy cattle farming	13 534	770	15	14 319
0141	Poultry farming(meat)	718	14	0	732
0142	Poultry farming (eggs)	533	33	0	566
0151	Pig farming	1 329	252	12	1 593
0152	Horse farming	1 879	79	4	1 962
0153	Deer farming	403	53	5	461
0159	Livestock farming nec	2 004	120	10	2 134
0161	Sugar cane growing	4 921	177	11	5 109
0162	Cotton growing	275	472	56	803
0169	Crop and plant growing nec	1 203	133	3	1 339
	Other (a)	3 564	473	91	4 128
	Total	**99 138**	**43 692**	**7 559**	**150 389**

(a) Non-agricultural establishments with agricultural activity.
Source: ABS Agricultural Census, 1994.

Poultry numbers in Australia were 70 million in 1993–94. The eastern States predominated (81%), with New South Wales at 25 million, Victoria with 15 million and Queensland at 10 million.

Meat production reflects the activities of those farm establishments classified to beef cattle, with most production (85%) occurring in the eastern States. Queensland accounted for 749,000 tonnes of beef and veal, New South Wales produced 484,000 tonnes and Victoria 329,000 tonnes. New South Wales accounted for 269,000 tonnes (32%) of the wool clip, Western Australia 218,000 tonnes (26%) and Victoria 152,000 tonnes (18%). The greatest proportion of milk production occurred in Victoria (61%) with 4,976 million litres, followed by New South Wales (14%) with 1,097 million litres.

6.4.6 Livestock numbers and livestock products, 1993–94

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*Aust. (a)*
	'000	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*
Livestock numbers								
Meat cattle	6 127	2 604	9 656	1 056	1 683	507	1 434	23 080
Milk cattle(b)	364	1 585	286	147	123	172	1	2 678
Sheep and lambs	46 531	23 439	11 547	14 679	31 952	4 324	0	132 569
Pigs	834	460	682	440	312	46	3	2 775
Poultry	29 872	11 668	11 067	5 988	6 002	595	218	70 610
Livestock slaughterings(c)								
Cattle	1 988	1 394	2 782	400	439	187	62	7 290
Calves	221	583	149	9	4	23	0	992
Sheep	6 067	3 976	857	3 078	2 952	526	0	17 641
Lambs	3 992	5 601	670	2 364	1 553	438	0	14 967
Pigs	1 491	1 189	1 208	5 621	550	96	np	5 190
Chicken (d)	129 736	85 798	54 133	28 376	31 482	np	np	329 525 (e)
Livestock Products(c)	*'000 tonnes*	*'000 tonnes*	*'000 tonnes*	*'000 tonnes*	*'000 tonnes*	*'000 tonnes*	*'000 tonnes*	*'000 tonnes*
Meat(f)								
Beef	466	315	743	94	102	48	11	1 786
Veal	18	14	6	0	0	1	0	39
Mutton	128	85	17	71	62	10	0	377
Lamb	69	101	11	45	25	7	0	265
Pigmeat	99	79	85	38	32	6	np	344
Chicken meat (g)	193	124	72	41	39	np	np	469 (e)
Wool								
Shorn wool (incl.crutchings)	253	137	58	99	209	19	0	776
Other wool	17	15	2	8	9	2	0	53
Total wool	269	152	60	107	218	21	0	828
Whole milk intake by factories (million litres) (h)	1097	4967	764	456	344	447	0	8076
Total eggs ('000 dozen)	67 802	39 493	na	12 705	na	3 755	1 742	128 813
Honey produced (tonnes)	11 270	4 905	2 919	4 096	2 172	623	0	25 990

(a) Includes ACT.
(b) Excludes house cows and heifers.
(c) Includes estimates of animals slaughtered on farms and by country butchers.
(d) Comprises broilers, fryers and roasters.
(e) Excludes Tasmania, NT and ACT.
(f) Dressed carcass weight, excluding offal.
(g) Dressed weight of whole birds, pieces and giblets.
(h) Source: Australian Dairy Corporation (ADC).
Source: ABS 1996 (7113.0).

6.4.7 Area of principal crops, pastures and grasses, 1993–94

	NSW	Vic.	Qld	SA	WA	Tas.	NT	Aust. (a)
	'000 hectares	'000 hectares	'000 hectares	'000 hectares	'000 hectares	'000 hectares	'000 hectares	'000 hectares
Cereals for grain								
Barley	623	639	232	1 115	799	15	na	3 424
Grain sorghum	99	0	399	na	0	na	1	499
Maize	14	0	28	na	2	na	0	44
Oats	369	186	16	101	268	7	na	947
Rice	125	na	na	na	na	na	0	125
Triticale	43	32	4	30	19	2	na	129
Wheat	1 978	780	556	1 216	3 852	2	na	8 383
Legumes								
Lupins for grain	96	55	0	70	929	1	na	1 150
Field peas for grain	27	200	na	138	34	1	na	400
Crops for hay								
Oats	62	46	na	47	78	na	na	233
Wheat	17	na	na	na	na	na	na	17
Other cereals	6	5	9	18	10	2	0	51
Oilseeds								
Canola	101	29	0	11	36	0	na	177
Other	77	37	88	14	1	na	na	216
Other crops								
Sugar cane	27	na	404	na	na	na	na	431
Cotton	210	na	84	na	na	na	na	293
Peanuts (in shell)	1	na	21	na	0	na	na	22
Tobacco	0	1	1	na	na	na	na	3
Pastures								
Cut for hay	235	431	46	100	111	50	3	977
Harvested for seed	16	18	22	34	14	1	0	105
Vegetables for human consumption								
Potatoes	7	12	5	7	3	7	na	40
Other	15	18	28	5	7	12	0	85
Total	22	30	33	12	10	19	0	125
Total	**4 148**	**2 489**	**1 943**	**2 906**	**6 163**	**100**	**4**	**17 753**

(a) Australia total inaludes ACT.
Source: ABS 1996 (7113.0).

Wheat for grain was a major crop in 1993–94, with almost half of all the land area cropped (8.4 million hectares) and considerable production (16.4 million tonnes) (Tables 6.4.7 and 6.4.8). Barley, lupins and oats made a significant contribution to production and to the total area of land cropped. New South Wales also recorded substantial production of rice.

The area of land planted to grain sorghum, sugar cane and cotton was extensive in New South Wales and Queensland. Sugar cane was the largest crop in terms of production with the bulk coming from Queensland. New South Wales also had considerable production of and area planted to canola.

The area sown to pastures cut for hay was significant, with New South Wales and Victoria accounting for more than two thirds of production and of the total area sown.

6.4.8 Production of principal crops, pastures and grasses, 1993–94

	NSW	Vic.	Qld	SA	WA	Tas.	NT	Aust. (a)
	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes
Cereals for grain								
Barley	1 357	1 386	261	2 242	1 381	41	na	6 668
Grain sorghum	228	0	852	na	2	na	2	1 084
Maize	100	2	87	na	15	na	1	204
Oats	618	362	8	135	511	13	na	1 647
Rice	1 042	na	na	na	na	na	0	1 042
Triticale	110	71	5	49	22	6	na	263
Wheat	5 086	2 022	555	2 121	6 689	5	na	16 479
Legumes								
Lupins for grain	156	6 082	0	82	1 181	1	na	1 480
Field peas for grain	36	293	na	197	31	2	na	558
Crops for hay								
Oats	226	190	na	169	346	na	na	931
Wheat	65	na	na	na	na	na	na	65
Other cereals	18	16	23	57	44	10	1	169
Oilseeds								
Canola	193	47	0	18	47	0	na	305
Other	108	36	82	13	1	na	na	240
Other crops								
Sugar cane	1 674	na	29 638	na	na	na	na	31 312
Cotton	766	na	308	na	na	na	na	1 074
Peanuts (in shell)	1	na	44	na	0	na	0	45
Tobacco	0	4	4	na	na	na	na	8
Pastures								
Cut for hay	938	1 752	262	356	427	229	13	3 979
Harvested for seed	3	7	1	9	3	1	0	24

(a) Australia total incorporates ACT.
Source: ABS 1996 (7113.0).

Crop yields

Australia's ability to maintain growth in the volume of agricultural production has been enhanced by improvements in crop yields over time. As Table 6.4.9 illustrates, crop yields for a selection of Australia's major crop varieties have increased. However, a study of Australian wheat yields has indicated that wheat yield increases have not been universal. "Although some cropping areas have yield trends greater than 20 kilograms per hectare per year others show no gain and some have declining trends despite major improvements in crop varieties, agronomic practices and technological advances" (Hamblin & Kyneur 1993). The regions in which yields have not risen much, or have declined, tend to be those which are drier and/or experience higher rainfall variability.

6.4.9 Yields of selected crops

	1960–61	1965–66	1970–71	1975–76	1980–81	1985–86	1990–91	1992–93	1993–94
Crop	t/ha	t/ha	t/ha	t/ha	t/ha	t/ha	t/ha	t/ha	t/ha
Wheat for grain	1.36	1.00	1.22	1.40	0.96	1.37	1.63	1.78	1.97
Barley for grain	1.38	1.02	1.19	1.37	1.09	1.48	1.61	1.83	1.95
Oats for grain	0.94	0.72	1.04	1.16	1.03	1.24	1.47	1.69	1.74
Grain sorghum	1.58	1.11	2.35	2.23	1.83	1.93	1.99	1.28	2.17
Rice	6.00	7.00	7.86	5.57	7.00	6.75	8.31	8.06	8.34
Cotton	na	na	1.64	2.69	3.04	5.27	4.05	3.48	2.69
Sugar cane for crushing	66.06	54.03	80.01	85.51	83.17	63.93	74.98	85.33	92.74

Source: ABS 1996 (7113.0).

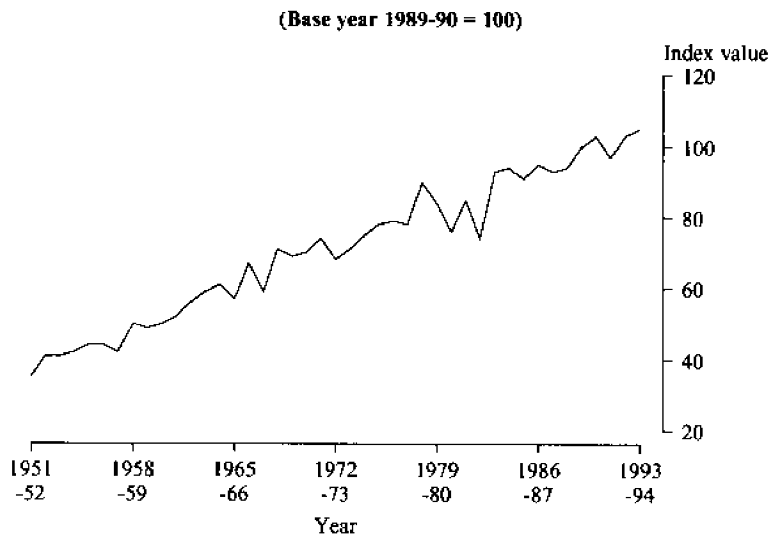
6.4.10 Indexes (a) of volume of agricultural production

Time period	*Crops*	*Livestock slaughterings*	*Livestock products*	*Total*
1955–56 to 1959–60	34	45	72	46
1960–61 to 1964–65	43	51	79	56
1965–66 to 1969–70	59	57	85	65
1970–71 to 1974–75	65	75	84	72
1975–76 to 1979–80	78	99	73	82
1980–81 to 1984–85	92	86	73	84
1985–86 to 1989–90	100	94	89	95
1990–91	103	103	98	103
1991–92	101	106	86	97
1992–93	113	108	88	103
1993–94	118	110	86	105

(a) The index value for each time period represents the average index value of the time period concerned. Base 1989–90 = 100.
Source: ABARE 1994.

Between 1952–53 and 1993–94 the volume of production has increased, with the output of crops and livestock slaughterings contributing the most. Technological advances (for example, introduction of bulk grain handling, increased mechanisation, the introduction of new crop varieties and improved rotation using legumes) have played an important part in this consistent growth (see Figures 6.4.10 and 6.4.11).

6.4.11 Index of volume of agricultural production, 1951–52 to 1993–94



Source: ABS 1996 (4606.0).

Water Use

Water is regarded as a highly valued but scarce commodity, of which the agricultural sector is the major consumer. Most of this consumption is for irrigation purposes, accounting for an estimated 10,240 gigalitres of water annually (see Table 6.5.3). Irrigation for pastures consumed 5,180 gigalitres (51%), while the remaining water was used to irrigate crops and horticultural plantings. A further 1,340 gigalitres of water was consumed in rural areas for purposes other than irrigation or industrial use (Australian Water Resources Council 1987).

The areas irrigated for pastures, crops and horticulture reflect consumption patterns and, on a State basis, are consistent with the various irrigation schemes (see Table 6.4.12). In 1993–94 2.4 million hectares of crops and pastures were irrigated, mostly within the Murray-Darling Basin. New South Wales had the largest area with 1.1 million hectares (48%) under irrigation. Victoria had a further 646,000 hectares (27%) and Queensland had 409,000 hectares (17%).

Surface water was the major source for irrigation purposes and again New South Wales, Victoria and Queensland accounted for most of that irrigation (see Table 6.4.13).

Most irrigation is applied by flooding or furrows, or by using sprays (Table 6.4.14). These application methods are often inefficient because more water is applied than is actually required, with associated water loss due to evaporation and seepage. Seepage adds to groundwater, raising the water table and in turn creating problems associated with land degradation and soil salinity.

Table 6.4.15 presents specific data on flood irrigation in a more recent context and outlines changing practices that farmers have adopted to mitigate the problems of land degradation associated with flood irrigation. In 1994 over half the land irrigated had been laser levelled in order to regulate flows and minimise water loss. Just

6.4.12 Area of crops and pastures irrigated (a), 1993–94

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Australia*
	'000 ha	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*
Pastures	635	556	70	53	14	33	1	0	1 362
Cereals	284	23	45	7	1	2	1	0	364
Vegetables	17	20	27	9	6	16	0	0	96
Fruit	33	35	25	40	7	3	1	0	144
Other crops	176	13	73	4	3	6	0	0	275
Sugar cane	0	0	168	0	0	0	0	0	168
Total	**1 145**	**646**	**409**	**112**	**32**	**61**	**3**	**0**	**2 408**

(a) figures are based on farms with an EVAO of $5,000 or more.
Source: ABS 1996 (7113.0).

6.4.13 Area irrigated by source of water(a), season 1993–94

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*Aust. (b)*
	'000 ha	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*
Surface water from State irrigation schemes							
Channels	460(c)	479	97(c)	8	13	3	1060(c)
Pipelines		21		14	2	2	39
Other surface water (d)							
Direct from regulated streams	458	30	35	12	1	18	554
From farm dams	41	60	39	10	9	33	191
Underground water supply (e.g. bore, spear, well)							
Within State schemes	67	32	97	47	5	2	250
Other	30	21	66	19	2	3	140
Town or country reticulated water supply	1	3	0	2	0	0	7

(a) Figures are based on farms with an EVAO of $5,000 or more.
(b) Includes the Northern Territory and the Australian Capital Territory.
(c) Includes number of hectares irrigated by pipelines in NSW and Queensland.
(d) Including private group schemes.
Source: ABS 1996 (7113.0).

6.4.14 Area of crops and pastures irrigated by method of irrigation, year ended 31 March 1990

	NSW	Vic.	Qld	SA	WA	Tas.	Australia
	'000 hectares	'000 hectares	'000 hectares	'000 hectares	'000 hectares	'000 hectares	'000 hectares
Sprays (excluding micro-sprays)	107	41	134	50	7	34	374
Flood and/or furrows	681	474	143	33	13	5	1 349
Trickle and/or micro sprays	11	12	12	13	5	1	55
Multiple and other methods	14	0	23	3	2	4	46
Total (a)	**820**	**526**	**312**	**99**	**29**	**44**	**1 832**

(a) Includes irrigation methods not stated.
Source: ABS 1990 (7330.0).

6.4.15 Flood irrigation, year ended 31 March 1994 (a)

	Area flood irrigated	Area laser levelled	Percentage of farmers re-using irrigated water	Percentage of farmers planning to introduce a water re-using system
	'000 ha	'000 ha	%	%
NSW	667	420	43	12
Vic.	428	179	37	8
Qld	141	76	24	13
SA	26	15	8	3
WA	14	7	24	3
Tas.	6	0	30	3
NT	0	0	40	0
Aust. (b)	**1 283**	**697**	**34**	**9**

(a) Figures are based on farms with an EVAO of $5.000 or more.
(b) Includes the ACT.
Source: ABS 1996 (7113.0).

over a third of farmers re-used irrigation water and a further 9% planned to introduce a water re-using system.

Fertiliser use

Most Australian soils are deficient in phosphorus. Because of this, and the significant but less widespread deficiency of sulphur in many soils, superphosphate is the one common fertiliser used.

Table 6.4.16 shows recent data for fertiliser and soil conditioner use which has shown an increasing trend, and Figure 6.4.17 presents fertiliser use by agro-ecological area. The impacts of fertiliser use are also discussed in Section 6.7.

Table 6.4.18 shows data on general fertiliser use in Australia. Phosphorus fertilisers, particularly single superphosphates, account for about 60% of fertiliser use in Australia. Of the 2.4 million tonnes of super-phosphate fertiliser applied to agricultural land in 1989–90, more than half was used on pastures in areas with moderate to good rainfall. Large quantities were also applied to cereal crops.

Use of other chemicals

Agricultural ecosystems tend to attract a variety of pests. One reason for this susceptibility is that crops are often grown in monoculture or in rotation with crops of a similar genetic make-up. Chemicals are widely used to control such pests (see Table 6.4.19). For the year ending 31 March 1992, 14.8 million hectares of land were treated with herbicides. Insecticides were used to treat 3.1 million hectares, and fungicides were used to treat 813,000 hectares.

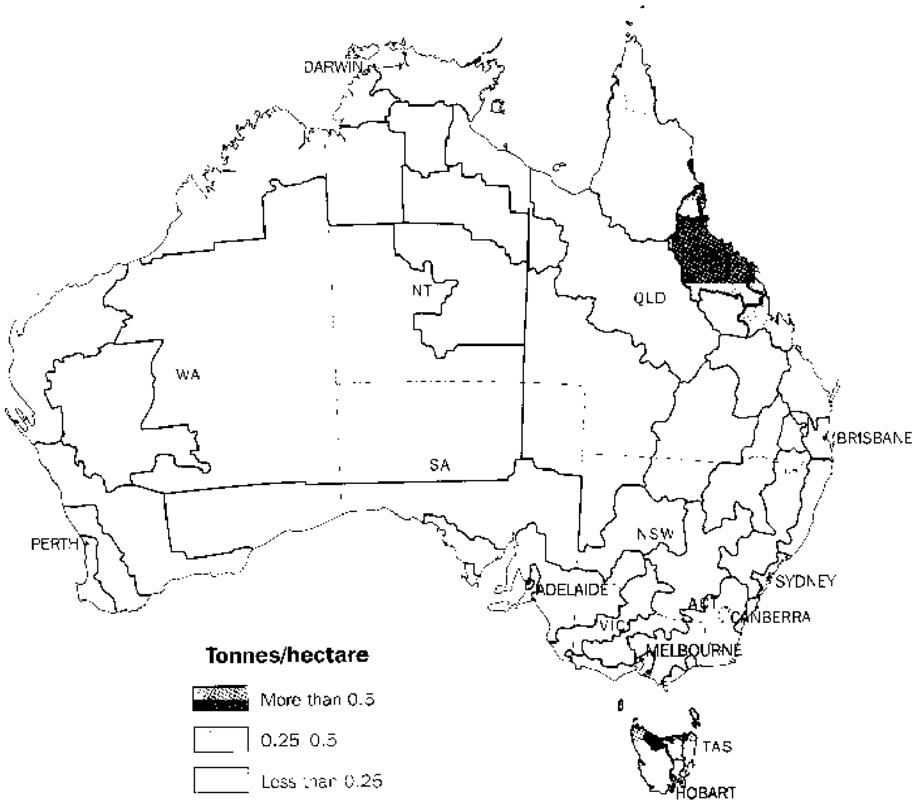
In addition to these products, dips and drenches are also used extensively in the treatment of livestock for parasites and pests. These chemicals have an impact on air, soils and water (see Sections 1.1 and 6.7). Agricultural chemicals may contaminate the soil, for instance pesticides associated with sites of former cattle and sheep dips (point source). Alternatively, pollutants may enter the water system through run-off or seepage (usually the ground and surface water), or they may be carried via the air through aerial spraying (diffuse source).

6.4.16 Fertiliser and soil conditioners usage, 1992 to 1994 (a)

	Fertiliser			*Soil Conditioner*		
	Area applied	*Quantity used*	*Application rate*	*Area applied*	*Quantity used*	*Application rate*
Year/State	*'000 ha*	*'000 tonnes*	*tonnes/ha*	*'000 ha*	*'000 tonnes*	*tonnes/ha*
1992	20 046	2 786	0.1	748	nc	na
1993	20 092	2 832	0.1	826	985	1.2
1994	20 529	3 000	0.2	857	1214	1.4
NSW	4 508	646	0.1	234	261	1.1
Vic.	3 761	642	0.2	251	412	1.6
Qld	1 032	407	0.4	81	159	2.0
SA	3 282	327	0.1	59	95	1.6
WA	7 557	866	0.1	188	195	1.0
Tas.	379	110	0.3	43	92	2.1
NT	8	2	0.2	0	0	0.4
ACT	4	1	0.2	0	0	0.5

(a) For year ended 31 March.
Source: ABS 1996 (7113.0).

6.4.17 Fertiliser use by agro-ecological region



Source: ABS 1996 (4606.0).

6.4.18 Fertilisers applied, 1989–90

Fertiliser/crop	NSW '000 tonnes	Vic. '000 tonnes	Qld '000 tonnes	SA '000 tonnes	WA '000 tonnes	Tas. '000 tonnes	NT '000 tonnes	ACT '000 tonnes
Super-phosphate fertiliser								
Pastures	410.2	330.0	24.7	201.7	628.1	68.2	0.3	1.0
Wheat	48.1	70.8	4.4	74.7	120.6	0.1	0.0	0.0
Sugar cane	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0
Other crops	53.6	80.6	18.1	70.0	143.6	12.1	0.6	0.0
Total	511.9	481.4	63.2	346.4	892.3	80.4	0.9	1.0
Nitrogenous fertiliser								
Pastures	17.5	12.3	21.2	2.8	7.4	0.8	0.0	0.0
Wheat	30.5	5.1	14.1	7.0	64.7	0.0	0.0	0.0
Sugar cane	0.0	0.0	88.7	0.0	0.0	0.0	0.0	0.0
Other crops	92.0	14.2	72.3	13.8	16.2	1.8	0.5	0.0
Total	140.0	31.6	196.3	23.6	88.3	2.6	0.5	0.0
Other fertiliser compounds and mixtures								
Pastures	13.7	176.8	11.1	18.4	43.1	28.4	0.5	0.0
Wheat	49.0	20.5	3.6	54.5	186.8	0.1	0.0	0.0
Sugar cane	0.0	0.0	119.3	0.0	0.0	0.0	0.0	0.0
Other crops	57.4	42.5	46.4	53.4	63.1	19.8	0.8	0.0
Total	120.1	239.8	180.4	126.3	293.0	48.3	1.3	0.0
Total	**772.0**	**752.8**	**439.9**	**496.3**	**1 273.6**	**131.3**	**2.7**	**1.0**

Source: 1989–90 ABS Agricultural Census.

6.4.19 Chemical use by State, year ended 31 March 1992

	Herbicides			Insecticides			Fungicides	
	Area	Quantity(a)		Area	Quantity(a)		Area	Quantity(a)
	'000 ha	tonnes	'000 litres	'000 ha	tonnes	'000 litres	'000 ha	tonnes
NSW	3 346	274	4 488	976	194	3 215	212	270
Vic.	2 116	219	2 121	484	96	979	132	343
Qld	1 108	270	1 936	346	227	1 499	103	462
SA	2 872	180	2 588	528	40	616	144	349
WA	5 353	1 422	4 356	759	109	383	196	131
Tas.	66	14	148	23	23	47	25	59
NT	18	0	13	0	0	3	0	0
ACT	1	0	1	0	0	0	0	0
Australia	**14 880**	**2 380**	**15 652**	**3 117**	**690**	**6 714**	**813**	**1 618**

(a) Undiluted.
Source: ABS, unpub.

6.4.20 Agricultural practices, season 1993–94

	Tillage method used			*Area of native vegetation on holding*	*Area of river/creek frontage*	
	Conventional tillage (a)	*Minimum/ reduced tillage (b)*	*No tillage (c)*		*River/creek frontage*	*Protected river/ creek frontage (d)*
State	*'000 ha*	*'000 ha*	*'000 ha*	*'000 ha*	*'000 km*	*'000 km*
NSW	2 313	1 215	659	982	74	7
Vic.	1 001	729	392	165	38	7
Qld	1 637	510	181	1 443	93	9
SA	1 449	1 217	1 180	1 561	11	1
WA	2 079	2 215	1 092	1 462	30	6
Tas.	77	11	26	117	7	1
NT	2	0	2	865	8	1
Aust. (e)	**8 558**	**5 899**	**3 531**	**6 595**	**260**	**32**

(a) Using only disc, line or ploughs for fallow weed control or seed bed preparation.
(b) Limited cultivation with some use of herbicides for fallow weed control.
(c) Weed control by herbicide and direct drilling or tillage seeding.
(d) Frontage protected from grazing animals.
(e) Includes the ACT.
Source: ABS 1996 (7113.0).

Particular tillage practices can require extensive use of herbicides and pesticides (see Table 6.4.20). These chemicals may create problems, as they can accumulate in the soil. Pests can also build up resistance to certain chemicals, necessitating either higher dosages or new chemicals to ensure pest control.

Sustainable agricultural practices

Sustainable agriculture has been defined as "the use of farming practices and systems which maintain or enhance:

- the economic viability of agricultural production;
- the natural resource base; and
- other ecosystems which are influenced by agricultural activities." (SCARM 1993)

Table 6.4.20 presents data relating to agricultural practices on tillage methods, native vegetation and river and creek frontage. In 1993–94, conventional tillage was used for 8.6 million ha (48% of all tillage), minimal or reduced tillage was used on a further 5.9 million ha (33%) and no tillage on the remaining 3.5 million ha (20%).

Native vegetation on farms in 1993–94 was 6.6 million hectares. In 1993–94, 32,000 km (11%) of the total river/creek frontage on agricultural holdings was protected from grazing animals.

In many areas where livestock have access to river frontage there has been damage to riparian vegetation, causing a change in ecological balance, increased streambank erosion and deterioration of water quality (see Section 1.1).

The traditional models of broadacre farming are such that livestock and farm machinery tend to compact soils. This results in soil structure decline and land degradation through erosion. Sustainable practices such as agroforestry combined with livestock grazing will, in part, ameliorate the effects of this land degradation.

The 1980s saw the emergence of alternative livestock industries such as emu and crocodile farming. In 1989 twenty licensed emu farms operated in Western Australia, with about 2,000 adults and 3,000 chicks. The regulatory controls for emu farming are such that they comply with State wildlife conservation legislation and international conventions and treaties (Meek & O'Brien 1992).

Emus are farmed on natural bushland and provide the opportunity for agricultural activity on marginal land with minimal impact on the environment.

Other practices which are conducive to sustainable agriculture include puddling and slotting. Puddling is a technique developed to mitigate deep percolation from flooded rice in the irrigation areas of southern New South Wales. It involves rotary hoeing the soil while it is flooded and can reduce deep percolation by as much as 20 millimetres per day (CSIRO 1992).

Slotting is an innovative deep tillage technique designed to improve crop production and water use efficiency in problem soils. Chemical or organic matter is incorporated in loosened soil cut to 15cm wide, 50cm–100cm deep and spaced 1–2 m apart. Experimental results showed marked improvements in crop yields and water use, and a reduction in water stress and erosion (CSIRO 1992).

The 1996 Agricultural Census includes questions on pasture management, cultivation, fallow land and disposal of stubble, irrigation scheduling, fertiliser and soil conditioner use, fencing for grazing management, and details about agroforestry. These results are expected to be published by mid-1997.

In 1994, 160,000 farmers throughout Australia were questioned about organic farming practices. Of these farmers 20,992 believed that adequate information on organic farming was available. However, very few were certified (795), with a further 911 seeking certification (see Table 6.4.21).

6.4.21 Organic farming, 31 March 1994

State	Farmers who believe there was enough information on organic farming	Certified producers (a)	Farmers seeking certification (b)
	Number	Number	Number
NSW	6 210	269	275
Vic.	4 773	187	204
Qld	4 750	141	205
SA	2 697	101	109
WA	1 757	68	83
Tas.	758	26	34
NT	29	1	1
ACT	18	2	0
Aust.	**20 992**	**795**	**911**

(a) Producers certified by an approved certifying organisation.
(b) Farmers seeking certification by an approved organisation.
Source: ABS 1996 (7113.0).

Farm planning

A whole farm plan is a valuable aid in assessing and managing resources with a view to ameliorating degradation. It can focus on particular aspects of managing a farm or cover a broad range of management issues. It may include mechanisms to handle financial and production trends which may eventuate in the future, a strategy to deal with periods of drought and a program which sets out future crop rotations or pasture improvements. The most common kind of farm plan tends to be one with a primary focus on planning farm layout to reduce, control or prevent land degradation. These farm plans usually include a map and may show the location of different land classes and the fences required to separate these land classes.

Table 6.4.22 presents results from the 1992–93 Agricultural Finance Survey (AFS) which show 32,494 farm businesses had a farm plan of some kind. Over half of these farms (17,071) had a documented plan (i.e. a farm plan which included aerial photographs, maps and/or other written documentation). Less still had a documented farm plan showing the location of different land classes (11,173 farms) and even fewer had documentation showing the fences required to separate them (7,458 farms).

Farm businesses in Western Australia were more likely to have a documented farm plan than those in other States (Table 6.4.22). Twenty nine per cent of farm businesses in Western Australia had a documented farm plan. In that State "Land Conservation District Committees were established as early as 1982 and self-help farm planning courses were introduced for landholders prior to their commencement in most other states" (Campbell 1992). South Australia and Tasmania (17%) also exceeded the national average of 16%.

Over one third of farm businesses in the grain, grain/sheep/beef, sheep and sugar industries had a farm plan of some kind. The grain and grain/sheep/beef industries, along with the sugar industry, also had a higher proportion of farm

6.4.22 Use of farm plans among farm businesses, 1992–93

State	Farm businesses with a farm plan of some kind		Farm businesses with a documented farm plan: Total		Plan shows land classes		Land classes separated by fences	
	Number	%	Number	%	Number	%	Number	%
NSW	8 567	29.8	3 603	12.5	2 556	8.9	1 660	5.8
Vic.	6 488	22.6	4 318	15.0	2 442	8.5	1 960	6.8
Qld	7 419	34.7	3 206	15.0	2 118	9.9	767	3.6
SA	3 573	28.8	2 140	17.2	919	7.4	477	3.8
WA	4 920	44.2	3 210	28.8	2 789	25.0	2 318	20.8
Tas.	1 377	43.9	525	16.7	307	9.8	234	7.5
Aust.(a)	**32 494**	**30.6**	**17 071**	**16.1**	**11 173**	**10.5**	**7 458**	**7.0**

(a) Includes Northern Territory and ACT.
Source: ABS unpub.

6.4.23 Use of farm plans among farm businesses by Industry, 1992–93

	Farm businesses with a farm plan of some kind		Farm businesses with a documented farm plan					
			Total		Plan shows land classes		Land classes separated by fences	
Industry	*Number*	*%*	*Number*	*%*	*Number*	*%*	*Number*	*%*
Poultry	169	14.6	57	4.9	3	0.3	3	0.3
Fruit	1 998	21.8	1 212	13.2	636	6.9	323	3.5
Vegetables	1 051	25.3	187	4.5	53	1.3	44	1.1
Grain	3 809	36.7	2 301	22.2	1 410	13.6	919	8.9
Grain/sheep/beef	7 069	37.6	4 088	21.8	2 930	15.6	1 935	10.3
Sheep/beef	2 710	30.0	1 625	18.0	1 269	14.2	991	11.0
Sheep	5 311	36.4	2 839	19.5	2 166	14.8	1 807	12.4
Beef	3 975	27.9	1 688	11.8	1 103	7.7	537	3.8
Dairy	2 806	21.4	1 767	13.5	650	5.0	620	4.7
Pigs	349	24.8	125	8.9	78	5.5	42	3.0
Sugar	1 781	38.2	478	10.2	408	8.7	0	0
Cotton	244	32.8	160	21.5	88	11.8	67	9.0
Other	1 213	25.6	540	11.4	377	8	166	3.5

Source: ABS unpub.

6.4.24 Farm plans and their attributes by State, broadacre industries, 1992–93

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*Aust.*
Farm plan	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Farmers possessing a farm plan	31	29	26	28	39	13	43	30
Farmers possessing a farm plan containing								
A map	29	27	25	25	38	13	42	28
Information on soil/land capability	19	19	17	16	32	8	29	20
Land management approved for tax purposes	7	5	2	2	12	3	4	6
Details of Landcare work	29	21	13	11	28	8	22	18
Capital improvements	18	26	17	12	24	9	29	19
Wildlife habitat or natural vegetation	11	14	13	13	21	8	21	14
Farm operating budget	18	15	14	20	27	9	22	18
Crop/livestock paddock performance records	12	13	11	15	24	4	21	14
Alternative drought strategies	12	15	11	12	10	5	18	12
Timetable for plan implementation	9	9	7	6	9	4	12	8
Other information	1	0	1	1	2	1	1	1

Source: Mues 1994.

businesses with a documented farm plan than was the case for other agricultural industries. Intensive agricultural industries (for example, poultry, pigs and vegetables) tended to have a lower proportion of farm businesses with a farm plan of some kind and a far lower proportion of farm businesses with a documented farm plan than any of the broadacre industries (Table 6.4.23).

Tables 6.4.24 and 6.4.25 present 1992–93 ABARE land management data for the broadacre industries by State, on the proportion of farmers with a farm plan and the proportion of farmers with farm plans which contain selected key attributes.

Commonwealth National Landcare Program (NLP)

In the 1980s, widespread awareness of the need to tackle land degradation problems and pursue a more sustainable approach to agriculture led to increased government support and assistance for farm planning initiatives undertaken by landholders. The Commonwealth Government established the National Landcare Program which aims to enhance the efficient, sustainable and equitable management of the nation's natural resources for the benefit of the overall community. This program includes funding for Landcare groups and the running of courses for farm planning for land holders. This commitment was reinforced in 1990 when an agreement between the Commonwealth and State

6.4.25 Adoption levels by farmers of selected farm practices

Farm practices which are part of the farmer's management program	Wheat & other crops %	Livestock & crops %	Sheep %	Beef %	Sheep & beef %	Dairy %
Conservative stocking rate	74	80	86	83	80	81
Use perennial pasture species	34	54	69	80	70	88
Subdivision of different land classes	36	42	43	34	34	29
Minimum/reduced tillage	68	73	35	26	32	27
Direct drilling	37	37	26	* 11	21	26
Spring/bare fallow cultivation	56	36	21	22	23	26
Tree and shrub planting	43	56	53	30	41	54
Regular soil testing	57	39	32	20	22	45
Regular monitoring of water quality	25	21	17	21	19	20
Regular monitoring of pasture	54	80	73	79	64	89
Exclude stock from areas affected by land degradation	30	40	33	26	22	21
Placement of watering points to minimise land degradation	34	37	36	31	27	26
Manage crop rotation to minimise land degradation	88	79	28	22	26	30
Stubble retention or mulching to minimise land degradation	82	69	29	17	16	10
Other practices	* 10	10	* 15	* 8	* 7	* 11

Source: Mues 1994.

governments was reached on a coordinated national Decade of Landcare Plan. "One of the most common land management activities of these groups has been property and catchment planning" (Campbell 1992).

The NLP fosters integrated approaches to the sustainable management of land, water and related vegetation. The goal of the Decade of Landcare Plan is to "develop and implement systems of land use and management which will sustain individual and community benefits, both now and in the future". Since the plan's inception, the network of Landcare groups across Australia has continued to expand.

Data from the 1992–93 Agricultural Finance Survey (Table 6.4.26) indicate that 14,271 (13.5%) of farm businesses were involved with Landcare Australia and 17,798 farm businesses (16.8%) were involved with other organisations with a Landcare focus. Involvement with Landcare Australia was highest in New South Wales (15.4%) and Victoria (15.2%), while the proportion of farm businesses involved with other organisations with a Landcare focus was highest in Western Australia (38.6%).

Table 6.4.27 shows that farm businesses from the sheep (20.0%), beef (18.9%) and grain/sheep/beef (18.2%) industries were more likely to have an involvement with Landcare Australia. Similarly, the grain/sheep/beef (24.9%), grain (21.6%) and Beef (19.1%) industries were more likely to have an involvement with other organisations with a Landcare focus.

6.4.26 Farm business involvement with Landcare Australia, or similar groups, 1992–93

	Farm businesses involved with Landcare Australia		Farm businesses involved with an organisation which has a Landcare focus	
State	Number	%	Number	%
New South Wales	4 426	15.4	3 683	12.8
Victoria	4 373	15.2	4 707	16.4
Queensland	3 162	14.8	2 472	11.6
South Australia	1 288	10.4	2 230	18.0
Western Australia	701	6.3	4 293	38.6
Tasmania	284	9.1	331	10.5
Australia (a)	**14 271**	**13.5**	**17 798**	**16.8**

(a) Includes Northern Territory and ACT.
Source: ABS unpub.

6.4.27 Farm business involvement with Landcare Australia or other groups with a landcare focus by industry, 1992–93

	Farm businesses involved with Landcare Australia		*Farm businesses involved with an organisation which has a Landcare focus*	
Industry	*Number*	*%*	*Number*	*%*
Poultry	2	0.2	36	3.1
Fruit	265	2.9	871	9.5
Vegetables	137	3.3	525	12.6
Grain	1 247	12.0	2 237	21.6
Grain/sheep/beef	3 425	18.2	4 382	24.9
Sheep/beef	1 609	18.0	1 551	17.4
Sheep	2 919	20.0	2 464	16.9
Beef	2 701	18.9	2 720	19.1
Dairy	1 261	9.6	1 624	12.4
Pigs	38	2.7	205	14.6
Sugar	176	3.8	406	8.7
Cotton	101	13.6	154	20.7
Other	387	8.2	321	6.8

Source: ABS unpub.

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6.5 Water consumption, limits and management

Introduction

As mentioned in Section 1.1, the natural water resources of Australia need effective management due to the high variability of the rainfall and the low runoff. Presented here are the most recent data on development of the resource, water consumption amounts by categories of use and the limits or constraints on use.

Surface water availability

Table 6.5.1 shows the amount of surface water by Drainage Division available for development, and what had been developed as of 1987. It should be noted that the storage capacity of Lake Argyle on the Ord River project in Drainage Division VIII is now 5,797 gigalitres and the agricultural development of that region has increased over the last decade (Wark, B. 1996, pers. comm.).

The storage capacity for surface water in Australia's major (over 100 gigalitres) dams and reservoirs in 1980 was just under 70,000 gigalitres. Total storage capacity by 1993 was estimated to be 81,000 gigalitres, or enough to provide every Australian with three olympic swimming pools of water. Australia has followed a post-war policy of enhancing water storage capabilities and has achieved the highest per capita water storage in the world (SoE 1996, p. 7–8). Dams and reservoirs provide for urban water supply, hydro-electric power generation, flood mitigation and multi-purpose development (ABS 1992,4140.0, p. 172). For more comprehensive information on dams and reservoirs, and water diversions, refer to Section 12.2.2.

Groundwater does not need to be stored as does surface water. Table 1.1.10 described the available amounts of groundwater by Drainage Division, as reported by the Australian Water Resources Council (1987). In 1984 Australia used about 16% of the total groundwater available (see Table 6.5.2).

6.5.2 Groundwater extracted in 1983–84 by Drainage Division

	Available Resource	*Extracted*	*Resource used*
Drainage Division	*Gl*	*Gl*	*%*
North-East Coast	2 000	586	29
South-East Coast	1 860	437	24
Tasmania	124	5	4
Murray-Darling	2 160	501	23
South Australian Gulf	85	56	66
South-West Coast	1 220	296	24
Indian Ocean	508	52	10
Timor Sea	2 820	15	1
Gulf of Carpentaria	1 930	95	5
Lake Eyre	619	172	28
Bulloo-Bancannia	100	15	15
Western Plateau	944	9	1
Total	**14 370**	**2 238**	**16**

Source: AWRC in ABS 1992 (4140.0), p. 164.

6.5.1 Divertible surface water (a) by Drainage Division, 1987

	Fresh	*Marginal*	*Brackish*	*Saline*	*Total*	*Developed resource*
Drainage Division (b)	*Gl*	*Gl*	*Gl*	*Gl*	*Gl*	*Gl*
North-East Coast	22 900	0	0	0	22 900	3 540
South-East Coast	14 700	236	113	16	15 100	4 280
Tasmania	10 900	0	0	0	10 900	1 020
Murray-Darling	12 300	42	32	0	12 400	10 000
South Australian Gulf	160	71	34	4	269	118
South-West Coast	1 390	466	894	164	2 870	385
Indian Ocean	235	50	7	4	295	27
Timor Sea	22 000	0	0	0	22 000	1 980
Gulf of Carpentaria	13 200	0	0	0	13 200	78
Lake Eyre	204	0	0	0	204	26
Bulloo-Bancannia	41	0	0	0	41	0
Western Plateau	102	0	0	0	102	0
Total	**98 100**	**865**	**1 080**	**188**	**100 000**	**21 500**

(a) Available for development, and developed.
(b) See figure 1.1.2 maps the Drainage Divisions.
Source: AWRC 1987 in ABS 1992 (4140.0), p. 158.

The South Australian Gulf region of Drainage Division V abstracts the greatest percentage of available groundwater. Tasmania has the least need for supplementation to its bountiful surface water system. Drainage Divisions I, II, and IV comprise the east coast and south-east Murray-Darling system. Groundwater is used in conjunction with surface water for irrigation and rural supply.

Irrigation, as shown in Table 6.5.3, accounts for about 70% of all water used annually. The Murray-Darling Basin, Drainage Division IV, clearly stands out as the major user with 75% of all irrigation water used in Australia. The east coast Divisions follow, with the agricultural south-west of Western Australia coming fourth — using about 3%.

Industrial use is low at about 5%. This figure does not include water used in the production of hydro-electricity, as that water is not consumed but is considered 'in-stream' use.

Domestic use accounts for about 12% of total Australian water use, second to irrigation. As can be seen from Table 6.5.4, a large percentage of household water is consumed for outdoor use. The east coast Drainage Divisions, including the Murray-Darling, are responsible for 74% of the domestic use.

Some major metropolitan areas are assessing various options for supplementing their water supplies, and for managing them, to accommodate population growth projections (e.g. refer to Melbourne Water Resources Review 1992 and Water Authority, 1994–95).

Diversion

The Australian continent has the highest stream flow variability in the world (Langford, J., 1995, pers. comm.). As already indicated, to allay water shortages during periods of drought and to maintain a consistent supply despite stream flow variability, Australia has built up the highest per capita water storage of any country. In so doing, the natural flows of rivers and streams have been altered, habitats destroyed and new, less productive ones created. Since European settlement, widespread destruction or

6.5.4 Average household water consumption in Australian capital cities 1993–94

Capital city	*Average household consumption* *Kl/year*	*Average rainfall* *mm*	*Outdoor use* *%*
Sydney	263	1 227	30
Melbourne	270	656	38
Brisbane	430	1 149	na
Adelaide	265	451	56
Perth	330	869	42
Darwin	500	1 659	45
Canberra	400	625	55

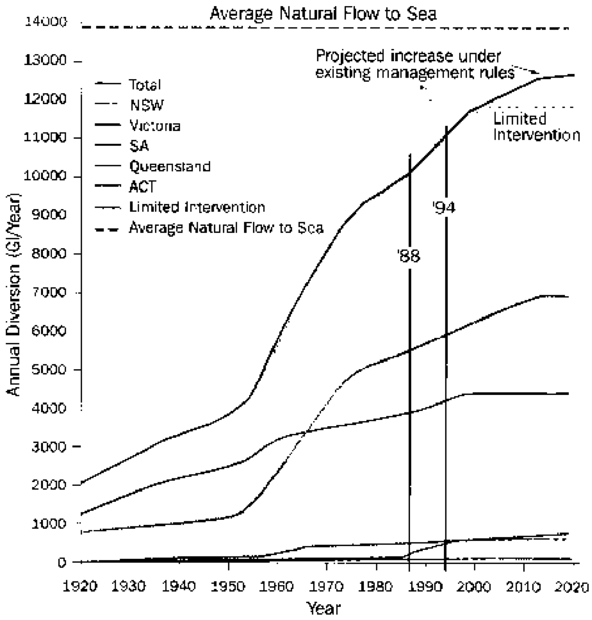
Source: SoE 1996, p. 7–12.

6.5.3 Mean annual water use by Drainage Division(a)

	Irrigation				*Urban and Industrial*					
	Pasture	*Crops*	*Horti-culture*	*Total*	*Domestic*	*Industrial*	*Com-mercial*	*Total*	*Rural*	*Total*
Drainage Division	*Gl*	*Gl*	*Gl*	*Gl*	*Gl*	*Gl*	*Gl*	*Gl*	*Gl*	*Gl*
North-East Coast	70.5	803.0	92.2	966.0	353.0	147.0	41.3	541.0	149.0	1 660.0
South-East Coast	711.0	137.1	176.0	1 024.0	747.0	386.0	228.0	1 360.8	144.1	2 530.0
Tasmania	45.9	46.8	4.0	96.7	33.0	23.2	9.9	66.1	11.4	174.0
Murray-Darling	4 119.3	2 438.1	1 090.0	7 649.0	225.5	55.1	46.7	327.0	1.0	8 660.0
South Australian Gulf	28.2	2.4	45.0	75.6	141.0	23.7	34.1	199.0	37.9	313.0
South-West Coast	168.0	23.5	75.1	267.0	211.0	74.0	96.9	382.0	30.0	679.0
Indian Ocean	0.1	1.7	6.8	8.7	24.4	17.4	5.9	47.7	7.8	64.1
Timor Sea	19.6	45.6	5.1	70.3	23.1	12.5	6.0	41.5	16.3	128.1
Gulf of Carpentaria	16.6	44.9	12.7	74.2	14.8	38.0	4.3	57.0	113.0	245.0
Lake Eyre	< 1.0	3.3	<0.1	3.0	10.1	4.0	4.6	18.7	113.2	135.0
Bulloo-Bancannia	0.0	0.0	0.0	0.0	0.2	0.3	0.0	0.5	17.5	18.0
Western Plateau	0.0	<.1.0	0.4	0.5	8.8	9.4	2.8	21.0	17.6	40.7
Total	**5 180.0**	**3 550.0**	**1 510.0**	**10 240.0**	**1 790.0**	**790.0**	**481.0**	**3 061.0**	**1 340.0**	**14 600.0**
% of Total	35.5	24.3	10.3	70.1	12.3	5.4	3.3	20.9	9.2	100.0

(a) Includes water from both reticulated and self-extracted sources.
Source: AWRC 1987, p. 34.

6.5.5 Growth in water use in the Murray-Darling Basin



Source: MDBMC 1995, p. 13.

degradation of native wetlands and floodplains, by either draining, flooding permanently or polluting, have reduced their natural functions in the ecosystem of filtering and absorbing nutrients and sediments on the way to the sea, and providing havens for wildlife.

Diversion of waterways also changes the natural seasonality and the rate of a river's flow. As mentioned in Section 1.1, when a river's flow is diminished there is a decrease in its ability to flush impurities and a consequent decrease in its water quality.

In the Murray-Darling Basin, water is diverted for both irrigation and water supply purposes. Irrigation accounts for over 95% of diversion, which has reached the point where it is seriously impacting on river health and the environment. A 1995 audit of State allocations and diversions by the Murray-Darling Basin Commission (MDBC) produced a limited intervention proposal to modify existing management rules in order to reduce diversion development (Murray-Darling Basin Ministerial Council 1995, p. 3).

Figure 6.5.5 shows how much of the Murray-Darling Basin's average annual flow to the sea is diverted, by State of use and in total. It follows on with projected increases in diversion to the year 2020, indicating a 14.5% increase, and a 7.3% increase under the limited intervention scenario. Table 6.5.6 shows the expected growth in diversions from the Murray-Darling Basin by State over the next 15 years, using limited intervention.

6.5.6 Expected growth in diversion from the Murray-Darling Basin under the Limited Intervention Scenario

State/Territory	*Gl/year*	%
New South Wales	412	7.0
Victoria	87	2.3
Queensland	107	25.1
South Australia	167	27.4
Australian Capital Territory	10	15.0
Total Basin	**783**	**7.3**

Source: MDBMC 1995, p. 13.

Groundwater abstraction

Groundwater is a vital and well used resource in Australia, with uses ranging from domestic to irrigation and stock watering.

There are more than 4,700 bores drilled in the Great Artesian Basin (ABS 1992, 4140.0, p. 170). Computer modelling of the Basin reflects the declining yields from these bores and suggests that extractions probably exceed recharge (Alpin et al. 1995, p. 60).

As groundwater is not seen by its users, it is hard to estimate overuse and abuse. Over-developed aquifers where the abstraction rate is higher than the recharge rate are considered to be under stress (ABS 1992, 4140.0, p. 170). Table 6.5.7 describes those aquifer systems where greater than natural recharge abstractions have been identified and a management scheme initiated.

Quality as a limiting factor

The quality of water limits its uses. Perhaps a classic example of this is the Sydney beaches and concern over pathogen levels associated with faecal coliforms (organisms) emanating from sewage discharge. Enteroviruses (pathogens), which include polioviruses and hepatitis A and E viruses found in raw sewage, have been associated with swimming-related illnesses (Ashbolt 1995, p. 32.).

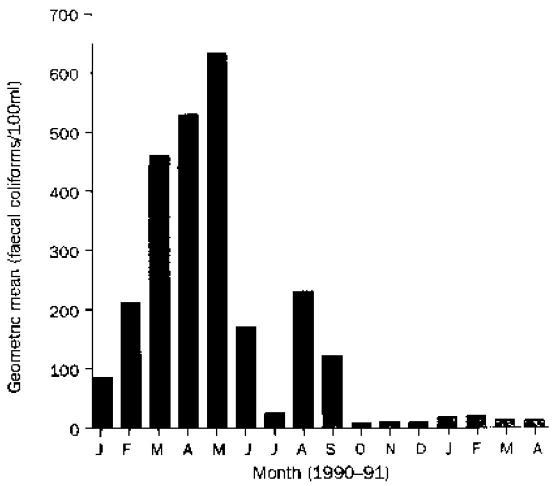
The Sydney sewage treatment plants were discharging at the shoreline prior to 1990. Water quality guidelines for the Health Department were not being met (Phillip 1995, p. 44.). Deepwater sewage outfalls were installed and, in 1990–1991, as part of the Sydney Water Board's study of the deepwater sewage outfall, beach water quality was monitored for faecal coliform density. A dramatic improvement from 1990 levels was shown in 1991 as depicted in Figure 6.5.8, which presents the monthly mean number

6.5.7 Groundwater systems under stress

System	Annual Use Gl	Annual recharge Natural Gl	Annual recharge Induced Gl	Present management	Future strategy
Burdekin Delta, Qld	263	200	53	Extraction limits and recharge.	Planned recharge to provide extra 50Gl.
Namoi Valley, NSW	160	110	0	Extraction limits.	Conjunctive use, reduced entitlements.
Bundaberg, Qld	100	na	0	Replace with surface water.	Surface water scheme.
Condamine Valley, Qld	87	13	0	Bore restriction, metering.	Supplementary surface water scheme.
Lockyer Valley, Qld	47	25	1	Recharge weirs, controls on use.	Additional storage, restrict bores.
Callide Valley, Qld	36	39	8	Metering, recharge weirs and diversion.	Increase dam storage.
Angus-Bremer, SA	25	na	0	Water quotas, metering.	
Padthaway, SA	24	na	0	Restrict irrigation area to prevent salinity increase.	
Pioneer Valley, Qld	21	35	3	Reduce supply.	
N. Adelaide Plains, SA	20	7	0	Water quotas to avoid salt intrusion.	
Millstream, WA	9	13	0	Limits on garden water.	conjunctive use, proposed dam.
Mt Newman, WA	10	3	7	Controlled release of surface storage, artificial recharge.	
Western Port, Vic.	10	na	0	Water quotas, metering.	

Source: ABS 1992 (4140), pp. 170–171.

6.5.8 Trend in bacteria levels at Maroubra beach, 1990 to 1991



Note: monthly figures beginning January, 1990.
Source: Phillip 1995, p. 44.

of faecal coliforms per 100 ml of water at Maroubra. The relocation of the sewage discharge has rendered previously unhealthy beaches swimmable.

Raw water sources for urban supplies which come from still bodies of water (e.g. dams and reservoirs) are under continual threat of contamination. Blue-green algae blooms have left reservoir waters unfit for drinking and swimming.

Nutrient, turbidity, salinity and sediment levels in waterways and estuaries (for further detail on these conditions see Section 1.1) have been closely linked to catchment clearances for agricultural and development purposes. Catchment clearance imposes limits on the resource. Figure 6.5.9 shows that for various rivers in Western Australia the phosphorus concentrations in runoff increases with increased catchment clearing.

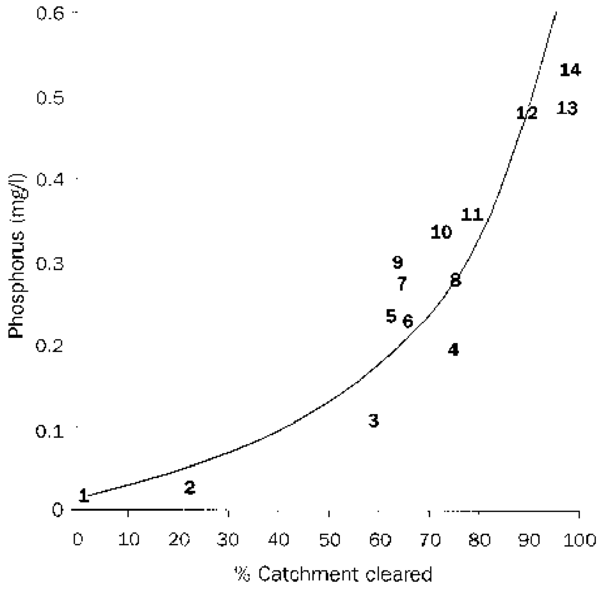
Management and response

Federal, State and local governments have joined forces with stakeholders and interest groups to respond to issues of water quality and management. Examples of initiatives taken are given in Table 6.5.10.

The Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand have developed the National Water Quality Management Strategy. The Strategy is a series of documents setting out principles, guidelines, policies and processes for water quality management. It has been incorporated into the Council of Australian Government's Water Reform Agenda. The objective of the strategy is :

" To achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development."

6.5.9 Phosphorus runoff in response to percentage of coastal catchment cleared



1	Mitchell River
2	Wilson Inlet (Denmark River)
3	Leschenault Inlet
4	Wilson Inlet (Cuppup Drain)
5	Moore Estuary (Gingin River)
6	Moore Estuary (Coastal)
7	Vasse Estuary (Abba River)
8	Wilson Inlet (Sleeman River)
9	Torbay Inlet
10	Vasse Estuary
11	Harvey Estuary
12	Wilson Inlet (Ag. Res. Stn.)
13	Oyster Harbour (King River)
14	Vasse River (Sabina River)

Source: Government of Western Australia 1992, p 73.

6.5.10 Some organisations and initiatives addressing water management issues

Organisation or initiative	*Management problem and method*	*Promoting organisation*
Algal Management Strategy	Managing inputs of Phosphorus and Nitrogen into the Murray-Darling through land and effluent management, wetland and riparian zone conservation and reclamation.	MDBC.
Salinity Mitigation Schemes	Reducing the salt load carried in the Murray-Darling by diverting either ground or drainage water to evaporative pans.	MDBC.
Wetland Management Strategies	Various programs to conserve, create and protect wetlands in order to promote wetland functions of filtering nutrients and sediments.	MDBC, WAWA, DOWR — NSW.
Murray-Darling Audit	An audit of water flow and diversion of the Murray Darling to gauge use limits and devise management strategies.	MDBMC.
Total and Integrated catchment schemes and National Whole Catchment Management	Initiative that looks at the problems of a catchment basin and then division in terms of land use and water quality and involves land owners and stakeholders in identification and solution of problems.	MDBMC, various community based, NSW State government, BHP.
Nutrient Pollution in the Murray-Darling System	Investigation and source identification of nutrient loads in the Murray-Darling.	MDBC.
Liability for identified pollution effects	More focus on environmental law and accountability of those responsible for pollution and contaminants.	EPAs in Vic. and NSW and ANZECC.
State Rivers and Estuaries Policy	River & estuary degradation. Initiative to slow, halt or reverse the problem.	DLWC, NSW.
Landcare	A community based education and problem-solving approach and resource pool incorporating the concepts of Integrated catchment management (see above listing).	Landcare.
Clean up Australia	A community based organization that organizes clean up activities including beaches and waterways and promotes individual and community awareness.	Clean up Australia.
Coastwatch	A community based organization that promotes an environmentally conscious use of the coast and monitors various biological and physical indicators of coastal health.	Coast Watch.
The Commonwealth Coastal Policy	A federal initiative to provide an umbrella body to coordinate and initiate policies and actions to promote the health and sustainability of Australia's coastal and marine environments.	The Commonwealth.
Water Pricing/user-pays	To conserve water by introducing user-pays principle in order to promote self-restriction.	Industries Commission & Council of State Governments initiated. Implemented through state & local governments.

Source: Alpin et al. 1995; CSIRO 1994; Zann and Sutton (eds) 1995; Government of Western Australia 1992; Melbourne Water Resources Review 1992; MDBMC 1995; MDBMC 1994; Water Resources Commission, New South Wales 1984; WAWA 1994–95.

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6.6 Minerals

Introduction

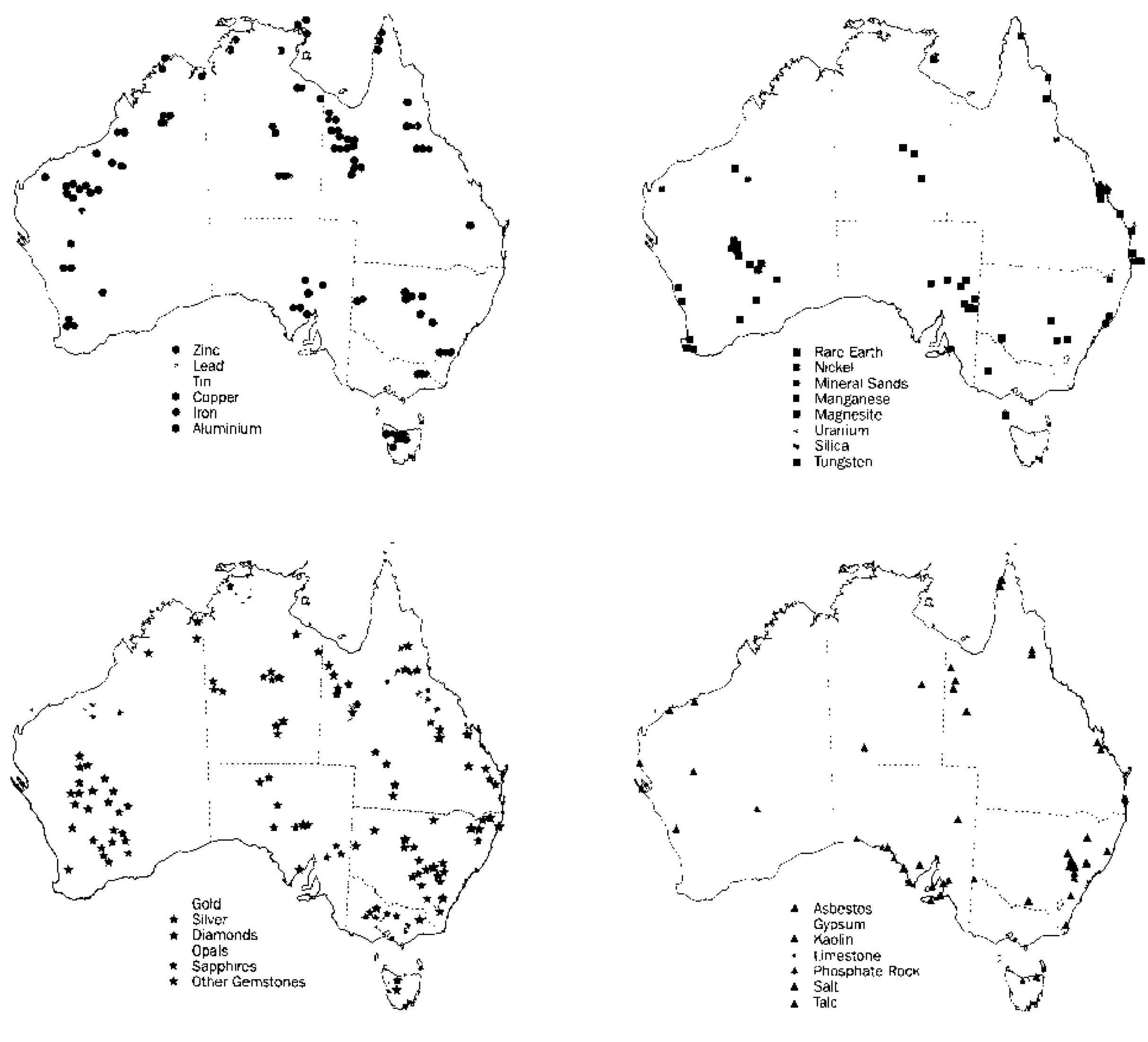
This section focuses on reserves, resources, exploration, production, export, consumption and use of minerals. Other issues considered include new technology, recycling and land access. Data are also reviewed about world mineral production and reserves, given Australia's role in world mineral markets. The section includes some information on minerals such as coal, gas and petroleum, though these are covered in more depth in Section 6.8.

The earth's crust is a rich source of minerals, which are defined as naturally occurring inorganic solids possessing a definite internal structure and a specific chemical composition. Over 2,000 minerals are known to exist and others continue to be discovered (Tarbuck & Lutgens 1987). Figure 6.6.1 indicates the location of major minerals throughout Australia.

Minerals prized for their economic value include ores of metals such as iron (haematite), copper (chalcopyrite), zinc (sphalerite) and lead (galena). There are also native elements which include gold, silver (though silver rarely occurs in its native form) and carbon (diamonds) (Bureau of Resource Sciences (BRS) 1996, pers. comm.; Tarbuck & Lutgens 1987).

The data in this section include not only information on minerals extracted but on basic metal products i.e. commodities which have been refined and/or smelted (e.g. alumina and aluminium), or cast and forged (e.g. iron and steel). Steel, for example, is an alloy, made of a

6.6.1 Location of major mineral resources Australia, 1996



Source: AUSLIG 1996

mixture of iron and one or more other substances (Clark & Cook 1993).

Due to their importance to Australian exports, this section concentrates mainly on minerals prized for their economic value and commodities refined from minerals.

Australia's territory available for mineral exploration

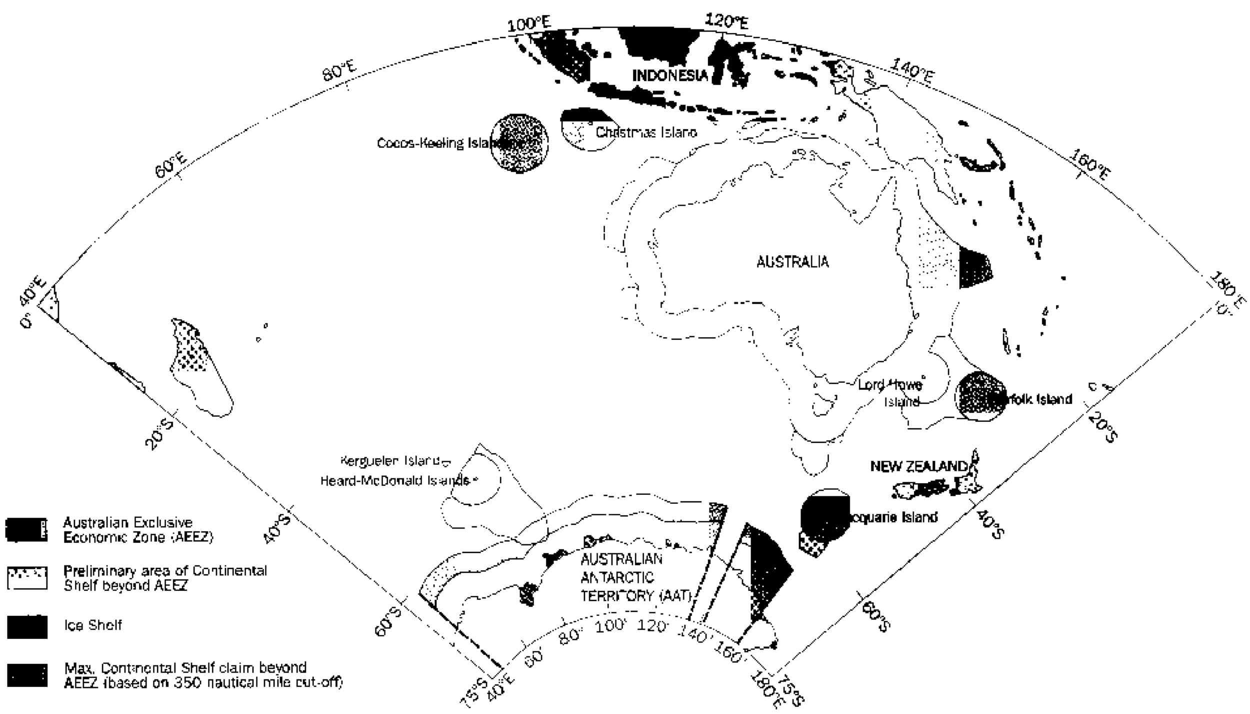
Australia became responsible, in November 1994, for what is one of the world's largest ocean territories (see Figure 6.6.2). Australia has sovereignty over its 12 nautical mile territorial sea. Beyond that limit it has sovereign rights for the purposes of exploring and exploiting the resources of both the Exclusive Economic Zone (EEZ) and the Continental Shelf. Sovereign rights are not equivalent to sovereignty, and so the Exclusive Economic Zone (EEZ) and Continental Shelf are not legally 'territory' (Prime Minister's Science and Engineering Council 1995).

Altogether, therefore, Australia has exploration rights to 30.1 million square kilometres, made up as follows:

- Australian land mass of 7.8 million square kilometres (See Figure 6.6.1);
- Australia's Antarctic Territory of 6.2 million square kilometres;
- Australian continental EEZ of 8.6 million square kilometres;
- Claimable Continental Shelf beyond the EEZ of 3.3 million square kilometres;
- Australian Antarctic EEZ of 2.4 million square kilometres; and
- Claimable Continental Shelf beyond the Antarctic EEZ of 1.8 million square kilometres (Prime Minister's Science and Engineering Council 1995).

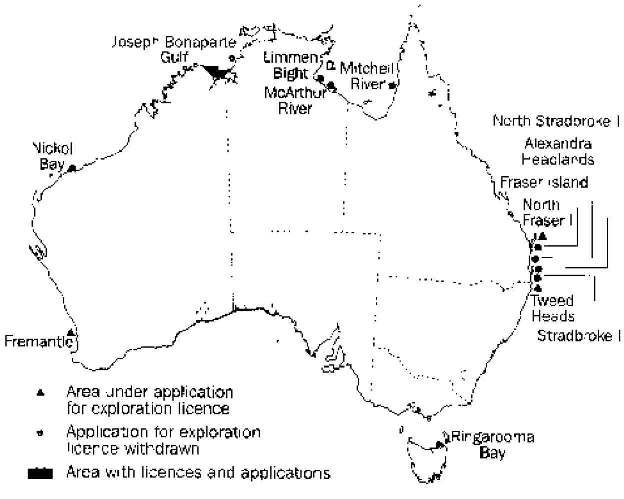
The offshore potential for minerals other than petroleum is mostly unknown. Potentially economic deposits in the short to medium term are likely to be in relatively shallow waters close to the coast and include construction materials (sand, gravel, limestone), diamonds, gold, heavy

6.6.2 Australia's ocean territory (a)



(a) Preliminary.
Source: Australian Geological Survey Organisation in Prime Minister's Science & Engineering Council 1995.

6.6.3 Offshore mineral exploration in Commonwealth waters, 1994



Source: Bureau of Resource Sciences 1995.

mineral sands and tin. Currently uneconomic deposits of heavy mineral sands and tin are known to occur in near shore waters. Some onshore deposits of coal, tungsten, manganese and iron ore are known to extend offshore. Other mineral commodities such as phosphates and polymetallic manganese nodules (containing nickel, cobalt and copper) in deep water are only likely to be of interest in the long term (BRS 1996 pers. comm.; BRS 1995). Since 1990, 39 mineral exploration licence applications had been made in Commonwealth waters, not all of which have been issued (see Figure 6.6.3) (BRS 1995).

Very little is known about the mineral resources in Antarctica as they are buried beneath the ice. Low grade iron and coal have been located in areas not covered in ice. Seven nations claim pieces of Antarctic ground, but these claims are not recognised by all other nations. Australia is the largest claimant. In 1991 the Protocol to the Antarctic Treaty on Environmental Protection was signed in Madrid. This Protocol defines Antarctica as a natural reserve and prohibits any mineral activity except research (Crossley 1995).

6.6.4 Land tenure

State	*Public* '000km²	*Private* '000km²	*Aboriginal & Torres Strait Islander* '000km²	*Total* '000km²
NSW	85.7	714.4	1.5	801.6
Vic.	72.3	155.3	0.0	227.6
Qld	18.0	1 567.0	42.2	1 727.2
SA	217.6	576.8	189.6	984.0
WA	1 095.0	1 105.0	325.5	2 525.5
Tas.	40.6	27.2	0.0	67.8
NT	137.2	673.0	536.0	1 346.2
ACT	1.5	0.9	0.0	2.4
Australia	**1 767.0**	**4 819.0**	**1 094.0**	**7 682.0**

Source: AUSLIG Land Tenure Database 1993.

In 1988 the Australian Encyclopedia stated that on private lands, in general, "the policy of the Australian mining law, in most States, is to make all of the mineral wealth of the nation accessible to persons ... regardless of questions of abstract ownership" (Australian Geographic Society (AGS), 1988). Mining on Crown land also allows for a holder of miner's rights to search for and commence mining of deposits, subject to compliance formalities and environmental requirements of each State and Territory (AGS 1988, BRS 1996, pers. comm.).

On 3 June 1992 the High Court of Australia brought down its decision in *Mabo and Others v the State of Queensland.* This decision, and the subsequent *Native Title Act 1993* which came into force on 1 January 1994, rewrote Australian law on the impact of colonisation. Together they will have profound significance for the indigenous people and the industry groups with interests in land, such as the mining industry. Any land that has been subject to tenure such as freehold will be free from the Act, as the tenure will be deemed to have extinguished native title. Future activities, such as exploration, which will have minimal effect on native title have been excluded from the Act. However, the Act has resulted in a degree of uncertainty within the mining industry (ABS 1996, 8414.0). Table 6.6.4 shows details of land tenure by State.

Restrictions to mining access exist, for example, in the form of conservation areas and reserves (see also Figure 6.6.16 for land access restrictions in Western Australia and Table 6.6.17 for land dedicated to reserves and national parks). It is, however, often the sheer remoteness and economics of removal which restrict mining activities. Vast areas, both on-shore and off-shore, are available for exploration or re-exploration by new technology. During 1994, for example, exploration titles for mining and on-shore petroleum exploration covered about 20% of Western Australia (Department of Minerals and Energy WA 1994; Minerals Council of Australia 1995). Though numerous mining sites exist throughout Australia the land area actually occupied by mines is still quite small (less than 0.02% of Australia's total land area) (BRS 1996, pers. comm.).

Mineral Resources

The earth's crust is a source of a wide variety of useful and essential minerals. Items produced from them underlie every enterprise of modern society. For example, minerals and their derivatives are essential for agriculture (e.g. phosphorus), construction (steel), manufacturing (aluminium, copper, nickel etc), mining (industrial diamonds), transportation (titanium, steel, lead etc) and new technologies such as communications (silica, gold etc) (BRS 1996, pers. comm.; Tarbuck & Lutgens 1987). Table 6.6.5 sets out Australia's demonstrated and inferred resources of major minerals in 1994, along with the world's demonstrated reserves in 1993. Table 6.6.6 looks at estimated world mineral reserves and substitutes.

The Australian Bureau of Statistics defines mining as the extraction of minerals occurring naturally as solids (such as coal and ores), liquids (such as crude oil), or gases (such as natural gas). This section concentrates mainly on solids, excluding coal (though some data provided include the coal, gas and petroleum industries, see Section 6.8 Energy).

Mineral resources are classified according to:

- the geological certainty of their existence; and
- their economic viability.

Resources which are well known geologically are referred to as demonstrated resources. Classifying a mineral resource as an economic

6.6.5 Identified resources of major minerals

		Australia 1994					World 1993
		Demonstrated			Inferred		Demonstrated Economic Reserves
			Sub-economic				
Mineral	*Unit*	*Economic*	*Para-marginal*	*Sub-marginal*	*Economic and sub-economic*	*Undifferentiated*	
Bauxite	Mt	2 538.0	0.0	5 303.0	0.0	2 134.0	23 000
Cadmium	kt	73.4	10.8	17.2	10.2	0.0	535
Chromite	Mt	0.0	2.4	0.5	21.4	0.0	1 400
Cobalt	kt	52.0	129.0	241.0	136.0	0.0	4 000
Copper	Mt	20.2	17.2	0.8	8.1	0.0	310
Diamonds	Mct						
gem and cheap gem		130.0	148.0	0.0	0.0	9.0	300
industrial		168.0	183.0	0.3	0.0	27.0	980
Fluorine	Mt	0.0	24.1	5.8	0.0	0.7	102
Gold	t	3 434.0	1 234.0	54.0	0.0	1 317.0	42 000
Iron Ore	Gt	18.0	13.8	0.4	17.2	0.0	150
Lead	Mt	19.7	4.6	9.0	12.7	2.2	63
Lithium	kt	159.0	0.0	3.0	0.0	7.0	2 200
Magnesite	Mt	246.9	0.0	288.5	0.0	230.0	2 500
Manganese ore	Mt	124.0	28.0	167.0	165.0	0.0	800
Mineral sands							
Ilmenite	Mt	132.5	67.2	0.1	0.0	99.4	380
Rutile	Mt	14.4	33.4	0.2	0.0	26.3	89
Zircon	Mt	21.0	24.2	0.2	0.0	20.9	75
Molybdenum	kt	0.0	5.0	3.0	238.0	0.0	5 500
Nickel	Mt	2.9	2.1	3.8	2.9	0.0	47
Niobium	kt	3.4	67.6	0.0	0.0	1 994.0	3 500
Phosphate rock	Mt	0.0	2 095.0	0.0	0.0	1 947.0	12 000
Platinum-group	t metal	17.7	36.8	16.7	119.0	0.0	56 000
Rare earth oxides	Mt	1.0	3.5	10.6	0.0	4.0	100
Silver	kt	44.7	9.4	11.0	9.4	9.1	280
Tantalum	kt	6.2	6.0	0.1	0.0	65.1	22
Tin	kt	159.0	64.5	150.3	340.4	5.3	7 000
Tungsten	kt	1.0	96.0	107.1	81.8	0.0	2 300
Vanadium	kt	15.0	1 739.0	8 425.0	2 282.0	0.0	10 000
Zinc	Mt	42.6	13.1	12.3	11.1	1.6	140

Source: Bureau of Resource Sciences 1995.

6.6.6 Selected minerals, reserve countries, estimated world reserves, substitutes available, 1994

Mineral	*Countries*	*Estimated World reserves*	*Substitutes*
Bauxite	S. America, Africa, Australia	55–75 billion t.	Bauxite only raw material used in commercial production of alumina. Other possible sources are clay, coal wastes etc .
Cadmium	USA, Australia	5–50 million t.	Zinc. Tin may be used in pigments but reduced performance.
Chromium	95% concentrated in southern Africa	<11 billion t — sufficient to meet conceivable demand for centuries.	No substitute for chromite ore in the production of ferrochromium, chromium chemicals or chromite refractories; no substitute for chromium in stainless steel.
Cobalt	Zaire, Cuba, USA, Australia	11 million t, plus speculation in crusts on ocean floor.	Nickel. Platinum, barium or strontium ferrite etc are potential substitutes.
Copper	USA, Chile, Australia	1.6 billion t, plus sea nodules 0.7 billion t.	Aluminium substitutes in various products. Titanium and steel, optical fibre and plastics.
Industrial diamonds	Australia, Zaire, Botswana	Unknown.	Technology exists to synthesise diamonds for industrial use. Competitive materials include cubic boron and nitride.
Gold	Rep. of S. Africa, Uzbekistan, USA, Australia	75,000 t, of which 15–20% are byproduct resources.	Generally palladium, platinum and silver.
Iron Ore	Australia, USSR, Brazil	<800 billion t of crude ore .	Crude ore will contain < 230 billion tonnes of iron. Iron ore is only source of primary iron.
Lead	Australia, USA, Canada	Identified subeconomic about 1.4 billion t .	Plastics, aluminium, tin, iron.
Lithium	USA, Australia, Chile	760 000 t in the US and 11.9 million t in other countries.	Substitutes for lithium compounds are possible in manufactured glass, ceramics (e.g. sodic); greases (calcium and aluminium soaps) and batteries (zinc and magnesium).
Manganese ore	Australia, Brazil, former USSR, Rep. of S. Africa.	Unknown but 80% identified reserves in former USSR and Republic of South Africa..	No satisfactory manganese substitute in its major applications.
Mineral Sands			
Ilmenite	Australia, Norway, China, Canada	1 billion t of titanium dioxide Ti 0_2.	Rutile and synthetic rutile are extensively used to produce titanium dioxide pigment.
Rutile	Brazil, Australia, Rep. of S. Africa	Approximately 200 million t of contained TiO_2.	Ilmenite, titaniferous slag and synthetic rutile.
Zircon	Australia, Rep. of S Africa	Exceed 14 million t .	Chromite and olivine in some foundry applications. Stainless steel and tantalum is limited substitution in nuclear service.
Nickel	USA, Canada, Australia Cuba. Russia, New Caledonia	130 million t — world deposits in lower grade nickel deposits are very large. Also extensive deep-sea resources.	Substitutes would probably increase cost or some trade off in economy or performance. Present and potential substitutes include aluminium, coated steels and plastics in construction and transport, titanium in severe corrosive applications and platinum, cobalt and copper in catalytic uses.
Phosphate rock	USA, Morocco and Western Sahara, Rep of S. Africa	Unknown — but resources in north and west Africa and Middle East. Large deposits on ocean floor.	No substitutes for phosphorus in agriculture. Estimates of reserves several times greater than present reserves. Resources continental shelves and sea mounts in Atlantic and Pacific Oceans. Australia a large importer of phosphate.
Platinum -group	Rep. of S. Africa, Russia, Canada	100 million kg.	Some experimentation with substituting palladium in catalytic converters.
Rare earth oxides	USA, China, former USSR, India, Australia, Malaysia	Relatively abundant in Earth's crust but minable concentrations are less common than for most ores.	Substitutes available but generally less effective. Australia main rare earth deposits are monazite. Other rare earths include bastnasite, ion-adsorption clays, loparite, phosphorites, apatite, eudyalite and spent uranium solutions.
Silver	USA, Australia, Canada, Mexico, Peru	Two thirds of world silver resources are associated with copper lead and zinc.	Aluminium and rhodium are used for mirrors, tantalum in surgical plates, stainless steel in tableware; non silver batteries are being developed; silverless black and white film is available.
Tantalum	Australia, Canada, Thailand, Brazil, Egypt	Resource considered adequate to meet projected needs.	Substitutions less effective. Include aluminium in electronic capacitors, titanium, zirconium and platinum in corrosion resistant equipment; tungsten in high-temperature applications.
Tungsten	China, Russia, Canada, Bolivia	41% of estimated reserves located in China.	Ceramics, ceramic metallic composites and other materials are being developed. Unsubstitutable material for filaments.
Vanadium	USA, China, Rep. of S Africa	Resources exceed 63 million t.	Steels containing various combinations of other alloying elements can be substituted for steels containing vanadium.
Zinc	USA, Australia	1.8 billion.	Many elements are competitors e.g. aluminium and plastics in diecasting material and galvanised sheet uses. Zinc in electronic, chemical and pigment uses.

Source: US Department of the Interior Bureau of Mines 1994.

demonstrated resource (EDR) reflects a high degree of certainty as to size and quality of the resource and its economic viability. Resources which are poorly known are referred to as inferred resources (see Table 6.6.5). (For further information on sub soil assets refer to Section 3, Subsoil Assets, of *Occasional Paper: National Balance Sheets for Australia — Issues and Experimental Estimates, 1989 to 1992* (ABS 1995, 5241.0).

Economic viability depends on whether at the time of determination the resources are deemed profitable to extract or produce. Para-marginal resources border on being economically viable and require only a small increase in price or improvement in technology to become viable. Sub-marginal resources, however, require a substantially higher commodity price, or a major cost-reducing advance in technology to become viable (ABS 1995, 8414.0).

Deposits also become more or less profitable because of economic and technological changes. Aluminium and steel, for example, replaced tin in many manufacturing processes such as food and drink can production. The quantities of tin mined, therefore, have fallen dramatically (BRS 1996, pers. comm.).

Reserves

Of the World's Economic Demonstrated Resources (EDR) (Table 6.6.5), Australia has approximately:

- 11% of the bauxite;
- 6% of the copper;
- 8% of the gold;
- 15% of the manganese; and
- 35% of the ilmenite.

Table 6.6.6 looks at estimates of world reserves of selected minerals, and shows that Australia holds major deposits of minerals such as cadmium, cobalt, lithium and silver. This table also shows that, in the majority of cases, minerals and commodities are capable of being substituted. There are exceptions in certain applications, however, such as bauxite (used in commercial production of alumina), chromium and manganese. Substitutes are not always efficient, either through reduced performance or increased cost. New technologies are emerging which increase substitution, for example the ability to synthesise industrial diamonds.

In New South Wales the main minerals (besides coal) are silver, copper, lead, zinc, mineral sands and gold. The Victorian minerals industry relies mainly on gold, copper, diatomite, gypsum and kaolin. Queensland is Australia's second largest mining State, with world class deposits of base metals, bauxite and magnesite (Jobson's 1994). Western Australia produces 50 different minerals, the major commodities being iron ore, gold and alumina (Department of Minerals and Energy WA 1995).

The South Australian mineral industry mainly relies on petroleum liquids, natural gas, opal and copper. The Olympic Dam deposits represent one of the world's largest accumulations of metals, with an estimated total resource of 2000 million tonnes of ore averaging 1.6% copper, 0.6kg/t uranium oxide, 0.6g/t gold and 3.5g/t silver (Jobson's 1994).

The Northern Territory (which has 3,500 known mineral occurrences) has world-class mineral deposits, including manganese, bauxite, uranium and zinc-lead-silver. 20% of the world's low cost uranium resource is found at Pine Creek. Potential reserves identified include gold, tin, tantalum, tungsten, base metals, platinum group metals, manganese, bauxite, diamonds and several other commodities (Department of Mines and Energy NT 1995a).

Jobson's (1994) reported that the known reserves in most of Tasmania's major mines would have reached the end of their life by 2000. Tasmania has a significant level of mining and a high mineral potential with deposits of iron oxide (including haematite, limonite and magnetite), lead, zinc, silver, copper and silica. As at June 1992, 807 mining leases and licences were in force covering a total of 61,527 hectares (Jobson's 1994; BRS 1996, pers. comm.).

As at 30 June 1992 the value of Australia's economically demonstrated resources (EDR) (also referred to as sub-soil assets), were estimated to be $145.2 billion (using the NPV approach and a discount rate of 7.5%). For further information on valuation of sub-soil assets, refer to ABS 1995 (5241.0).

During 1994 the EDR of gold, ilmenite, manganese, magnesite, zinc, tin and silver rose substantially. The EDR of other commodities, such as cadmium, diamond and vanadium fell significantly (BRS 1995).

Exploration

In 1994 Australia attracted 21% (US $431 million) of global mineral exploration expenditures, second only to South America which received 26.5%. Third was the United States with 15.7%,

6.6.7 Mineral exploration (other than petroleum) — expenditure and metres drilled

Period	Expenditure: Production leases	Expenditure: All other areas	Expenditure: Total	Metres drilled: Production leases	Metres drilled: All other areas	Metres drilled: Total
	$m	$m	$m	Km	Km	Km
1990–91	115	486	602	1 760	4 452	6 212
1991–92	131	473	604	1 626	4 253	5 877
1992–93	148	483	632	1 944	5 049	6 993
1993–94	184	608	793	2 770	6 810	9 580
1994–95	202	691	893	3 329	7 001	10 330

Source: ABS 1995 (8412.0).

then Canada with 13.6% (Department of Minerals and Energy WA 1995).

During the financial year 1994-95, mineral exploration expenditure totalled $893 million, an increase of 13% on the previous year. $555 million, or 62% of all mineral exploration expenditure, was used looking for gold. From 1988–89 to 1994–95 base metals exploration expenditure doubled to $201 million, and over the last five years diamond exploration expenditure has increased by 45% to $48 million. For the same period exploration expenditure for uranium has fallen 73% to just $8 million (ABS 1996, 8414.0).

During 1994-95, exploration expenditure rose in all States except South Australia when compared with 1993-94. Expenditure decreased in South Australia by $4 million. Increases ranged from 51% in Victoria to 8% in New South Wales (ABS 1996, 8414.0).

Western Australia accounted for 55% of the nation's total mineral exploration expenditure in 1994-95. Gold dominated WA's exploration expenditure, increasing by more than 20%, making up 76% of total exploration costs during 1994–95 (Department of Minerals and Energy WA 1995; ABS 1996, 8414.0).

Tasmanian exploration expenditure increased 46% to $14.9 million during 1994–95, while expenditure in the NT reached $74.3 million (excluding uranium) (Department of Mines & Energy NT 1995; ABS 1996, 8414.0).

Over the past three years, new capital expenditure in mining has increased at an average of 17% per year in real terms, reaching $6.7 billion in 1994–95. Similarly, the resources supporting future minerals and energy sector growth have been sustained by exploration expenditure, increasing by an average of 10% a year (in real terms) over the past three years, and reaching $1.6 billion in 1994-95. This investment has resulted in a number of new mines (expansions to mines) and minerals processing facilities commencing recently (Fisher 1996). Table 6.6.7 sets out mineral exploration expenditure and metres drilled since 1990–91 (ABS 1996, 8412.0 ; ABS 1995, 1301.0).

Production

"Australia is the world's leading producer of bauxite, diamond (by volume) and ilmenite, rutile and zircon. Australia is the third largest producer of gold and the fourth largest producer of iron ore" (MCA, 1995). Figures 6.6.8 and 6.6.9 show time series information on the production of selected minerals.

Mineral and coal commodity production is dispersed across Australia. During 1992-93 Western Australia accounted for the largest share by value with 41%, Queensland with 28%, New South Wales with 21%, the Northern Territory with 4%, and Victoria, South Australia and Tasmania each with 2% (ABS 1993, 1301.0).

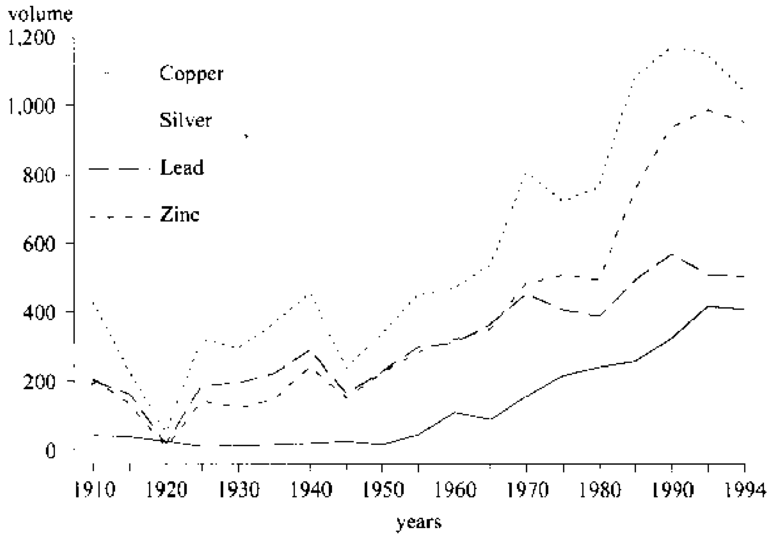
Since the end of World War II, the volume and value of mineral production and exports have grown rapidly, as demonstrated in part by Figures 6.6.10 and 6.6.11 (Vamplew, 1987; ABARE 1995). Further production and other economic data on the mining industry are contained in Sections 5.1 and 12.2.1, and in Chapter 11.

Exports

Australia's economy is resource dependent, being mainly reliant on the mineral and agricultural sectors. In 1994–95 minerals and energy exports totalled $30.3 billion, of which:

- Iron ore and steel ($4.2 billion);
- Bauxite, alumina and aluminium ($4.5 billion); and
- Gold ($4.7 billion).

6.6.8 Production of selected minerals



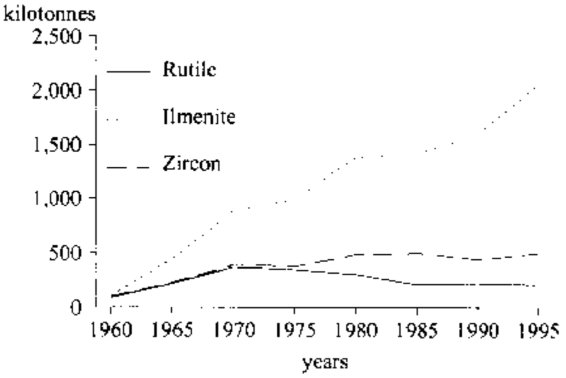
Production in kilotonnes, except for silver which is kilograms.

Source: Saddler 1987; Vamplew 1987; ABARE 1995.

Australia is one of the world's major mineral exporters. More than 80% of Australia's minerals are exported. This represented 50% of merchandise exports (goods only) and 40% of total exports (goods and services) during 1994-95. Gold, iron ore, aluminium, and iron and steel appear in the top ten commodity exports (ABS 1996, 8414.0; ABS 1995, 5422.0).

Merchandise exports by the mining industry (including coal, oil and gas) rose in value by 2% from $14,603 million in 1993–94 to $14,914 million in 1994–95, although this had still not reached the 1992–93 figure of $15,860 million. The metal ore and other mining sub-divisions accounted for $5,023 million in exports during 1994–95 (ABS 1996, 8414.0; ABS 1995, 5422.0). Further data on exports are provided in Chapter 11.

6.6.9 Production of Mineral Sand, 1960–95



Mineral sands are located along, or near the coast of New South Wales Queensland and Western Australia. Rutile & Ilmenite production is dictated by demand for TiO2 pigment

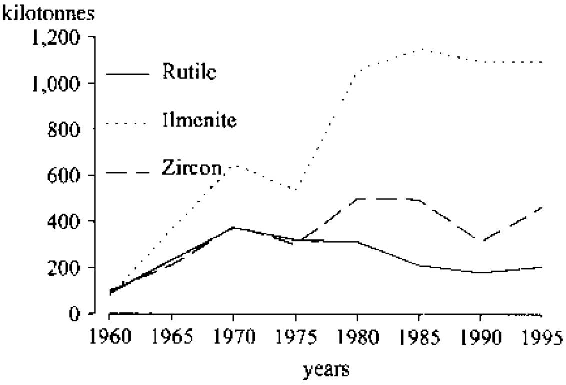
Source: Saddler 1987; Vamplew 1987; ABARE 1995.

6.6.10 Australian exports of selected minerals, 1993–94

		Exports	
Commodity	*Unit*	*Quantity*	*$m*
Aluminium			
Alumina	Mt	10.2	2 293
Aluminium	Mt	1.1	1 823
Copper			
In mine products	kt	. .	. .
Refined	kt	310.0	739
Diamond	Kct	31 715.0	562
Gold			
In mine products	t	. .	. .
Refined (a)	t	299.0	5 260
Iron and Steel			
Ore and Pellets	Mt	114.0	2 777
Iron and Steel	Mt	2.9	1 307
Lead	kt	490.0	340
Nickel	kt	na	620
Mineral Sands			
Ilmenite concentrates	kt	1 054.0	88
Rutile concentrates	kt	208.0	111
Synthetic rutile	kt	187.0	85
Titanium dioxide pigment	kt	114.0	255
Zircon concentrates	kt	454.0	94
Zinc	kt	1 045	810

(a) Includes gold of Australian and overseas origin;
Source: ABARE 1995.

6.6.11 Export of mineral sand, 1960–95



Source: Saddler 1987; Vamplew 1987; ABARE 1995.

New Technology

The remoteness, large resources and concentration of minerals in Australia have required the development of highly efficient mining and transport systems capable of handling large tonnages over long distances. New processes have also been brought into production to treat ores not previously thought economic to extract (Clark 1996). Data collected by the ABS on the impacts of new technology show large percentages of producers reporting increases in the quantity of outputs and products (see Table 6.6.12).

The mining industry is using a range of scientific disciplines to provide innovative techniques. The value of research and development (R&D) expenditure in the mining industry in 1993–94 was $309 million, an increase of 80% in current prices over 1992–93. Human resources, measured in person years of effort, devoted to R&D decreased by 5% (42 years) in 1993–94 (see Table 6.6.13) (ABS 1995, 8114.0 cited in ABS 1996, 8414.0).

6.6.13 Research and development in mining industry

	Expenditure	Person years of effort
	$m	years
1992–93	172	840
1993–94	309	798

Source: ABS 1995 (8114.0).

Satellites, airborne surveys and the use of helicopters reduce the disruption caused by exploration. Data from satellites, combined with airborne geophysics surveys fed through sophisticated software, are used to prepare geological maps and interpret the geology. Technological progress has also allowed the exploitation of resources even under the most adverse natural conditions (AMC 1995; Gould 1996).

Due to the increase in identified reserves and efficiencies in extraction and production, prices to the consumer have been falling. Lower prices can increase demand and thus production rates. Production rates for the majority of main minerals have been climbing rapidly over the last few years (see Section 12.2.1).

Recycling

Minerals can also be re-used. As metals degrade slowly and often have a relatively high intrinsic value as scrap, they are often recycled even years after their first use (see Tables 6.6.14 and 6.6.15). In September 1994 a report handed down by the Senate Standing Committee on Environment, Recreation and the Arts relating to Waste Disposal recommended:

"that technologies designed to re-use or recycle be given priority ... where technology is available governments [should] work with industry to

6.6.12 Effect on production by industry and factor of new technology

Industry Description	Increase		Decrease		No Change	
	1990–91	1993–94	1990–91	1993–94	1990–91	1993–94
	%	%	%	%	%	%
Output Quantity						
Metal Ore	46	55	4	1	49	44
Other Mining	33	51	8	1	60	48
Product Quantity						
Metal Ore	51	51	1	0	48	49
Other Mining	45	57	0	0	55	43
Production costs						
Metal Ore	32	21	49	57	19	22
Other Mining	30	19	25	55	45	26

Source: ABS 1996 (8413.0).

encourage the use of recycled materials instead of raw materials" (Parliament of the Commonwealth of Australia September 1994).

Data on waste recycling are often difficult to obtain because of the commercial-in-confidence nature of the operations. Figures for aluminium and steel show that in 1994 the rate of recycling was 60% for aluminium cans, and 4% for steel cans in 1993 (Environmental Protection Agency (EPA) 1994; Industry Commission (IC) 1991). Details on waste reduction targets are provided in Table 12.1.3.5.

Aluminium can recycling has been occurring commercially, on a large scale, for about 20 years. The industry has implemented new technologies to reduce the amount of metal used in cans. There has been a 10% reduction in weight since 1990, and a further 15% weight reduction is believed possible. Data provided by Comalco indicated that of the 2,623 million cans sold in 1992, 1,600 million were returned for recycling, producing 26,666 tonnes of aluminium (EPA 1994).

Lead has a high level of recovery in Australia. In 1989-90 about 36,000 tonnes or 60% of consumption was recovered, 20,000 tonnes being exported during that year (26% of consumption). About 90% of the lead scrap is recovered from lead-acid batteries from vehicles (IC 1991). In 1994 EPA found that Australia produced around 3.8 million lead acid batteries per year, and that about 66% (or 2.5 million) are recycled in Australia. The remainder are exported for recycling (ABS in press, 4605.0). Further details on batteries are covered in Section 12.1.4.

Copper recovery was about one-fifth of copper consumed in Australia, about 24,500 tonnes. In 1988, 2,500 tonnes of scrap copper were imported. As Australia exports considerable quantities of copper, reprocessed copper accounted for only 12% of total production (IC 1991).

Steel scrap amounts to about 1.6 million tonnes per year (26% of the steel consumed in Australia). This does not include the scrap recovered directly and used in-house by steel producers (IC 1991). Steel cans can be processed into dense, clean, high grade scrap. Over the last ten years a 'typical' steel can has been reduced in weight by 18%. The local price for scrap often does not match the cost of recycling. Figures provided by BHP Steelworks indicated that 81 tonnes of steel cans were returned to BHP during 1994 and a further 25 tonnes extracted from a landfill at Lucas Heights (EPA 1994). Table 6.6.15 lists some recyclable materials.

6.6.14 Recovery and reprocessing of products, 1988–89 (a)

			Net imports of scrap material			
	Quantity recovered	*Recovery rate (b)*	*Quantity*	*Proportion of consumption*	*Quantity reprocessed*	*Proportion of consumption reprocessed*
Product or Commodity	*'000 tonnes*	*%*	*'000 tonnes*	*%*	*'000 tonnes*	*%*
Aluminium						
all scrap	99	31	−51	−16	48	15
Used Beverage Cans	28	62	−5	−10	23	52
Lead	36	60	−20	−33	16	26
Copper	24	19	3	2	27	21
Steel	1 616	26	−791	−13	825	13
Tin	<1	37	0	0	<1	37
Glass						
reprocessed						
all glass	290	25	0	0	290	25
containers	204	24	na	na	204	24
reused (refillable bottles)	<13	65	0	0	<13	65

(a) Estimates are for 1988-89 but may refer to different years (both calendar and June), and are intended as a guide only.
(b) Proportion of consumption recovered.
Source: IC 1991.

Restrictions on access

Land access has been a major factor for Australian mining since the early 1970s. Burton (1987) reported that more than 20% of total land area was either unavailable for mineral exploration or available under severe constraints. For example 45% of Australia's mineral sands resources fall within national parks or other reserves (Burton 1987 p. 2) (see Table 6.6.16 for reserve and crown lands and Figure 6.6.17 for access to land in WA). However, some States allow mining in national parks even though these areas are set aside because of their ecosystems, outstanding scenic values or geological formations. Conservation reserves, meanwhile, are mainly small in size and provide special localised habitats or remnant vegetation. Many are close to urban areas and include bushlands and wetlands (Coveney 1993).

Offshore restrictions also include aquatic reserves (also referred to as Marine and Estuarine Protected Areas). In 1991, these areas comprised about 2 to 3% of the whole area of coastal waters around Australia. In September 1991 Australia had 173 marine parks established to protect the marine and estuarine environments in the same way as national parks and reserves on land (Coveney 1993). Further details on marine parks can be found in Section 7.2. As mentioned earlier, the Australian Antarctic Economic Exclusion Zone of 2.4 million km^2 is only open for scientific research at present.

6.6.15 Selected minerals – recycling and uses

Mineral	*Recycled*	*Use*
Bauxite	scrap	Aluminium packaging, building, electrical.
Cadmium	batteries	Batteries, pigments, plastics and synthetic products.
Chromite	steel scrap	Stainless Steel and heating resisting steel, full alloy steel.
Cobalt	superalloy scrap	Super alloys in aircraft gas turbine engines, paint dryers, magnetic alloys.
Copper	scrap	Building construction, electrical and electronic products, industrial machinery and equipment, transport equipment.
Diamonds	salvage stone, sludge, swarf	Machinery, mineral services, stone and ceramic products, abrasives, contract construction, transportation equipment.
Gold	scrap	Jewellery, computer.
Ilmenite	unknown	Byproduct of sand and gravel production. Pigment in surface coatings such as paint and plastic.
Iron Ore/Steel	Scrap iron and steel and steel slag	Transportation, construction, cans and containers.
Lead	mainly from scrap batteries	Batteries, fuel tanks, solder, electrical, electronic and communication, ammunition, TV glass, radiation shielding and protective coatings. Also ballast and weights, ceramics, crystal glass, foil, wire and specialised chemicals.
Lithium	unknown	Ceramics, glass, primary aluminium production also lubricants, greases and synthetic rubber products.
Magnesite	unknown	Refractories, agricultural chemicals, construction and industrial applications.
Manganese ore	scrap	Constituent in aluminium magnesium products, desulphurisation of iron and steel, cathodic protection.
Molybdenum	superalloys, spent catalysts, steels and iron	Used in iron and steel production, machinery, electrical, transportation, chemicals, oil and gas industry.
Nickel	scrap	Stainless steel alloy production, nonferrous alloys and superalloys, electroplating. Used in transportation, chemical industry, electrical equipment.
Platinum-group	scrap	Automotive, electrical and electronic, chemical, dental and medical.
Rare earth oxides	magnet scrap	Petroleum fluid cracking catalysts, chemical and pollution-control catalysts, metallurgical applications, glass and ceramics.
Rutile	unknown	Titanium dioxide pigment, welding-rod coatings and fibreglass.
Silver	scrap	Manufacture of photographic products, electrical and electronic products, electroplated ware, sterlingware and jewellery.
Tantalum	scrap	Electronic components, tantalum capacitors.
Tin	tin and alloys	Cans and containers, metal consumption.
Tungsten	scrap	Electrical and electronic machinery and equipment, lamps and lighting, chemicals.
Uranium	scrap	Production of electricity, medical and weaponry.
Zinc	scrap, brass, dust, oxide	Galvanising, zinc-base alloys, brass and bronze. zinc dust used in chemicals, agricultural, rubber and paint industries. Major co-products of mining and smelting are lead, cadmium, silver and sulfur.
Zircon	scrap	Nuclear fuel road cladding and other finished metal and glass products.

Source: United States Department of the Interior Bureau of Mines 1994; Hogan 1996.

6.6.17 Reserve land and Crown land

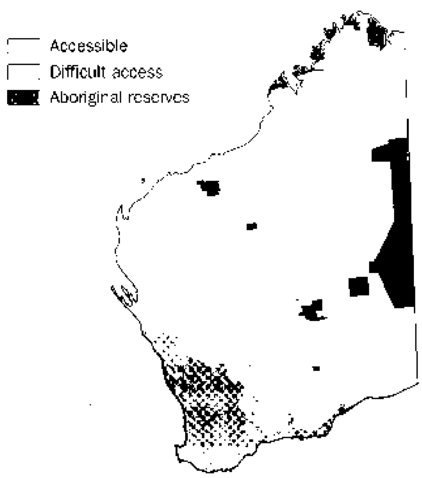
Category	*NSW*	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
	'000 km^2	*'000 km^2*	*'000 km^2*	*'000 km^2*	*'000 km^2*	*'000 km^2*	*'000 km^2*	*'000 km^2*	*'000 km^2*
Reserve and National parks									
Nature conservation reserve	38.1	30.6	52.9	203.7	154.8	13.4	15.0	1.2	509.7
Aboriginal freehold national park	0.0	0.0	0.0	0.0	0.0	0.0	24.3	0.0	24.3
Forestry reserve	34.6	36.4	43.9	1.0	20.9	15.2	0.0	0.1	152.1
Water reserve	2.8	1.4	0.3	0.2	5.3	0.9	0.0	0.0	10.9
Total	**75.5**	**68.4**	**97.1**	**204.9**	**181.0**	**29.5**	**39.3**	**1.3**	**697.0**
Crown Land									
Vacant Crown land	1.4	0.0	0.6	8.3	863.5	4.3	82.8	0.0	960.9
Other Crown land	6.4	2.0	13.9	0.8	42.8	2.5	12.3	0.0	80.7
Leasehold Crown land	308.9	0.1	939.3	418.5	900.1	0.0	668.2	0.9	3 236.0
Total	**316.7**	**2.1**	**953.8**	**427.6**	**1 806.4**	**6.8**	**763.3**	**0.9**	**4 277.6**

Source: AUSLIG Land Tenure Databse 1993.

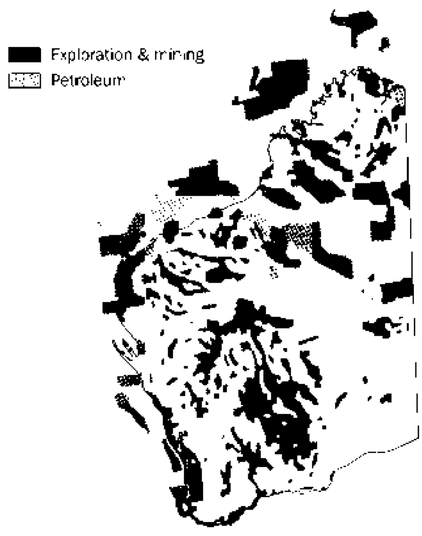
In Western Australia, at 30 June 1994 there were 17,412 km^2 of mining titles. The total area available for development represented less than 1% of the State's land area, and it is estimated that less that 0.05% of the State is being disturbed by mining (Department of Minerals & Energy WA 1995). In comparison, pastoral leases take up 35.0%, private agriculture 6.9%, Aboriginal heritage sites and reserves 11.4% and National parks, timber reserves and nature reserves occupy 6.8% of the State (Department of Minerals and Energy WA, 1994; MCA, 1995).

6.6.16 Land access in Western Australia

Land access



Areas under exploration and mining



Source: Dept of Minerals and Energy WA 1994.

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6.7 Soil conditions

Introduction

Soils in many parts of Australia are physically fragile and of low nutrient status. Activities and processes that use soils have great scope for significantly modifying these conditions, e.g. soil structure and fertility. This can be observed in the acceleration of soil degradation in Australia.

As rates of soil formation are very slow in most parts of Australia, soils may require inputs of non-renewable resources (such as phosphates and nitrates) to maintain production (also discussed in Sections 1.3 and 6.4). The degradation of soils is of concern because in some cases it is irreversible or not economically feasible to restore soils to their productive potential. The capability of such lands for production or other non-human land uses is therefore reduced. The ecological sustainability of these activities is brought into question.

Soils may be considered a non-renewable resource if activities and processes that interact with them degrade them faster than formation rates.

This section looks at a number of issues relating to soil use. First some of the activities dependent on soil conditions are discussed. The extent of degradation caused by these activities is then considered, including the processes by which this degradation occurs. Finally, economic quantification is provided of estimates of some soil degradation losses.

Section 6.4 discusses some issues in agriculture including soil management practices, farm planning and involvement in the DPIE program Landcare. It is these practices that will determine the condition of Australia's agricultural soils and farming activities in the future.

Activities using soils

Central to all land use activities and processes is a dependence on the physical and/or chemical attributes of the soil (see Table 6.7.1). For example, plant growth is heavily dependent on both (e.g. soil structure and chemical availability), while construction is more heavily dependent on the physical conditions that soils provide (e.g. good drainage). Land use is governed by a soil's capacity to sustain a given activity.

In Australia, activities and processes that depend on the soil include agriculture, forestry, non-human biotic communities, mining and urban industrial activity. Table 6.7.1 summarises the ways in which these activities use the soil, the potential changes they can make to soils and potential impacts that these changes may have on other systems.

The ways in which these activities use the soil are quite different. Agriculture, forestry and natural biotic communities require and attempt to maintain the soil characteristics which are favourable to plant growth. Mining operations use soils in rehabilitation activities to re-establish native flora, as well as containing toxic materials used in the extraction process. This section, however, concentrates on the human activities using soils, particularly agriculture.

The issues of sustainability are determined by the ability of these activities and processes to change soil conditions, together with the sensitivity of these activities and processes to the changes in soil conditions.

The intensity of land use is a consideration when assessing changes to soils, as they have different thresholds. These will vary according to the type of activity and the type of soil. Section 12.2.1 discusses the amounts of land dedicated to these activities and the general changes made by them.

Contribution of these activities and processes to changes in soils

Soil structural decline

As discussed in Section 1.3, soil structure is essential in soils to assist in the movement of water, biota and gases through the soil profile. Soil structure decline is often associated with agricultural activity although certain pre-existing soil conditions can give a soil greater or less resistance. Soil structure decline is not always apparent, but it is recognised as a major constraint to long term sustainability of agricultural production in Australia (Land and Water Resources Research and Development Corporation (LWRRDC) 1995a).

Figure 6.7.2 shows the extent of area where yields have been affected by soil structural decline. The actual area could be larger, but it has not been quantified (LWRRDC 1995). The areas where this has been recorded coincide with areas of cropping (see Figure 6.4.1).

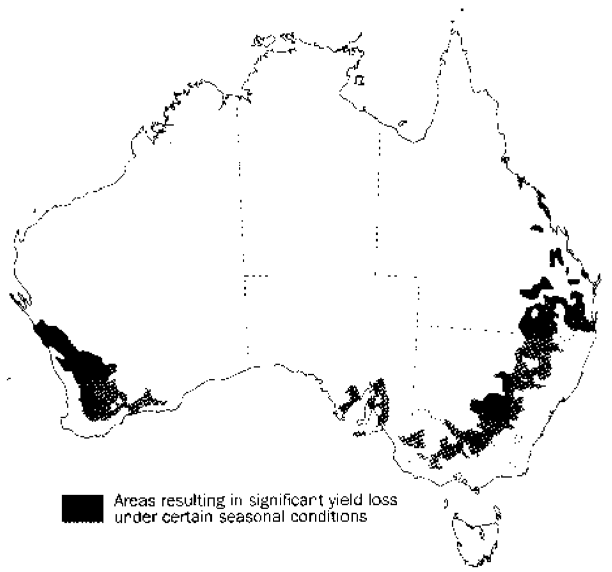
Soil structural decline can occur as surface sealing and crusting, compaction of the entire A horizon (see Section 1.3 for an explanation of soil horizons) or compaction of the subsoil to form a 'plough pan' (ed. Charman and Murphy 1991). This can lead to water runoff or waterlogging problems and is likely to affect seedling emergence and yields.

6.7.1 Attributes of soils required for activities and processes and their associated changes

Activity	*Attributes of soil required for activity*	*Potential changes to soil conditions associated with activity*	*Other soil & environmental impacts*
Agriculture			
extensive grazing	Physical and chemical requirements for plant growth to maintain pasture cover for feed. In some cases, suitability for improved pasture species.	Removal of plant cover by grazing animals, both native and non-native, leaving bare soil surface (contributing to erosion by water and wind and soil structural decline). Replacement of native, deep rooted perennial grass species with shallow rooted annual species (exacerbating salinity problems and, in times of drought or overstocking, leaving the soil surface bare). Introduction of leguminous pasture species (contributing to acidic soil conditions in some circumstances). Pulverisation of soil surface by hard hoofed grazing animals (contributing to erosion by water and wind and structural changes in the soil surface). Export of nutrients in product removal (contributing to nutrient decline and acidity).	Sedimentation Changes in soil biodiversity. Salinity damage to local area, even off farm.
intensive grazing	Well drained, stable soils. Fertile soils (e.g. for dairy pastures).	Localised pulverisation and compaction in pens (e.g. cattle feedlots). Waterlogging in irrigated pastures.	Sedimentation. Eutrophication of surface water supplies. Acidification.
cropping	Chemical and physical requirements for plant growth.	Physical disturbance of the soil surface, oxidation of organic matter (contributing to soil structural decline and erosion) Bare soil surfaces exposed to rain or irrigation events (erosion and structural decline). Export of nutrients in product removal (contributing to nutrient decline and acidity).	Sedimentation. Eutrophication. Salinisation.
horti-culture	Physical and chemical requirements for plant growth (higher fertility required due to intensive nature of operations).	Changed hydrological conditions due to irrigation. Increased fertility due to intensive conditioning of the soil (e.g. addition of organic matter and addition of fertilisers).	Eutrophication. Pollution of surface and groundwater.
Forestry	Chemical and physical requirements for plant growth (soils of low agricultural value are often used).	Bare soil surfaces after intensive harvesting, particularly in even aged coupes (erosion and soil structural decline). Activity often on sloping land, increasing runoff. Export of nutrients in product removal (possibly contributing to nutrient decline and acidity in some cases).	Sedimentation Simplification of soil ecosystems that could result in changed plant communities.
Mining	Chemical and physical requirements for plant growth (on rehabilitation of sites). Valuable minerals for trade (e.g. sands and clays).	Complete restructuring of the entire soil surface in open cut mining operations. Some mixing of soil horizons (contributing to unfavourable soil conditions e.g. mixing dispersible material from lower horizons into the surface soil). Oxidation of organic matter and leaching of soil nutrients from stockpiled soil materials. Escape of chemicals from extraction processes (leading to salinity of contamination of site).	Localised contamination of soil. Sedimentation.
Urbanisation and industrial	Physical stability to support intensive land use and engineering works. Chemical stability to minimise depreciation of capital works.	Soil surfaces left bare during construction phases (contributing to erosion.) Increased nutrient loading due to insensitivity of land use. Concentrated application (intentional and otherwise) of toxic substances including wastes to soils (pollution.) Increasing run-off from non-permeable areas and the contamination of the run-off with oils and chemicals.	Increased runoff. Sedimentation. Eutrophication. Pollution of soils.

Source: ed Charman & Murphy 1991.

6.7.2 Areas experiencing yield losses as a result of soil structural decline



Source: AUSLIG 1992 in ABS 1992 (4140.0).

Tillage of the soil surface physically breaks up the soil aggregates into smaller units, affecting the overall structure of the soil. The properties of plant roots and fungal hyphae that bind the soil particles together can be reduced by oxidation when exposed to air and light after continuous tillage events. Table 6.7.3 shows the effects that different cultivation methods have on organic matter. In most cases shown in the table, directly drilled soils showed consistently higher amounts of organic matter than soils under conventional, continuous cultivation.

Irrigation regimes affect the soil structure through the modification of hydrological cycles (increasing levels of sodium in the upper soil horizons). The impact of the droplets of water on the soil aggregates can also change the soil structure, so it is important that the soil is wetted at a slower rate to reduce the risk of disintegration by slaking.

The graphs in Figure 6.7.4 show organic carbon percentages and infiltration rates under different management practices throughout the cereal belt of southern New South Wales and northern Victoria. This 1991 sampling of lighter textured surface soils found that:

- 30% of sites had low surface infiltration;
- 30% had restricted water flow in the topsoil;
- 40% were susceptible to waterlogging due to poor soil structure; and
- less than 50% had soil strength high enough to restrict root growth.

The most severely affected cropping site sampled had an infiltration rate of less than 5 mm per hour, while the best had rates over 100 mm per hour (LWRRDC et al. 1995).

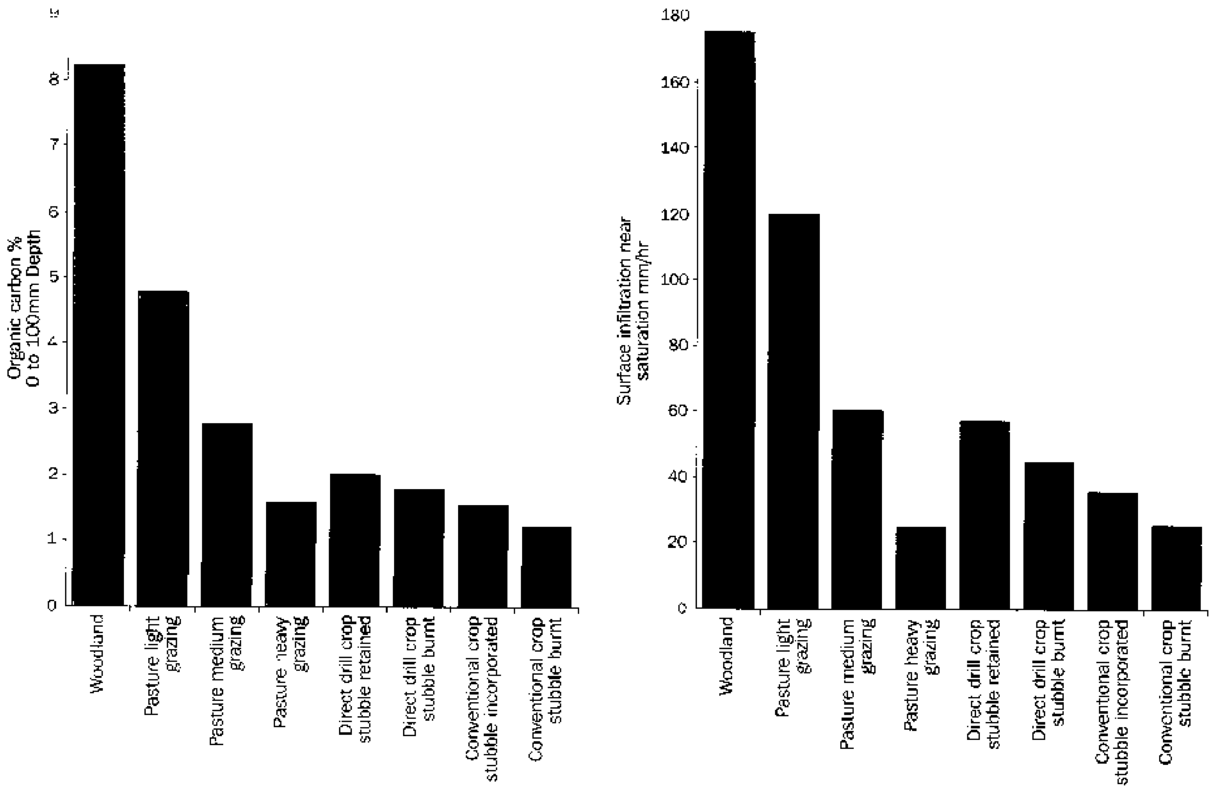
Figure 6.7.4 shows that infiltration rate and organic carbon content are considerably less in soils on sites under various agricultural management regimes than sites with similar soils under woodland.

6.7.3 Percentage organic carbon in topsoils in Western Australia using different tillage regimes

	Earthy sand		*Sandy loam*		*Sandy clay loam*	
	Direct drill	*Conventional cultivation*	*Direct drill*	*Conventional cultivation*	*Direct drill*	*Conventional cultivation*
Year	%	%	%	%	%	%
1976 (a)	0.79	0.79	1.55	1.55	1.03	1.03
1980	0.84	0.80	1.60	1.37	1.03	0.94
1983	0.80	0.70	1.57	1.35	1.02	0.92
1986	0.64	0.51	1.52	1.30	0.92	0.85

(a) 1976 measurements taken from the first 10 cm of soil. Measurements for other years taken from the first 5 cm.
Source: Hamblin and Kyneur 1993.

6.7.4 Organic carbon and surface infiltration rates of lighter textured soils under selected management practices, 1991



Note: Soils sampled were from the cereal belt of southern NSW and northern Victoria.
Source: LWRRDC et al. 1995.

Erosion

As discussed in Section 1.3, erosion is a naturally occurring process in soil formation and degradation. Certain management practices have exacerbated erosion problems, resulting in widespread removal of topsoil in many parts of Australia, in both urban and non-urban settings.

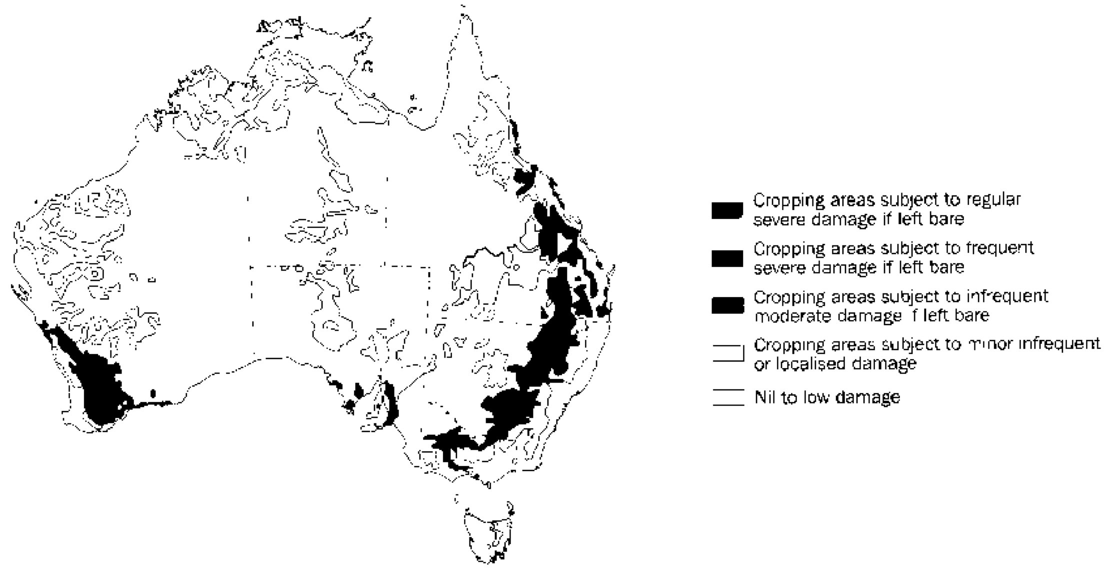
There is little experimental data available for soil erosion rates, but it has been suggested that they have increased 10 to 100 times in the last 100 years within agricultural areas (LWRRDC et al. 1995). This source also suggests that the main phase of erosion that coincided with widespread clearance of vegetation has passed, when rates of erosion of 10 to 50 tonnes of soil were estimated per hectare per year. Table 6.7.5 shows erosion rates for two sites in the Darling Downs in Queensland. The rates of erosion are quite different for the two soil types under the same management practices. Erosion can also occur in the urban environment, particularly around building development sites where the vegetation has been removed leaving bare soil.

6.7.5 Erosion rates for different crop management practices on two soils, Queensland

Soil type	*Crop management practice*	*Erosion rate (a)* t/ha/year
Black earth (b)	bare fallow prior to sowing crop.	61.0
	summer cropping with winter fallow.	22.3
	stubble incorporation.	17.9
	stubble mulching.	5.3
	zero tillage.	2.1
Grey clay (c)	bare fallow.	31.6
	summer crop.	19.8
	stubble incorporation.	7.8
	stubble mulching.	3.9
	zero tillage.	1.8

(a) Tonnes of soil removed per hectare per year.
(b) Trial conducted over an eight year period.
(c) Trial conducted over a six year period.
Source: Edwards 1991.

6.7.6 Areas that experience damage as a result of water erosion when soil surfaces are bare



Source: AUSLIG 1992 in ABS 1992 (4140.0).

Water erosion

Water erosion is the most common form of land degradation in Australia (ABS 1992, 4140.0). Figure 6.7.6 shows the areas most susceptible. Water erosion can occur in a number of forms. Sheet and rill erosion is the process whereby only surface materials are translocated. Sheet erosion can cause the topsoil of an entire paddock to be removed if left with no vegetative cover (especially following heavy rainfall on bare earth). Rill erosion is the process whereby soil movement occurs in a line of drainage. Severity of the erosion increases as slope angle, slope length and the velocity of water flow increases. A criterion of depth is usually used to distinguish between rill and gully erosion. Rill channels are less than 30 cm deep, while gully erosion etches out a gully to a depth greater than 30 cm (Office of the Commissioner of the Environment 1991). Gully erosion can be responsible for taking large areas of land out of production.

Tunnel erosion is caused by the flow of water below the soil surface. When subsoils are unstable (often due to high levels of exchangeable sodium) water creates underground tunnels which can go undetected until the surface soils collapse. Mass movement is the slippage of soil and rock materials due to weakening of structure. Types include soil creep, earthflow, slumps, landslips and landslides.

While sheet and rill erosion can be very destructive, the other forms are harder to remedy.

Erosion by wind

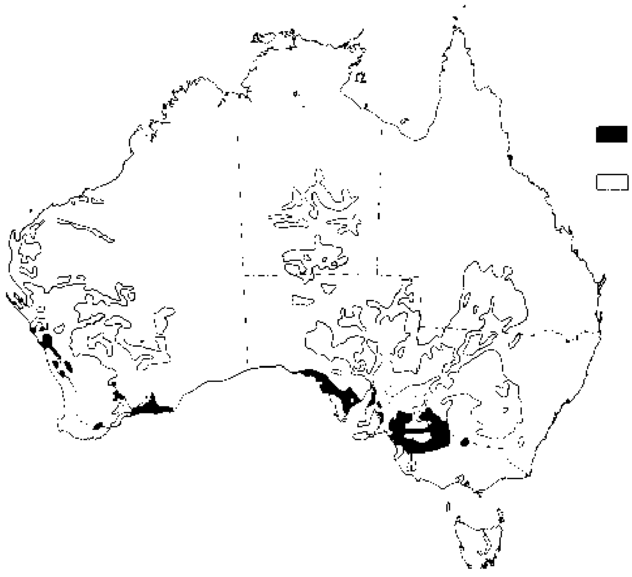
Figure 6.7.7 shows areas susceptible to wind erosion. These are areas subjected to agricultural activity, so the total area affected may be underestimated. The sandy soils of southern and central Australia are considered to be the most susceptible to wind erosion.

Soil nutrient status

As discussed in Section 1.3, Australia's soils are largely of very low nutrient status. Few studies, however, have been undertaken to determine the changes within the cycles of the major soil nutrients in Australia with respect to nature and human activities and processes (McLaughlin, Fillery & Till 1992). While measurements of nutrient levels are possible it is difficult to generalise soil nutrient status for the entire country. There is also difficulty in determining the nutrient status as not all the minerals present in the soils are in a form which can be assimilated by plants.

Agricultural activities in Australia often depend on fertiliser use, such as the application of phosphatic fertilisers which has dramatically increased yields of wheat since the turn of the century (Hamblin & Kyneur 1993). Large amounts of phosphorus are quickly made unavailable through microbial activity and mineralisation after application so that, while total phosphorus levels in the soil may be increasing, available phosphorus is not. McLaughlin, Fillery & Till (1992) regard

6.7.7 Areas that experience damage as a result of wind erosion



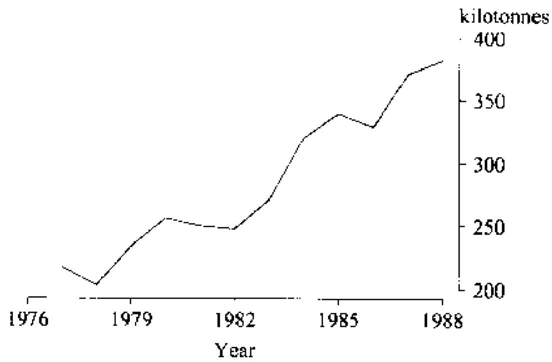
Source: AUSLIG 1992 in ABS 1992 (4140.0).

phosphorus as a non renewable resource since the rate at which it is cycled is on a geological, not ecological time scale. Most farming systems, including organic systems, are dependent on external inputs of phosphatic fertilisers.

Nitrogen is the most limiting nutrient to plant production. Leguminous pasture leys (the phase of the rotation where soils are under permanent pasture) in cropping rotations have been used to increase nitrogen fixation in the soil. There has also been a general increase in the amount of nitrogenous fertiliser used in Australia from 217 kt in 1977 to 382 kt in 1988 (see Figure 6.7.8). In some areas these efforts have been beneficial, in others they have contributed to acidification.

Soil nutrient decline may be either measured in the soil or monitored as the decline in quantity or quality in yields (McLaughlin, Fillery & Till 1992). Table 6.7.9 shows the decline in protein of wheat from 1967 to 1991. It is important to realise, however, that yield and protein are not positively correlated in many instances. Lower yields can produce higher protein, for example, because of varietal improvements. A study undertaken by Hamblin and Kyneur (1993) found some yields increasing at the cost of protein levels. Figures quoted showed a deficit of 12–15 kg of nitrogen per hectare of cropping soil per year in certain Australian soils. This deficit can range from 16.5kg in a wet year to 8.1kg in a dry year for wheat cropping per hectare.

6.7.8 Nitrogenous fertiliser use in Australia



Source: McLaughlin, Fillery & Till 1990.

6.7.9 Annual yield and protein content (a) of wheat in Australia (b)

(a) Average of State protein contents weighed by production.
(b) Excludes Queensland due to missing data for several years.
Source: Hamblin & Kyneur 1993.

Acidification

Table 6.7.10 shows areas affected by induced soil acidity. Figure 1.3.9 showed estimates of the total area of acidic soils in Australia, by extent of acidification. Many of Australia's acidic soils are naturally occurring. Soils of concern are those that show accelerated acidification, particularly those in the prime cropping and pastoral zones in Australia under irrigation or in high rainfall areas (LWRRDC 1995a). These sites have been estimated to have dropped 1 pH point (measured in water) in the last 30 to 50 years (LWRRDC 1995a). Soils that are subject to product removal undergo accelerated acidification due to the imbalance of acidifying and alkalising processes if conditions are appropriate (Chartres et al. 1992).

Application of acidifying nitrogenous fertilisers on soils which are also susceptible to leaching of mineral salts makes them susceptible to acidification.

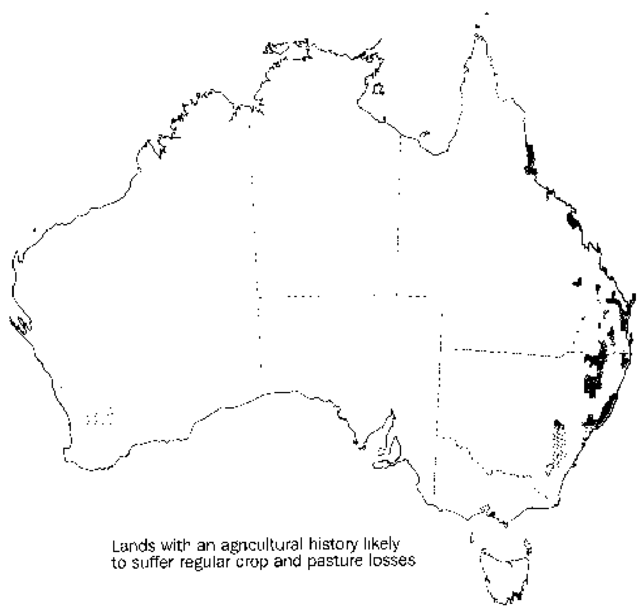
The LWRRDC (1995b) suggest that rates of acidification in NSW will result in a drop of 1 pH point in 23 years in sandy soils, and 113 years in clayey textured soils under present management practices.

Salinity

Figure 6.7.11 shows estimates of the areas affected by salinity in Australia in 1992. Salinity hinders plant growth and affects water quality.

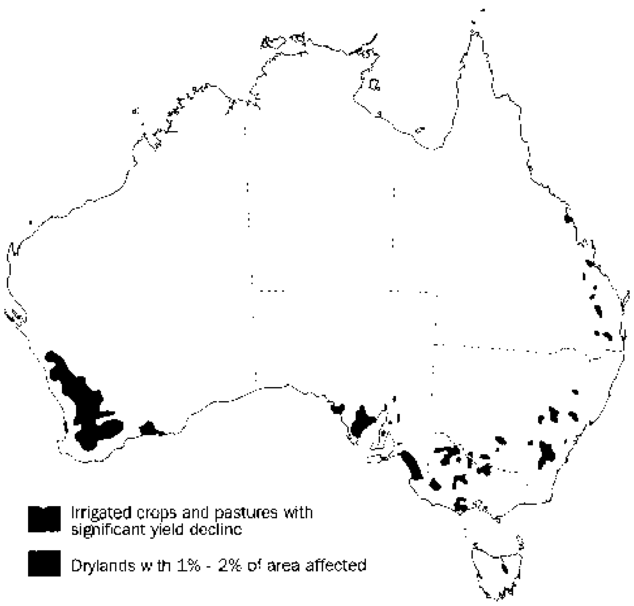
Salinity can hinder sensitive plants in their ability to take up water and cause specific toxicities depending on the salt present (Cumming & Elliot 1991). Not only are valuable crops and pastures lost, but the resulting bare patches become compacted, assisting in water runoff and erosion. While salinity is a naturally occurring process, human activities in Australia have exacerbated the problem.

6.7.10 Areas of induced acidity



Source: AUSLIG 1992 in ABS 1992 (4140.0).

6.7.11 Areas affected by salinity



Source: AUSLIG 1992 in ABS 1992 (4140.0).

Dryland salinity

Australia has an estimated 2,239,000 hectares of land affected by dryland salinity (LWRRDC 1995a). The widespread clearance of deep rooted perennial vegetation in favour of shallow rooted annual crops and pastures in many areas since European settlement has resulted in a changed hydrological cycle (Figures 12.2.1.12 and 12.2.1.13 show the distribution and patterns of land clearance in Australia). Over time, groundwater has risen into the root zone of plants, bringing with it dissolved salts from further down the soil profile. These salts can become concentrated in the surface on evaporation of water, causing scalds. In other cases the groundwater stays at the surface, causing seepages.

Irrigation salinity

156,000 hectares are thought to be affected by irrigation salinity in Australia (Williamson 1990 cited in ABS 1996, 4606.0). This problem relates to the increasing build-up of salts in the soil and water system. This is caused by the repeated use of salinised river water and rising saline water tables (Charman & Murphy 1991).

Pollution

Soil may be contaminated by chemicals from a wide range of activities that are toxic to biota and persist in the soil. Soil pollution usually becomes of concern when land is being upgraded to a more sensitive land use activity, for example from industrial or agricultural use to urban residential. Contaminated sites are recorded on a State or Territory basis. Each has its own criteria for the registration of contaminated sites and sites at risk.

Costs and losses associated with soil degradation

The types of losses and costs associated with soil degradation will affect the long term sustainability of activities dependent on soils. Costs and losses due to soil degradation are felt both on site and off site.

In most cases it is difficult to quantify the losses attributable to soil degradation. As discussed earlier, the extent of the main forms of soil degradation is not known accurately, so that a base to calculate losses is not available. It is difficult to establish causality of factors contributing to losses in revenue from soil based activities, as factors such as climate variability can influence yields, and markets influence prices. The accuracy of measurements on a broad scale also has inherent problems due to the variations in severity of the problem.

6.7.12 Costs of nutrients removed with eroded sediments in two storm events, Cowra Research Station

	Estimated concentration in sediment leaving plot		*Cost of replacing this nutrient with fertiliser (a)*	
	Total N	*Total P*	*Total N*	*Total P*
Tillage method	*%*	*ppm*	*$/ha*	*$/ha*
Traditional	0.096	52	203.00	28.00
Reduced	0.097	37	220.00	21.50
Direct drill	0.168	140	29.00	6.20

(a) Costs calculated based on $0.70 per kg N (urea) and $1.78 per kg of P (DSP), as at February, 1992.
Source: ABS (4606.0) after Australian Journal of Soil and Water Conservation Vol. 6 No 4, 1993.

Table 6.7.12 shows estimates of the cost of nutrients lost from eroded sediments in two storm events from experimental trial sites under different management systems, conducted by the Cowra Research Station. The concentration of nutrients was highest for the direct drill sites, but the volumes of nutrient needed were less. It should be noted that the costs only take account of the fertiliser material and not application costs or costs associated with lost production.

Table 6.7.13 shows estimates of the amounts of alkaline product (calcium carbonate) needed to replace that removed from production of various agricultural commodities.

Estimates of the costs of amelioration of soil acidification have been made for some regions in Australia that are of particular concern (see Table 6.7.14). Great variations may be observed in the estimates of difference between liming and not liming for the various systems. For example wheat showed great differences in current gross margins and in liming costs from region to region. This resulted in net present value differences ranging from $11.48 per hectare to $206.54 per hectare. The financial benefits from liming are still estimated to be positive for wheat. Lupin farming systems in Western Australia showed negative financial benefits from liming. These estimates may indicate that losses in production could be incurred if remediation with lime is not performed. These estimates are model estimates and may not account for climatic variation, differences in management practices, soil types or market variability.

6.7.13 Calcium Carbonate required to replace the alkali removed from farm products

	Yield	*Calcium Carbonate*
Commodity	*t/ha/ year*	*Kg/ha/year*
Hay		
Lucerne	3.50	210.0
Mixed grasses	3.40	150.0
Lupin	1.62	32.4
Barley	3.59	28.7
Triticale	3.51	24.6
Wheat	2.50	22.5
Lamb	10.00 (a)	6.0
Wool	0.01	0.8

(a) Dry sheep equivalents.
Source: Evans 1991.

Table 6.7.15 shows some of the off-farm features affected by salinity in the Murray-Darling Basin. Most councils have experienced some form of damage to utilities and other features, including roads, water pipes, houses and public buildings. Damage to natural systems such as rivers and forests was also observed.

The cost of repairs and maintenance to these features as a result of salinity or rising water table damage was estimated at almost $8.2 million dollars for a 12 month accounting period, between July 1993 to June 1994 (some councils supplied data for the calendar year from January 1993 to December 1994). Most of this expenditure was on roads and bridges totalling $7.1 million (Gomboso et al. 1995). This represents about 8% of the total amount of expenditure on repairs and maintenance to roads and bridges for these councils.

6.7.14 Estimates of the economics of lime application to manage soil acidification

Region	Farming system	Gross margin $/ha	Average liming costs $/ha/yr	Internal rate of return %	Benefit cost ratio	Net present value (a) $/ha
Northern Queensland						
	Milk	551.14	57.50	119	3.42	1 113.37
	Sugar	1 353.45	33.30	198	8.80	2 671.11
Eastern Queensland & NSW						
	Milk	629.66	57.50	73	2.67	765.72
	Beans	2 603.17	57.50	416	11.44	4 794.73
NSW & Queensland tablelands						
	Peanuts	275.42	32.50	43	1.76	222.90
	Maize	195.00	32.50	34	1.57	164.95
	Peanuts and maize	283.81	32.50	40	1.69	201.75
NSW & Victorian Riverina						
	Wheat	255.41	18.20	43	1.82	151.82
NSW western slopes						
	Wheat	252.58	18.20	53	2.10	206.54
Central Victoria & south-east SA						
	Sheep	182.27	6.00	42	2.52	114.62
	Beef	169.60	6.00	38	2.36	102.50
South Australian near north						
	Wheat	252.96	9.00	13	1.10	11.48
	Canola	260.43	9.00	50	2.20	136.15
North-west WA						
	Wheat and lupins	140.02	2.00	50	2.91	48.02
	Wheat	130.64	2.00	86	5.33	109.07
	Lupins	131.93	2.00		0.00	−25.19
	Sheep	52.29	2.00	27	1.85	21.37
East central WA						
	Wheat and lupins	25.33	4.00	1	0.67	−16.38
	Wheat	49.50	4.00	15	1.24	11.97
	Lupins	3.82	4.00		0.00	−50.38
	Sheep	44.60	4.00	5	0.81	−9.74
South coastal WA						
	Sheep	74.72	5.00	10	1.01	0.81
	Beef	65.50	5.00	10	1.00	0.05

(a) Difference between per hectare gross margins with liming and without liming. Calculated over a 15 year period with a discount rate of 10%.
Source: LWRRDC 1995b.

6.7.15 Features in Local Government Areas affected by salinity

Feature	Feature present	Feature damaged by salinity		One of three most damaged features		Expected to be one of three most damaged features in three years time	
	No.	No.	%	No.	%	No.	%
Roads and bridges	89	63	71	56	63	57	64
Street lighting	87	1	1	0	0	0	0
Footpaths, bicycle paths	78	11	14	2	3	1	1
Aerodromes	55	5	9	2	4	1	2
Railway lines	74	4	5	2	3	2	3
Water pipes, supply structures	88	23	26	9	10	10	11
Sewerage pipes, disposal systems	72	25	35	17	24	17	24
Septic systems	87	33	38	19	22	19	22
Gas pipes, supply systems	34	2	6	1	3	1	3
Electricity supply infrastructure	86	4	5	2	2	3	3
Telephone supply infrastructure	87	6	7	0	0	0	0
Public fencing, stockyards	78	3	4	0	0	0	0
Houses (including sheds, garages)	89	25	28	14	16	16	18
House gardens	88	17	19	4	5	6	7
Other buildings (shops, schools etc)	88	15	17	4	5	4	5
Sports/show grounds, playing fields	88	21	24	8	9	5	6
Municipal parks and gardens	89	16	18	4	4	2	2
Cemeteries	86	9	10	1	1	1	1
New housing estates infrastructure	63	8	13	5	8	4	6
State forest plantations	44	4	9	2	5	2	5
State/national parks, wildlife sanctuaries	55	14	25	6	11	6	11
Streams and rivers	83	39	47	31	37	29	35
Other	13	10	77	8	62	9	69
Total	**90**	**82**	**91**	. .	. .	. .	. .

Source: Gomboso et al. 1995.

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6.8 Energy

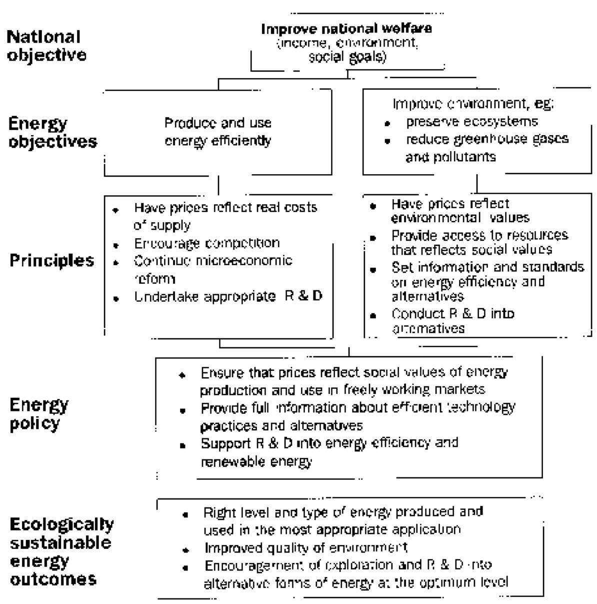
Energy and ecologically sustainable development

Energy contributes substantially to the welfare and standard of living of Australian society, and its supply underpins activity in all parts of the economy. The efficiency with which energy is produced, converted and used affects economic performance, domestic costs and international competitiveness. The production and use of energy can also deplete and degrade natural resources, produce waste heat and other pollutants, and place undue stress on natural systems (ESDWG, 1991).

The production and use of energy involves large material flows and has a wide range of environmental impacts, on a local, regional and global scale. A growing consciousness of environmental issues, and of the need for ecologically sustainable development, has resulted in an increasing acceptance that further changes in energy use are needed, in part due to the fact that most people (especially in Western societies) affect the environment more by their use of energy than by many of their other activities (ESDWG, 1991).

Australia's Ecologically Sustainable Development process for the energy sector has sought to discover ways in which people and businesses can continue to meet their current and future energy needs, while ensuring that their usage is ecologically sustainable and provides for the needs of future generations.

6.8.1 Issues for ESD and energy



Source: DPIE 1991, p. 2.

Table 6.8.1 outlines strategies for sustainable energy use.

ESD Working Groups have explored future energy scenarios to the year 2020 by using the MENSA (Multiple Energy Systems of Australia) computer model run by the Australian Bureau of Agricultural and Resource Economics. The model has proved useful because it identifies the relative value of actions to improve energy efficiency and use and reduce emissions in different sectors, leading to a more informed set of government policy priorities (Dovers 1994, p. 120). Projections of the likely long term outlook for energy use in Australia also need to take into account observed trends, assumptions as to economic and other influences on energy production and use, and industry intentions and technological impacts.

Actions towards achieving the goal of ESD over the long term for energy use include:

- increasing efficiency, which can encompass more fuel efficient motor vehicles, improved industrial and energy conversion processes, householder use of energy efficient light globes and appliances, and more energy efficient designs for buildings;
- charging consumers the full cost for supplying energy. Price is generally a key incentive to improve efficiency and reduce wastage;
- greater use of public transport systems;
- changes in fuel mix. Because the energy efficiency of a given process often depends on the fuel used, changes in the fuel mix will generally lead to an overall efficiency change (Wilson, Ho Trieu & Bowen 1993);
- education, and access to information, about waste reduction and conservation practices; and
- research and development into energy use and renewable sources (DPIE, 1991).

The remainder of this section discusses the main sources and uses of non-renewable and renewable energy.

Non-renewable energy sources

Energy reserves

As illustrated in Table 6.8.2, Australia has large reserves of energy resources available, particularly in relation to the size of the population. At current production rates the life of demonstrated economic reserves ranges from tens to many hundreds of years.

In terms of fossil fuel supply for Australia the most critical situation is that of oil (Dovers 1994, p. 34).

The vast reserves of most energy commodities allow Australia to meet both domestic requirements and be a substantial net exporter. They also mean that "overall, resource availability is unlikely to be a constraint on Australian energy consumption" (Bush, Holmes & Ho Trieu 1995, p. 3).

In energy terms, Australia's economic energy resources are dominated by coal, followed by uranium, natural gas, crude oil and condensates, and Liquefied Petroleum Gas, as shown in Table 6.8.3 (Bush, Holmes & Ho Trieu 1995).

Figures 6.8.4 and 6.8.5 illustrate the locations of Australia's extensive black coal resources, and natural gas reserves and pipeline networks.

6.8.2 Life of reserves of energy commodities, as at 1991

Fuel	*Years*
Black coal	330
Brown coal	880
Crude oil	13
Natural gas	45
Liquefied petroleum gas	30
Uranium	140

Source: Dovers 1994, p. 34.

Production of energy commodities

Australian production of non-renewable energy was 8,781 petajoules in 1993–94 (see Table 6.8.6), with black coal the primary energy source with 55% of energy production, a dominance which has been the pattern for the last 20 years. New South Wales and Queensland accounted for 98% of black coal production in 1993–94 while Western Australia and Victoria between them accounted for 83% of crude oil and 75% of natural gas production. figure 6.8.7 shows the location of the major petroleum fields and facilities.

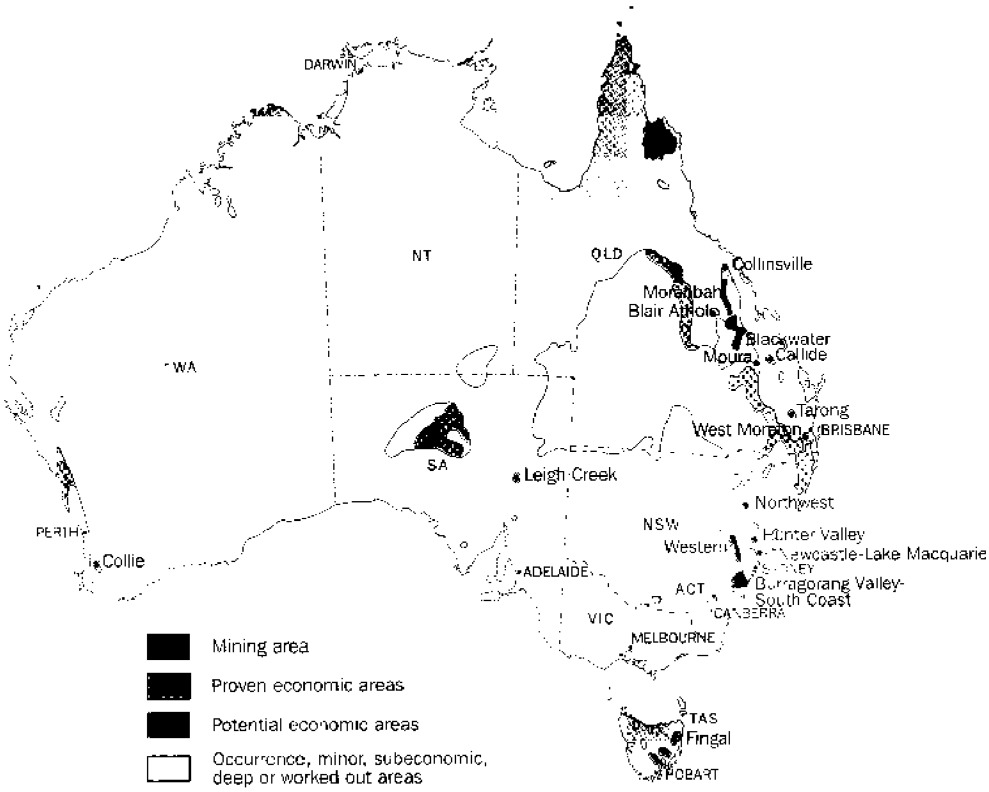
In 1993–94 about 71% of Australia's production of energy resources was exported. Around three-quarters of black coal produced is exported, making it the major energy export. About a third of crude oil produced is exported. Since 1989, the major changes in exports have been the growth of Liquefied Natural Gas, and of crude oil following deregulation of the industry (Bush, Holmes & Ho Trieu 1995).

6.8.3 Australian identified energy resources

		Demonstrated resources			
Resource	*Unit*	*Economic*	*Subeconomic*	*Inferred resources*	*Production 1993–94*
Black coal (a)	Gt	52	5	very large	0.18
Brown coal (a)	Gt	41	3	165	0.05
Petroleum (b)					
Crude oil (c)	Gl	382	106	na	28.67
Natural gas	Tl	950	1 088	na	26.35
LPG (d)	Gl	131	83	na	3.70
Shale oil	Gl	0	4 564	40 468	0.00
Uranium	kt	631	76	2 600 (e)	2.33

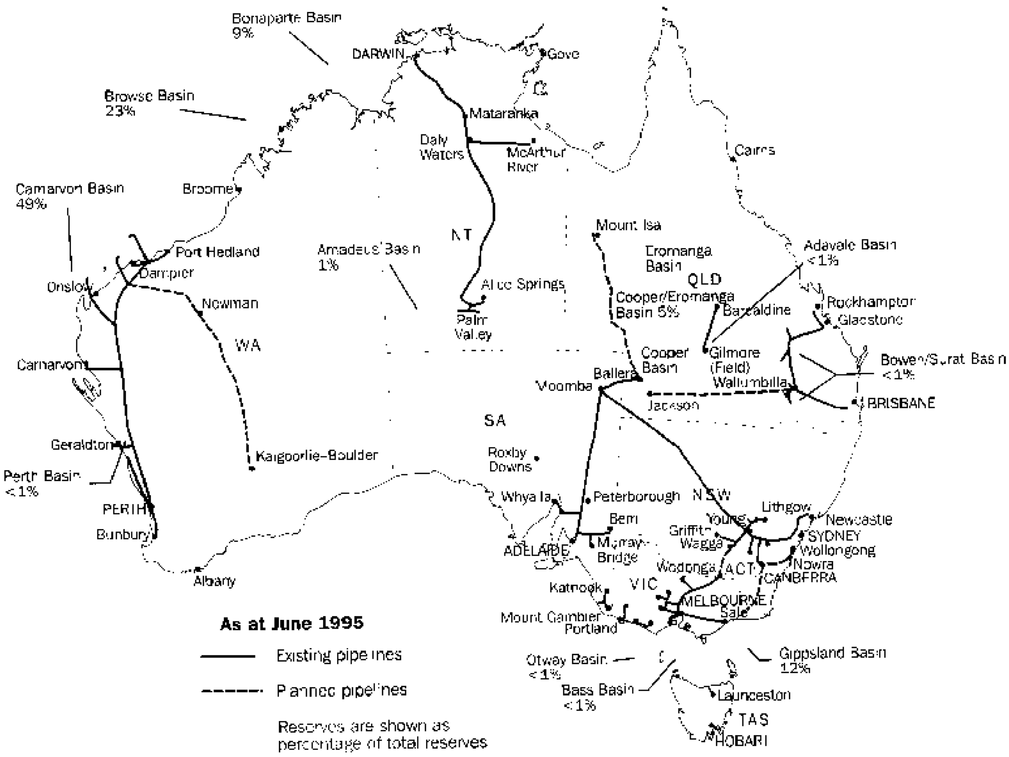
(a) as at December 1993.
(b) as at January 1992.
(c) Includes condensates.
(d) Naturally occurring.
(e) A 75% probability of undiscovered potential resources.
Source: Bush, Holmes & Ho Trieu 1995, p. 22.

6.8.4 Australian black coal resources, 1994



Source: AUSLIG 1996.

6.8.5 Australian natural gas reserves, 1995



Source: AGA 1995, p. 66.

6.8.6 Energy production from non-renewable fuels, 1993–94

Fuel	*Petajoules*	*%*
Black coal	4 786.6	54.5
Uranium	1 293.0	14.7
Crude oil	1 060.8	12.1
Natural gas	1 054.1	12.0
Brown coal	486.8	5.5
LPG	99.9	1.1
Total	8 781	100

Source: Bush, Holmes & Ho Trieu 1995, p. 20.

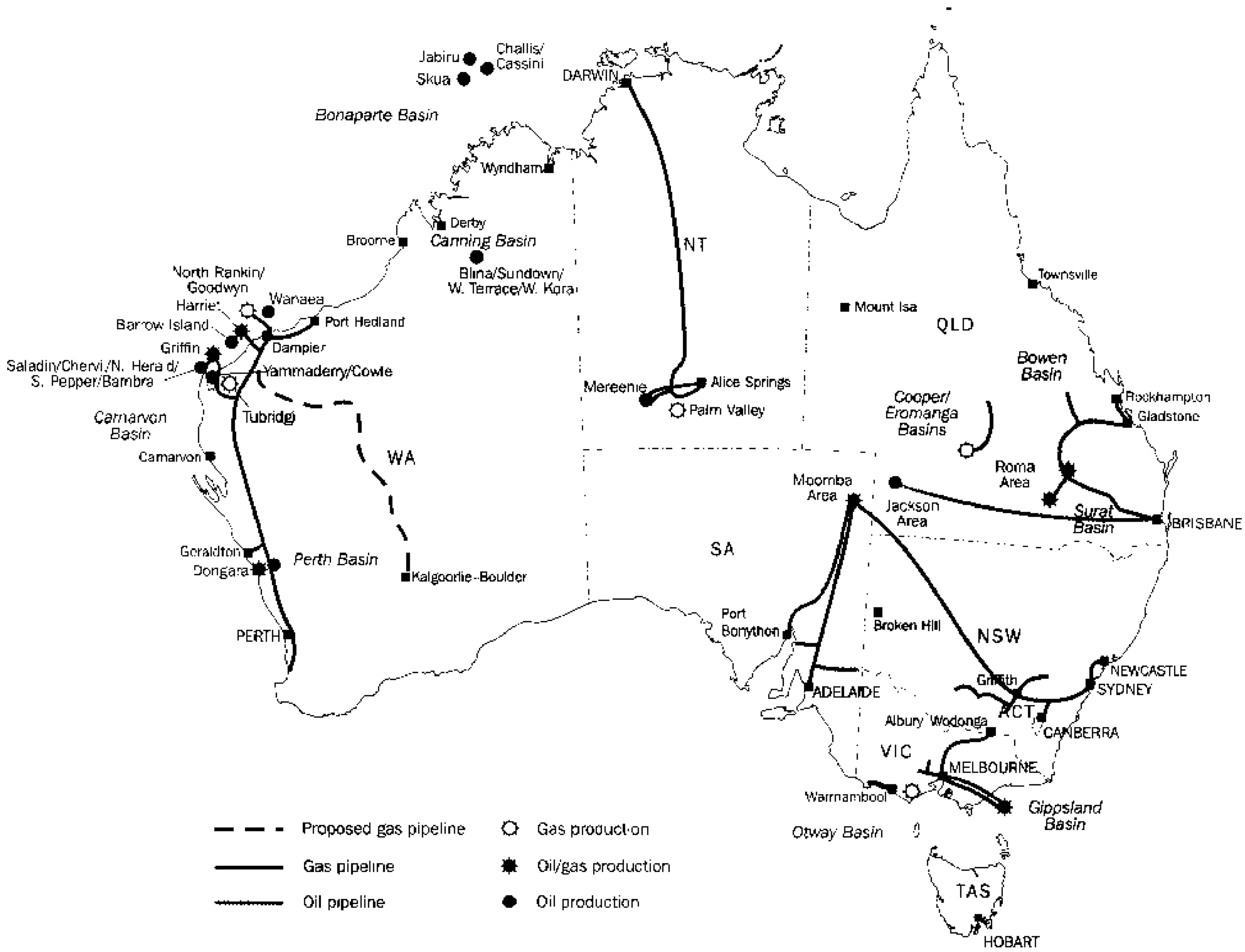
Energy consumption

Total energy consumption in Australia in 1993–94 was estimated at 4,174 petajoules. the primary fuels consumed were crude oil, at 36% of the total, and black coal at 29% (see Table 6.8.8). Of the total energy consumed, an estimated 32% was consumed by the energy conversion sector, with the remaining 2,854 petajoules consumed by end use sectors, where consumption is dominated by petroleum products (49%). The other major energy sources for end uses are natural gas (19%) and electricity (18%).

Across the final use sectors, fuel consumption varies widely. Energy consumption by the transport sector is dominated by petroleum product fuels, whereas manufacturing, with its diverse forms, uses a range of fuels. For residential users electricity and natural gas are the main fuels consumed.

As illustrated in Table 6.8.9 there has been an average annual growth rate of 2.4% in Australia's energy consumption over the past twenty years. Since 1973–74, energy consumption has increased by 60% (Bush, Holmes & Ho Trieu 1995). At 7.5%, natural gas has shown the highest growth in consumption, increasing its share of fuel consumed from 6.6% to 17.6%, whereas crude oil and sources of renewable energy have

6.8.7 Oil and gas production, 1995



Source: Bureau of Resource Sciences 1996.

6.8.8 Energy consumption by fuel and end use, 1993–94

End use	*Black coal*	*Brown coal*	*Coke*	*coal by-products*	*Briquettes*	*Wood*	*Bagasse*	*Crude oil (a)*	*Petroleum products (b)*	*Natural gas*	*Town gas*	*Electricity*	*Solar*	*Total*
	Pj	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*	*Pj*
Agriculture									53.1	0.1		9.1		62..3
Mining	6.0		0.2	2.0				0.6	43.0	106.1		38.2		196.1
Iron and steel	8.2		2.4	42.0					1.6	23.1		19.0		96..3
Chemical	3.1			7.1	3.4				47.3	55.7		13.5		130.1
Other industry	95.6	0.5	5.5		4.1	24.9	84.5		60.9	228.5		174.5		679.0
Construction									42.5	0.2		0.1		42.8
Road transport									848.7	1.2				849.9
Rail transport									23.3			6.2		29.5
Air transport									144.5	0.4		0.4		145.3
Water transport	3.8								43.1	0.1		0.6		47.7
Commercial	2.3				1.7	0.6			13.1	39.7	0.7	111.0		169.1
Residential	0.1				0.2	81.6			16.5	98.7	1.5	148.3	2.4	349.3
Lubricants, greases, bitumen and solvents									56.0					56.0
Total energy consumption (c)	**119.2**	**0.5**	**8.1**	**51.1**	**9.4**	**107.1**	**84.5**	**0.6**	**1 393.8**	**553.8**	**2.3**	**520.9**	**2.4**	**2 853.5**

(a) Includes other refinery feedstocks.
(b) Includes naturally occurring liquid petroleum gas.
(c) After conversion sector use and losses.

Source: Bush, Holmes & Ho Trieu 1995, p. 84.

grown at less than the overall growth rate, with a fall in their share of the primary fuel market.

The electricity generation and mining sectors have shown the greatest annual growth in energy consumption over the past 20 years, with electricity accounting for 27% of total consumption in 1993–94, compared with 19.5% in 1973–74, as illustrated in Table 6.8.10.

Projected trends in energy consumption and production

A wide range of factors and uncertainties affect long term projections for the energy sector, particularly future government policies aimed at addressing climate change and other environmental issues. Other factors include changes in technology and prevailing economic conditions.

6.8.9 Energy consumption growth by fuel, 1973–74 to 1993–94

Fuel	*Average annual growth*	*Share 1973–74*	*Share 1993–94*
	%	%	%
Black coal	3.0	25.3	28.7
Brown coal	3.1	10.0	11.7
Natural gas	7.5	6.6	17.6
Crude oil	0.6	50.5	36.0
Renewables	1.3	7.6	6.0
Total	2.4	100.0	100.0

Source: Bush, Holmes & Ho Trieu 1995, p. 16.

6.8.10 Energy consumption growth by sector

Sector	*Average annual growth*	*Share 1973–74*	*Share 1993–94*
	%	%	%
Agriculture	2.4	1.5	1.5
Mining	6.1	2.3	4.7
Manufacturing	0.8	35.1	26.0
Electricity generation	4.0	19.5	26.9
Transport	2.3	26.2	25.8
Construction	2.6	1.0	1.0
Commercial and services	3.6	3.2	4.1
Residential	2.1	8.8	8.4
Other	0.4	2.4	1.6

Source: Bush, Holmes & Ho Trieu 1995, p. 17.

6.8.11 Projected energy consumption by fuel

Fuel	Consumption 2009–10	Average annual Growth	Share 1993–94	Share 2009–10
	Petajoules	%	%	%
Black coal	1 528.3	1.5	28.7	27.8
Brown coal	574.7	1.0	11.7	10.4
Crude oil	1 854.9	1.4	35.9	33.7
Natural gas	1 271.6	3.5	17.6	23.1
Renewables	276.8	0.5	6.1	5.0
Total	5 506.3	1.7	100.0	100.0

Source: Bush, Holmes & Ho Trieu 1995, p. 28.

6.8.12 Projected energy production by fuel

Fuel	Production 2009–10	Average annual growth 1993–94 to 2009–10
	Petajoules	%
Black coal	7 191.5	2.6
Brown coal	574.7	1.0
Uranium	3 760.0	6.9
Crude oil	646.3	−3.0
Natural gas	2 218.2	4.8
Petroleum products	130.9	1.7
Renewables	276.8	0.5
Total	14 798.4	3.1

Source: Bush, Holmes & Ho Trieu 1995, p. 40.

Australia's total energy consumption is projected to grow at an average rate of 1.7% per year to 2009–10 which, if realised, would result in a total consumption of 5,506 petajoules in that year, as shown in Table 6.8.11. This projected rate of growth is less than the past 20 year average (2.4%) due to factors such as future growth coming from a substantially larger base level of consumption, expected energy efficiency improvements, and the impact of policies to reduce emissions.

Crude oil is expected to continue to dominate primary fuels (34% of projected total energy consumption in 2009–10), with continuing strong growth in natural gas usage (rising from a 17.6% share to 23.1%). However, black coal and crude oil are still expected to account for the largest shares of the fuel mix, with demand for coal remaining strong due to its use in electricity generation, and crude oil demand due to consumption of petroleum products, primarily automotive petrol and diesel oil. The established importance of these two non-renewable fuels will be a major influence on attempts at sustainable energy use.

Renewable energy consumption is expected to increase at 0.5% per year, less than the growth rate over the past 20 years (1.3%).

Total energy production is projected to be 14,798 petajoules in 2009–10, more than 60% above the 1993–94 level, with black coal production expected to continue to dominate, along with strong growth in natural gas, as illustrated in Table 6.8.12.

Renewable energy

Renewable energy consists of energy resources that are, or can be, used at a rate that enables them to continue to be used indefinitely. Such sources include hydro-electricity, solar, wind, geothermal, ocean or tidal, and biomass such as wood, bagasse, manure and crops (to produce fuel such as ethanol). On a global scale, renewable energy (including large-scale hydro-electric power) represents about 18% of total energy supply. Excluding large hydro-electricity sources and traditional biomass, it accounts for only about 2% of total supply.

In Australia, the types of renewable energy consumed vary depending upon the resources available. For example, in Tasmania about three-quarters of the renewable energy consumed is hydro-electricity (Bush, Holmes & Ho Trieu 1995), whereas in Queensland most renewable energy is bagasse used in powering sugar refineries. Another major renewable fuel, wood, is mainly consumed by the residential sector for home space heating (particularly in Tasmania), while solar energy is used to provide domestic hot water, as well as drying crops and extracting salt.

In 1994 about 18% of households used wood as the principal form of space heating, while 5% used solar energy to heat water.

Tables 6.8.13 and 6.8.14 provide a broad indication of the current Australian situation for renewable technologies, and cost projections of specific energy technologies.

The main disadvantages to renewable forms of energy at present are their cost relative to existing conventional sources of energy, and the issue of storage. The use of mixed or hybrid energy systems, new/improved storage techniques, and legislative goals and priorities towards energy use, may contribute to the future resolution of these restrictions, and allow renewable energy sources to contribute significantly towards the goals of ESD for energy use.

6.8.13 Status of renewable energy technologies

Technology	*Current technological status (a)*	*Current economic viability (b)*	*Potential long-term future contribution in Australia (c)*
Solar heat			
Various drying (salt, clothes, farm products)	1	1	1
Passive solar buildings	1	1	2
Domestic hot water	1	1	2
Residential heat	2	2a	2
Industrial heat	2	2a	2
Solar electric			
Photovoltaics-flat panels	1	2b	1
PV concentrators	2	2a	1
Solar thermal-parabolic troughs	2	2a	1
paraboloidal dishes	2	2a	1
central receivers	3	3	2
Other electrics			
Hydro	1	1	2
Wind	1	1	2
Ocean thermal currents	3	3	3
Tidal	1	3	3
Geothermal	1	2a	2
Wave	2	3	2
Fuels			
Biomass for burning (wood, bagasse)	1	1	3
Biomass for alcohol fuels (especially ethanol)	1	2a	2
Hydrogen	3	3	1
Energy storage			
Batteries - standard	1	1	3
advanced	2	2a	2
Rock beds	2	2a	2
Liquid salt, oil, etc	2,3	3	2
Chemical reactions	3	3	2
Hot water storage	1	1	2

(a) 1: Existing technology, commercially available (but not discounting further development).
2: Near-term technology for large markets (development to viable stage expected in the next decade).
3: Longer-term prospects for large markets (more than a decade).
(b) 1: Economically viable now on a significant scale in Australia.
2a: Within 10 years of being viable on a significant scale.
2b: Economically viable now for small niche markets.
3: Not economically viable at significant or niche scales in Australia now, and not expected to be so within 10 years.
(c) 1: Large contribution (assuming it becomes economically viable).
2: Intermediate contribution.
3: Small contribution at best.
Source: Dovers 1994, p. 113.

Solar energy

In Australia, about 4.5–6.5 kilowatt hours of solar radiation falls on each square metre of land each day (Dovers, 1994, p. 129). The use of various forms of collecting devices and techniques, such as flat plate collectors, high concentration paraboloidal dishes, and glasshouses and evaporation, allows solar energy to be viable for many uses. These can include heating water for domestic use, generating electricity in rural and remote areas, and drying of crops and salt extraction. A number of institutional and economic constraints remain to be overcome, but solar energy could become a potentially significant energy resource in the future. Figures 6.8.15 and 6.8.16 show the solar radiation levels and potential wind sites for Australia, and existing experimental and commercial solar power stations and wind generators.

Windpower

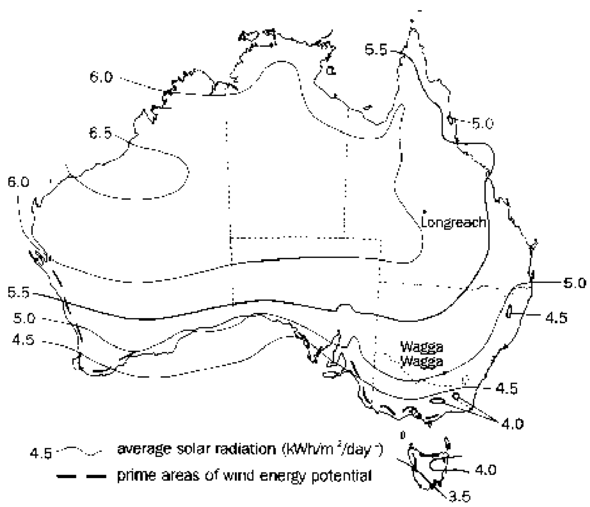
In late 1992 there were about 2,500 megawatts of wind plant installed around the world. There are a number of single wind generators of greater

6.8.14 Supply cost of selected technologies

	1992	2010	2030
Technology	*¢/Kwh*	*¢/Kwh*	*¢/Kwh*
Pulverised coal	3.5	na	na
Combined cycle gas	4.5	na	na
Methane from landfill	5.5	na	na
Bagasse	5.6	na	na
Wood	6.3	na	na
Wind	7.1	4.9	1.1
Solar thermal	21.0	6.7	5.2
Photovoltaics	44.0	9.0	5.3
Battery storage	33.0	7.0	7.0

Source: Dovers 1994, p. 205.

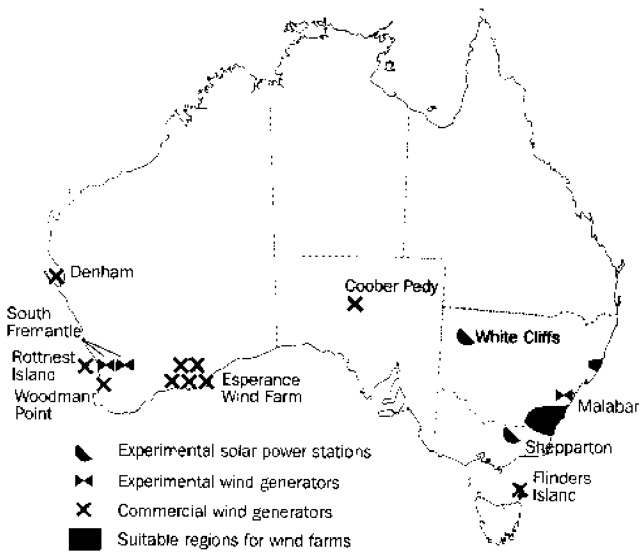
6.8.15 Solar radiation and potential wind energy sites



Source: Dovers 1994, p. 130.

than 30 kilowatts installed across Australia, with an array of nine 225 kilowatt wind generators located at Esperance in southern Western Australia, as illustrated in Figure 6.8.16 and Table 6.8.17.

6.8.16 Solar and wind power stations



Source: Macquarie Library 1994, p. 167.

The sites for wind generators are crucial to their operating success, with the windiest sites generally located on exposed, treeless areas of coastline (including offshore), hillsides and mountains. Issues constraining wider use of windpower include variation in availability, visual impact, noise, bird mortality and telecommunications interference.

Geothermal

Commercially available technology for geothermal power plants relies upon heat extracted from acquifers located in regions with significant geothermal activity. Possible areas identified in Australia are near the Great Artesian Basin and in central Australia. Significant costs would be associated with transmitting electricity from these sources to major metropolitan centres. Hot water from bores in these areas could however provide an opportunity to

6.8.17 Wind generators of capacity greater than 30 kilowatts operating in Australia, late 1993

Company	*Capacity (kilowatts)*	*Country of origin*	*Location*	*Date of installation*
Nordtank	55	Denmark	Rottnest Island, WA.	1983
Westwind	60	part Australia	South Fremantle, WA.	1984
	60	(imported blades, alternator, etc)	Woodman Point, WA.	1985
	6x60		Esperance, WA.	1986
	60		Breamlea, Vic.	1987
Windmaster	175	Belgium/Holland	Malabar, Sydney, NSW.	1985
Foden	55	part Australia	Flinders Island, Tas.	unknown
Nordex	150	Denmark	Coober Pedy, SA.	1991
Vestas	9x225	Denmark	Esperance, WA.	1993

Source: Dovers 1994, p. 152.

6.8.18 Research and experimental development for energy supply, 1992–93

Socio-economic objective	*Business enterprise* *$'000*	*Commonwealth government* *$'000*	*State government* *$'000*	*Higher education* *$'000*	*Private non-profit* *$'000*	*Total* *$'000*
Energy transformation	27 559.9	8 682.1	1 393.8	5 007.3	0.0	42 643.1
Renewable energy	5 357.9	464.0	0.0	10 469.6	0.0	16 291.5
Hydro-electric	na	0.0	0.0	0.0	0.0	na
Wind	na	213.0	0.0	115.0	0.0	na
Ocean	na	39.0	0.0	120.9	0.0	na
Solar-thermal	na	0.0	0.0	360.9	0.0	na
Solar-photoelectric	na	212.0	0.0	722.1	0.0	na
Solar-thermal electric	na	0.0	0.0	8 670.4	0.0	na
Not classified (e.g. geothermal)	na	0.0	0.0	480.3	0.0	na
Energy distribution	13 605.7	3 549.0	0.0	6 862.0	41.3	24 058.0
Conservation and efficiency	8 199.8	1 934.5	467.5	4 445.6	143.1	15 190.5
Other	660.5	1 734.3	0.0	4 098.0	0.0	6 492.8
Total	**55 383.8**	**16 363.9**	**1 861.3**	**30 882.5**	**184.4**	104 675.9

Source: ABS 1995 (8112.0).

produce electricity for local homesteads and communities. A 120 kilowatt demonstration plant is operating in Birdsville, Queensland. In Portland, Victoria, geothermal energy is currently being used for water heating at the municipal swimming pool, and also for space heating at the hospital and police station.

Energy research and development

In 1992–93, research and development expenditure on Australia's energy supply was $105m (see Table 6.8.18). This represented 1.7% of the total expenditure for research and development activity in Australia. Of this, $16m (0.26% of total research and development expenditure) was spent on the renewable energy sector; the bulk of this expenditure was incurred by higher education institutions (which concentrated it on solar-thermal electric research) and business enterprises. Commonwealth government expenditure was split primarily between wind and solar-photoelectric research.

Around $15m was spent on research and development into energy conservation and efficiency. This represented 14.5% of 1992–93 research and development expenditure into the energy supply.

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Chapter 7 — Protected Environments

As the last chapter in Part 1, Chapter 7 focuses again on the stock of Natural Assets and Natural Processes in the PEP model. It presents statistics which indicate some ways in which the environment may be conserved, in particular noting efforts to maintain the stock or diversity of natural assets. This material in Chapter 7 therefore contrasts with that in Chapter 6, which dealt with issues of resource consumption and use.

Chapter 7 presents statistics on protecting environments in two sections:

- Conserving habitats (Section 7.1); and
- Conserving biota (Section 7.2).

7.1 Conserving habitats

The purpose of protected areas in Australia has changed with time. Parks were traditionally declared on land that was marginal for economic purposes or was of particular scenic beauty. Their main purpose was health and recreation. Conservation was not an issue, as the natural world was viewed largely in terms of its resources. As a result other habitats, equally important but more accessible and less spectacular, suffered greater damage. Wetlands, for example, which are particularly rich habitats, were considered to be wasteland.

This absence of any co-ordinated approach to conservation was reflected in legislation. Responsibility for conservation was vested with various authorities, as a function of their activities. The result has been a variety of approaches to management and protection. The emphasis is shifting now, as new Acts are proclaimed. There are now some 300 Acts of Parliament impacting on nature conservation, including Acts which apply specifically to many external territories.

Whether or not conservation was the issue, Australia has been progressive in its establishment of national parks by comparison with other developed countries. Table 7.1.1 shows the dates of establishment of the first national parks in each State. Table 7.1.2 shows that many national parks were in place before the 1970s, when the Commonwealth National Parks and Wildlife Conservation Act, and many State and Territory Acts relating to wildlife and conservation, came into effect. Importantly,

7.1.1 First national parks in each state

State	*National Park*	*Year declared*
NSW	Royal National Park	1879
SA	Belair	1891
Vic.	Tower Hill	1892
WA	Greenmount	1900
Qld	Witches Falls	1908
Tas.	Mount Field	1915

Source: Coveney 1993, p. 15.

7.1.2 Numbers (a) of national parks

Jurisdiction	*1968*	*1978*	*1988*	*1991*
	No.	*No.*	*No.*	*No.*
NSW	16	45	68	69
Vic.	15	19	30	32
Qld	223	279	311	339
SA	6	8	12	14
WA	27	42	46	49
Tas.	9	12	13	14
ACT	0	0	1	1
NT	4	4	7	12
Commonwealth	0	1	4	4
Total	**300**	**410**	**492**	**534**

(a) indicates the total number of national parks at the specified date
Source: Hooy & Shaughnessy 1991, Appendix 1 pp. 2–60.

7.1.3 Expansion of national parks and other conservation reserves, 1968 – 1988

	Area covered by reserves		
	1968	*1978*	*1988*
Jurisdiction	*'000 ha*	*'000 ha*	*'000 ha*
NSW	862.2	2 073.2	3 812.2
Vic.	201.3	294.9	1 830.0
Qld	940.7	2 212.4	3 663.8
SA	1 169.6	3 920.9	11 117.2
WA	1 150.9	12 649.4	15 252.2
Tas.	288.3	681.1	967.0
ACT	4.9	9.8	112.2

Source: Coveney 1993 p. 220. © Cambridge University Press. Reprinted with permission.

7.1.4 Numbers of protected areas by jurisdiction, 1991

	Terrestrial protected area	Marine protected area
Jurisdiction	No.	No.
NSW	464	8
Vic.	501	15
Qld	649	88
SA	294	14
WA	1 179	7
Tas.	228	5
NT	96	3
ACT	5	0
Commonwealth	13	18
Total	**3 429**	**158**

Source: Hooy & Shaughnessy 1991, pp. 6–9.

7.1.6 National parks by jurisdiction, 1991

		Protected area	Proportion of State
Jurisdiction	Number	ha	%
NSW	69	3 188 180	4.0
Vic.	32	2 390 651	10.5
Qld	339	4 019 484	2.3
SA	14	3 035 293	3.1
WA	59	4 849 395	1.5
Tas.	14	1 359 548	20.0
NT	12	1 775 688	1.3
ACT	1	94 000	39.2
C'wealth	4	2 122 145	. .
Total	**544**	**22 834 384**	**3.0**

Source: Hooy & Shaughnessy 1991, pp. 6–9.

though, many of these early parks were small and did little to help in the conservation of biodiversity. Table 7.1.3 presents the area covered by national parks and other conservation reserves over a similar period. Tables 7.1.4 and 7.1.5 show numbers of protected areas and the coverage of States and Territories by those areas. In 1991 about 6% of Australia's land area was in conservation reserves. About half of this was national park (see Table 7.1.6). A great deal of vacant crown land is also under State control. Only about 20% of the country is freehold (see Table 7.1.7) (Graetz, Wilson & Campbell 1995, p. 23).

An important issue relating to protected areas is the weighting to be placed on conservation as against non-destructive human use. While designating some areas as wilderness is better for conservation values, allowing some activities within reserves may be beneficial by increasing both the appreciation of natural areas and awareness of conservation issues. Aboriginal and Torres Strait Islander use of land and animals for traditional purposes must also be worked into the management of protected areas. Responses include establishing a hierarchy of protected areas, with varying degrees of emphasis on conservation.

A classification developed by the World Conservation Union (IUCN) has been used to categorise Australia's protected areas. Category 1 sites are essentially undisturbed by other activities. Category 2 covers national parks and equivalent reserves containing one or more ecosystems in outstanding natural areas. Category 3 covers specific natural monuments of special significance. Category 4 is particularly concerned with maintaining habitats for certain species of flora and fauna. Category 5 covers areas that show a harmonious interaction of people and nature. Table 7.1.8 lists the numbers of terrestrial and marine protected areas covered by the IUCN categories.

7.1.5 Area and percentage of land area protected, States and Territories, 1991

	Protected area	Proportion of State
State/Territory	ha	%
NSW	3 888 950	4.9
Vic.	2 940 364	12.9
Qld	4 141 586	2.4
SA	16 675 080	16.9
WA	15 731 974	6.2
Tas.	1 814 339	26.8
NT	2 114 413	1.6
ACT	101 495	42.3
C'wealth	2 731 220	. .
Total	50 139 421	6.5

Source: Hooy & Shaughnessy 1991, pp. 6–9.

7.1.7 Land tenure in Australia

	Area	Proportion of total land area
Tenure	Km^2	%
Freehold, mining leasehold	1 591 592	21
Pastoral leasehold, Defence tenure	3 257 354	42
Forestry, water supply, other uses	247 467	3
Aboriginal freehold/leasehold, national park	1 110 656	14
Unallocated crown land (unused)	961 057	12
Dedicated nature conservation	523 875	7

Source: Graetz, Wilson & Campbell 1995, p. 23.

7.1.8 Number of protected areas, by World Conservation Union (IUCN) category

	Category 1		Category 2		Category 3		Category 4		Category 5		Not Specified	
Govt.	Terrestrial	Marine	Terrestrial	Marine	Terrestrial	Marine	Terrestrial	Marine	Terrestrial	Marine	Terrestrial	Marine
NSW	291	0	87	0	6	0	49	7	29	1	2	0
Vic.	36	0	49	0	409	4	2	1	0	10	5	0
Qld	62	0	106	0	420	0	8	82	53	6	0	0
SA	0	0	137	0	67	0	65	13	22	0	3	1
WA	0	0	62	0	21	0	1 096	7	0	0	0	0
Tas.	0	0	16	0	73	0	89	5	14	0	36	0
NT	0	0	13	1	8	0	19	2	48	0	8	0
ACT	0	0	2	0	1	0	1	0	1	0	0	0
C'wealth	8	5	5	0	0	0	0	0	0	2	0	11
Total	397	5	477	1	1 005	4	1 329	117	167	19	54	12

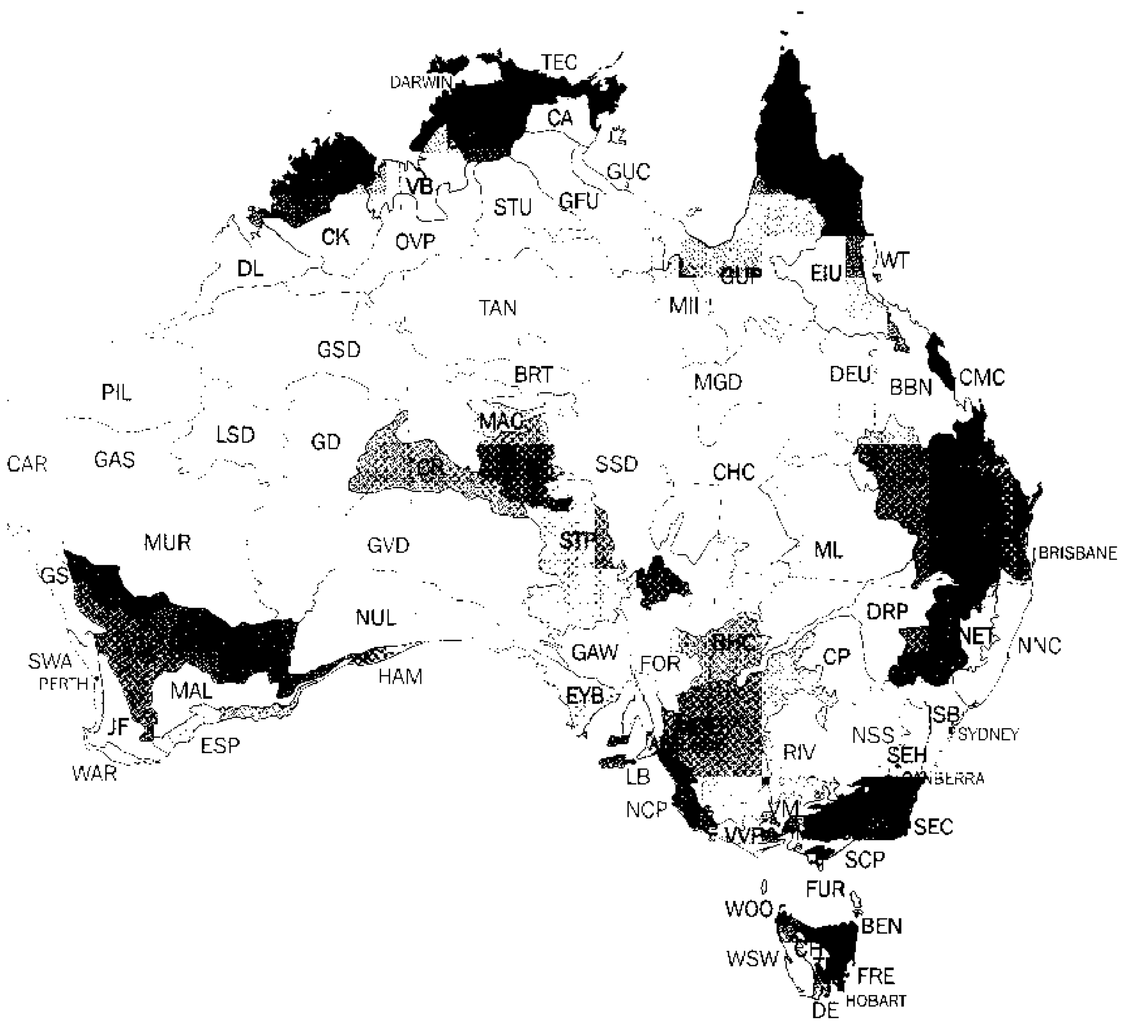
Category 1 = Scientific reserves and wilderness areas
Category 2 = National Parks and equivalent reserves
Category 3 = Natural monuments
Category 4 = Habitat and wildlife management areas
Category 5 = Protected landscapes/seascapes
Source: Hooy & Shaughnessy 1991, pp. 11–14.

7.1.9 Proportion of biogeographic regions protected

Biogeographic code & region		Protected area %	Biogeographic code & region		Protected area %	Biogeographic code & region		Protected area %
AA	Australian Alps	18.9	FUR	Furneaux	9.3	NSS	NSW South Western Slopes	1.2
AW	Avon Wheatbelt	0.5	GAS	Gascoyne	1.9	NUL	Nullarbor	28.6
BEN	Ben Lomond	9.3	GAW	Gawler	9.9	OVP	Ord-Victoria Plains	5.4
BHC	Broken Hill Complex	1.4	GD	Gibson Desert	12.0	PCA	Pine Creek-Arnhem	7.6
BRT	Burt Plain	2.3	GFU	Gulf Fall and Uplands	0.9	PIL	Pilbara	5.6
CA	Central Arnhem	7.6	GS	Geraldton Sandplains	14.0	RIV	Riverina	0.2
CAR	Carnarvon	6.9	GSD	Great Sandy Desert	1.9	SB	Sydney Basin	32.4
CH	Central Highlands	9.3	GUC	Gulf Coastal	0.0	SCP	South-east Coastal Plain	16.6
CHC	Channel Country	6.6	GUP	Gulf Plains	0.0	SEC	South-East Corner	16.6
CK	Central Kimberley	0.0	GVD	Great Victoria Desert	17.1	SEH	South-Eastern Highlands	18.9
CMC	Central Mackay Coast	6.6	HAM	Hampton	28.6	SEQ	South-Eastern Queensland	3.0
COO	Coolgardie	7.6	JF	Jarrah Forest	8.1	SSD	Simpson-Strzelecki Dunefields	26.7
CP	Cobar Peneplain	0.9	LB	Lofty Block	4.9	STP	Stony Plains	4.9
CR	Central Ranges	0.0	LSD	Little Sandy Desert	4.9	STU	Sturt Plateau	0.0
CYP	Cape York Peninsula	11.7	MAC	MacDonnell Ranges	2.3	SWA	Swan Coastal Plain	8.1
DAB	Daly Basin	7.6	MAL	Mallee	19.3	TAN	Tanami	0.0
DE	D'Entrecasteaux	9.3	MDD	Murray-Darling Depression	12.8	TEC	Top End Coastal	9.8
DEU	Desert Uplands	1.6	MGD	Mitchell Grass Downs	0.3	TM	Tasmanian Midlands	9.3
DL	Dampierland	0.3	MII	Mount Isa Inlier	2.3	VB	Victoria Bonaparte	11.2
DRP	Darling Riverine Plains	0.5	ML	Mulga Lands	1.6	VM	Victorian Midlands	4.7
EIU	Einasleigh Uplands	0.8	MUR	Murchison	1.1	VVP	Victoria Volcanic Plain	4.7
ESP	Esperance Plains	19.3	NAN	Nundewar	2.1	WAR	Warren	8.1
EYB	Eyre and York Blocks	6.6	NCP	Naracoorte Coastal Plain	4.7	WOO	Woolnorth	9.3
FIN	Finke	0.0	NET	New England Tablelands	2.1	WSW	West and South-West	49.0
FOR	Flinders and Olary Ranges	10.1	NK	Northern Kimberley	12.0	WT	Wet Tropics	16.1
FRE	Freycinet	9.3	NNC	NSW North Coast	8.0	YAL	Yalgoo	1.1

Source: Thackway and Creswell in SoE 1996, pp. 4–25.

7.1.10 An Interim Biogeographic Regionalisation of Australia



Source: Thackway and Cresswell 1995.

If a particular protected area is large, a zoning system may be used. The Great Barrier Reef Marine Park has seven zones of increasing conservation significance. Recreational fishing is only allowed in the first three zones, while traditional fishing is permitted in all but the preservation zone. Research is the only activity allowed in the preservation zone (Coveney 1993, p. 74). The emphasis for conservation is now on protecting threatened habitats and species, and conserving biological diversity through a national system of reserves.

The National Reserves System Cooperative Program, within the Department of Environment, Sport and Territories (DEST), aims to produce a representative system of terrestrial protected areas by the year 2000, concurrent with a marine protected areas program. Other Commonwealth initiatives protect wild rivers, wilderness areas, forests, grasslands, rangelands, wetlands and endangered species. Along with the diversity of flora and fauna, there is also a great diversity of habitats in Australia. These habitats have varying degrees of coverage by the existing reserve system. Precedence in the creation of reserves will be given to under-represented habitats. To assist in this process, Australia has recently been classed into biogeographic regions based on climate, geology, landform, vegetation, flora and fauna and land use (the Interim Biogeographic Regionalisation for Australia—IBRA—by Thackway and Cresswell 1995). These regions provide a national picture of the distribution patterns of ecosystems. Table 7.1.9 shows the percentage of each bioregion covered by a protected area; Figure 7.1.10 is a map of the bioregions.

Alpine mountain and forest are two bioregions which tend to be well represented, as do some of the arid zones of marginal value to grazing. Specific areas such as south-west Tasmania and the Wet Tropics, have been recognised as particularly important and also enjoy a far higher coverage. The most threatened habitats, and

7.1.11 Australian wetlands of international importance, 1996

Jurisdiction	No.	Area ha	Year declared
NSW	3	20 687	1984, 1984, 1986
Vic.	10	252 893	All 1982
SA	4	2 154 300	All 1982
WA	9	500 931	All 1990
Tas.	10	18 150	All 1982
NT	3	1 551 600	1974, 1980, 1989
Christmas Is.	1	<1	1990
Total	**40**		. .

Source: Hooy & Shaughnessy 1991, p. 41 - unpublished update from ANCA 1996.

some of the most poorly protected, are those that are most suited to farming and grazing. These include native grasslands and open woodland, which were particularly accessible, and drier country, which could not support permanent farming, but was still used as rangeland for occasional grazing. As the open lands were taken over, clearing of forests began in earnest. Sixty-one per cent of the continent has been affected by grazing and 7.5% directly by clearing, with clearing having a particularly destructive effect at a regional level

The IBRA reveals a band of low protection in the woodland and plain country along the west side of the Great Dividing Range, location of the eastern wheat and sheep belt. Further west, entering the truly arid zone, the degree of protection increases in direct relation to the decreasing economic value of the land.

A biogeographic regionalisation is just part of an approach to conservation. Conservation is also approached from a habitat perspective. Certain types of habitat occur across a number of bioregions, with varying levels of threat. Wetlands, for example, have traditionally been among the most threatened of habitats. Regarded as wasteland, they were frequently drained and filled. Grazing of floodplains destroyed them and water diversion dried them up. Wetlands used as water sources, particularly springs in arid zones, were damaged by heavy use. Today, wetlands are known to be very productive ecosystems supporting a large and complex range of flora and fauna species. They also play an important role as nurseries for fish and crustaceans and as sediment traps and nutrient recyclers, and conservation measures place strong emphasis on maintaining the integrity of wetlands. The term 'wetlands' covers a variety of freshwater and saltwater habitats which involve a transition between aquatic and terrestrial environments. Wetlands are specifically addressed by the National Wetlands Conservation and Management Program (ANCA 1994, p. 62). Australia is a signatory to the Ramsar Convention, which conserves wetlands of international importance. In 1996, there were forty-nine internationally important wetlands in Australia (see Table 7.1.11).

Many nature conservation programs operate both within and outside reserves. This recognises the fact that much which needs conserving is still not in reserves, and that simply setting aside reserves is often not enough to conserve ecosystems. Each species or ecosystem has certain minimum requirements in order for it to flourish. One of these is access to a sufficiently large habitat. If a reserve is too small, a species may continue to decline despite adequate protection from threats such as introduced predators. Isolated habitats also increase the vulnerability to disaster from a single event such as a fire. Many existing reserves are located in populated areas, isolated from similar habitat, and have difficulty sustaining populations of wildlife. Table 7.1.6 showed a particularly large number of national parks in Queensland. Again, this must be viewed in light of the different purposes of the parks; there are many small parks, which may not be large enough to help conserve biodiversity. To counteract the effects of isolation, access can be maintained between remnant patches of habitat by the use of wildlife corridors along roads, railways, watercourses, stock routes or farm shade and shelter belts.

Marine Protected Areas

Australia plays a significant international role in the protection of marine areas. In 1995 it was responsible for 24% of the total number of the world's marine protected areas (MPAs) (Zann 1995, p. 82, and it also has responsibility for the management of marine species in its recently declared 200 mile Exclusive Economic Zone. There has been a 60% increase in the coverage of MPAs in the past decade, with 5.2% of Australia's marine area now protected by over 400 reserves. Although this is on a par with the coverage on land, the areas protected are not so representative; 64% of marine reserve is on either the Great Barrier Reef or the north-east coast of Queensland, both of which are totally protected (Zann 1995, p. 82). All the islands off the Queensland coast have been declared as fauna reserves. Coral reefs, which are among the richest ecosystems anywhere, are generally well protected wherever they occur in Australian waters, much more so than reefs in the temperate zone. Nonetheless, Australia's northern waters in particular provide some of the last refuges for species endemic to the South Pacific and

7.1.13 Proportion of marine areas protected, by biogeographic region

Geographic zone	Area protected %
North-East Oceanic	11.0
Sout-East Oceanic	0.2
South Oceanic	0.0
West Oceanic	0.4
North-West Oceanic	0.2
Gulf of Carpentaria	3.0
Great Barrier Reef	100.0
North-East Coast	100.0
Central East Coast	26.8
Lower East Coast	0.2
Tasmanian Coast	1.8
Bass Strait	0.4
Southern Gulfs Coast	0.4
Great Australian Bight	<0.1
South-West Coast	<0.1
Lower West Coast	0.3
Central West Coast	23.0
North-West Coast	0.0
North Coast	0.6

Source: Bleakley et al in Zann 1995, p. 81.

South-east Asia. A number of Australia's external territories are oceanic reefs, with associated islands. These are managed as complete protected units and provide safe breeding sites for birds, turtles and dugongs, and stopover points for migratory birds. Important parts of the Southern Ocean Whale Sanctuary fall within Australia's 200 mile Exclusive Economic Zone, including calving zones for such species as the Southern Right Whale.

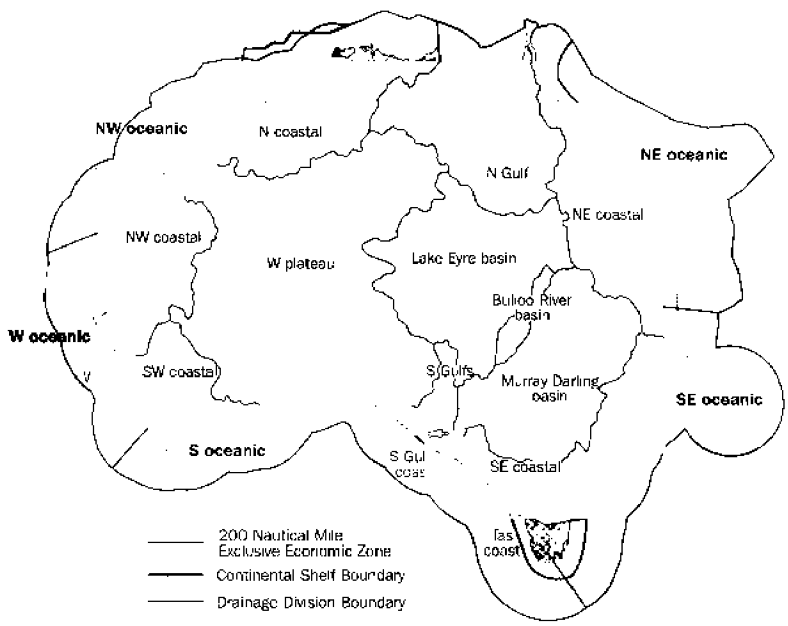
Management of marine areas is complicated by their size and remoteness. It is also difficult to exclude pollutants or restrict their movement once they are present.

A biogeographic regionalisation has been prepared for Australia's waters (see Figure 7.1.12). The representation of protected areas on a bioregion basis is uneven, even more so than for the land-based regionalisation (see Table 7.1.13).

Ocean Rescue 2000 is a national conservation program to develop a representative set of marine parks. It has also produced the Australian Marine Conservation Strategy. The State of the Marine Environment Report has identified major issues in this area.

Mangroves and seagrass are particularly important to the marine system. They are nurseries and feeding grounds of estuaries and ocean. Mangroves also provide protection and help to stabilise coasts by trapping silt in their roots. These ecological roles of mangroves and

7.1.12 A tentative biogeographic regionalisation of Australia's marine environment



Source: Zann 1995 p. 81.

seagrass were not recognised until recently. Mangrove areas were often cleared, and both mangrove and seagrass continue to suffer the effects of eutrophication from polluted rivers.

One possibility for integrating conservation reserves is to place marine protected areas adjacent to terrestrial protected areas. Coastal areas incorporate a variety of habitats, and have the greatest density of threatened species nationally, due to heavy use and urban development.

Special Protected Areas

World Heritage Areas

Natural or cultural sites which are recognised as being of international importance may be given World Heritage listing (see Table 7.1.14). Sites representing world heritage values are identified and nominated by the Commonwealth. Australia has eleven World Heritage properties. Uluru, Kakadu and the Willandra Lakes Region are listed for both natural and cultural values, with the remaining eight World Heritage properties representing outstanding natural values. Natural values include evidence of major stages of the Earth's evolutionary history, outstanding examples of ongoing ecological and biological processes, superlative natural phenomena or natural beauty, and important habitats for conservation of biodiversity. If a site is nominated for natural values, an assessment is made of the uniqueness of the species, habitat or physical features; integrity of the ecological unit; diversity of the species and habitats in the site; naturalness (how affected the site is by humans) and dependency (how critical the site is to key species and ecosystems). Australia represents a significant component of natural World Heritage, as the majority of properties around the world are cultural. Table 7.1.14 summarises some of the important characteristics of Australia's World Heritage properties.

Existing activities may continue in a World Heritage area, but may be prohibited by the Commonwealth under the World Heritage Properties Conservation Act 1983 if they are considered to interfere with the area's significant values. Some World Heritage properties, such as the Great Barrier Reef Marine Park, the Wet Tropics of Queensland and the Lord Howe Island Group, have their own Acts.

Biosphere reserves

The biosphere reserve is a type of protected area that aims to protect representative examples of ecosystems and gene pools and provide opportunities for research and education. They contain a core area of undisturbed self-sustaining natural land, a buffer zone where experimentation can be conducted and a transition zone for human uses which are complementary to the natural environment. The emphasis is on ecosystems, rather than physical features or particular species habitats (Hooy & Shaughnessy 1991).

7.1.14 Australian world heritage areas, 1995

World Heritage Area	*Important natural characteristics.*
Australian Fossil Mammal Sites (Riversleigh/Naracoorte)	Outstanding fossil records representing major ecological and biological evolution.
Central Eastern Rainforest Reserves	Over 50 areas; ongoing biological and geological evolution, four major types of rainforest, rich biodiversity including ancient lines of flora and fauna, many rare plants.
Fraser Island	Word's largest sand island; natural beauty, complex dune systems, dune lakes, rainforest on sand, many bird species.
The Great Barrier Reef	World's largest reef system with almost 3000 individual reefs; natural beauty, possibly the world's richest fauna diversity, ongoing ecological and biological processes, important site for biodiversity conservation, nesting and breeding.
Kakadu National Park	Natural beauty, ongoing geological and biological processes, records of ecological evolution, important habitat including internationally significant wetlands.
Lord Howe Island Group	Natural beauty, endemic flora and fauna, important site for biodiversity conservation, nesting sites, temperate /tropical marine transition zone, reefs.
Shark Bay	Land refuge for endangered species, rich bird, reptile, amphibian and marine life, important breeding and feeding site for marine animals, species representative of evolutionary history.
Tasmanian Wilderness	Rare example of temperate wilderness, international importance for plant diversity, many vegetation types, outstanding geological record, fauna refuge.
Uluru-Kata Tjuta National Park	Outstanding geological features, rare plants and mammals, great diversity of reptiles
Wet Tropics of Queensland	Natural beauty, refuge for much rare flora and fauna, very rich biodiversity, almost complete record of evolution of plant life on earth, rainforest wilderness.
Willandra Lakes Region	Dry lake beds; outstanding record of evolutionary history and ongoing geological processes.

Source: DEST 1995, p. 4–36.

National Estate

The National Estate is a register of important natural or cultural sites. Nominations for listing based on natural values consider the long-term sustainability of a site based on genetic variation, strength of natural restorative processes, size of areas, degree of fragmentation and outside influences. National Estate listing conveys no legal protection, but it does set a direction for conservation, and can be a step on the way to conservation reserve status. Current National Estate listings include the Warrumbungles, Grampians (Gariwerd) National Park, East Gippsland, North Keeling Island, Cape York and the Lake Eyre region.

Wilderness areas

Wilderness is a natural area that has undergone little or no human intrusion and where ecological processes continue undisturbed. Wilderness areas seek to conserve this condition with human access kept to a minimum, and a buffer zone maintained around the area. The National Wilderness Inventory is a database designed to identify wilderness quality across Australia. This will assist the development of plans for wilderness conservation and management.

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7.2 Conserving biota

Section 7.1 addressed the protection of habitats, lands and waters. This section focuses on programs designed to conserve biota (flora and fauna) and looks at some examples of programs to conserve specific species. Since the conservation of species is interwoven with the conservation of habitats, elements of the discussion will apply across both sections.

Conservation of native biota, as was the case with the conservation of habitat, lands and waters, is a fairly recent concept. Early in Australia's history, wildlife management was even concerned with the successful establishment of exotic animals and plants. Australia's plants and animals were often misunderstood and seen as alien.

Today species are conserved for various reasons. The maintenance of ecological processes and adaptation to changes require the widest possible range of species and the greatest variation within species. The contribution of a species may be unknown, but protection is necessary in case it does play an important role. The economic potential of the sustainable use of biodiversity is also largely unknown. There is also the consideration of a species' intrinsic right to exist.

Native plants and animals have developed complex interrelationships and, for conservation to work effectively, an understanding is needed of the ecological processes operating within an ecosystem. Animals rely on a variety of living and non-living components in their environment for food, shelter and successful breeding.

Australia's endangered biota

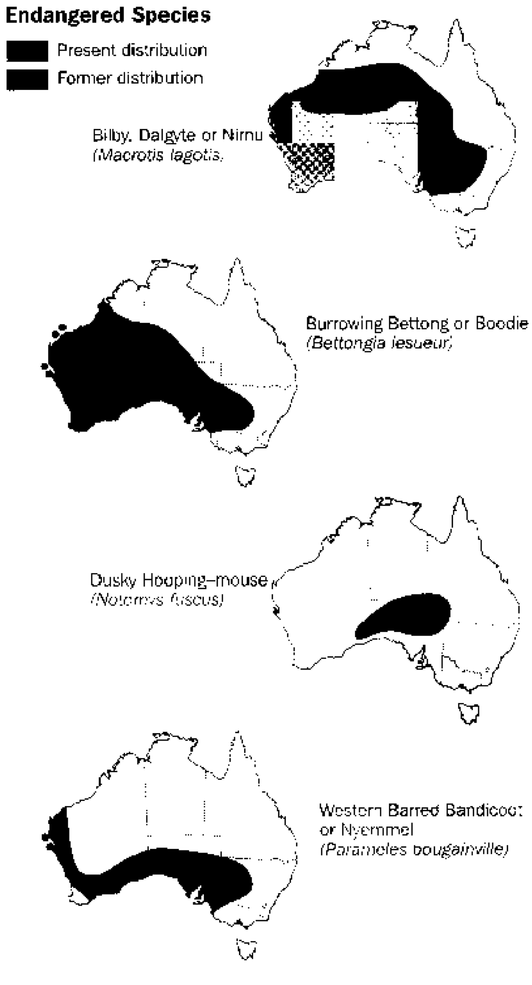
Australia's biodiversity is vast. The numbers of rare and endangered animals and plants are correspondingly large. With 1031 threatened species, Australia is second only to the USA in this regard. It has more threatened species of amphibians and reptiles than any other country, and a third of all the recorded world extinctions of mammal species this century have occurred in Australia. Section 1.4 presents more detail of Australia's biodiversity.

Australia's development has been characterised by a rapid rate of change to natural ecosystems, which has made any adaptation to changing conditions particularly difficult. The threats which have necessitated conservation programmes for biota include such broad concerns as:

- competition and predation from introduced species;
- habitat change and degradation;
- altered fire patterns, weeds (either exotic plants, or native plants which are not indigenous to a particular area);
- salinisation;
- erosion;
- over-grazing by herbivores (domestic and wild);
- conversion of native forest to plantation;
- root rot from introduced pathogens; and
- trampling.

These threatening processes are discussed in more detail in the relevant sections of the publication, including Sections 1.1, 1.3, 6.1, 6.4, 6.5, 9.3 and 12.2.

7.2.1 Current and former distribution of selected endangered species



Source: AUSLIG 1992 p. 63.

Some habitats and biota have been particularly vulnerable to direct and indirect human interference. In the arid zone, for example, a number of species became extinct and the ranges of the remaining species contracted quickly, particularly in intensively used areas such as agricultural zones. Offshore islands provided final refuges for some of these species. Figure 7.2.1 shows how the distribution of some arid zone animals has diminished. Table 7.2.2 lists some endangered species of the arid zone and any recovery plans which are in place for their conservation. Where no plan is yet in place, work may be underway with related species. For example, experience from the Eastern-barred bandicoot recovery plan will help with a plan for the Western-barred bandicoot.

Approaches to conservation

Australia has a commitment and responsibility to the conservation of biota through its ratification of the international Convention on Biological Diversity. The Convention's requirements include:

- establishing protected areas in locations requiring special conservation measures;
- establishing wildlife corridors;
- restoring degraded ecosystems;
- eradicating exotic species that threaten native habitats;
- introducing legislation for the protection of threatened species and populations; and
- undertaking national surveys of biodiversity.

Priorities in conservation generally are for restoration and rehabilitation of habitats and species, and management of threatening processes. Particular emphasis is given to endangered and vulnerable plant and animal species and communities, and to remnant vegetation.

The goals of Australia's National Conservation Strategy are: maintenance of essential ecological processes and life-support systems; conservation of genetic diversity; sustainable use of species and ecosystems; and enhancement of environmental qualities. Subsequent efforts, such as the Ecologically Sustainable Development strategy, and the Biological Diversity Strategy develop this work further.

7.2.2 Endangered species of the arid zone 1992

Species	*Recovery Plan*
Long-tailed dunnart	No
Sandhill dunnart	No
Numbat	Yes
Western-barred bandicoot	No
Bilby	Yes
Brush-tailed bettong	Yes
Burrowing bettong	No
Rufous hare-wallaby	Yes
Banded hare-wallaby	No
Bridled nailtail wallaby	Yes
Greater stick-nest rat	Yes
Shark Bay mouse	Yes
Dusky hopping mouse	No

Source: ANCA 1992.

The National Strategy for the Conservation of Australia's Biological Diversity was introduced to increase environmental knowledge, increase conservation activities, achieve sustainable use of biological resources and reduce the impacts of their use. A National Strategy for the Conservation of Australia's Endangered Species and Communities is soon to be ratified.

Much of what needs conservation lies outside reserves. As an example, 12 of 73 endangered species of eucalypt grow only on private land (ANPWS 1989, p. 2). Conservation outside reserves is often managed by 'conservation covenants' or special planning agreements with the land holders and governments. The National Threatened Species Network is a non-government program promoting community involvement in the conservation of species and habitats. Greening Australia and National Corridors of Green are also community-based programs, aiming to create wildlife corridors, stabilise rivers and filter nutrients flowing to the rivers. An example is the River Murray Corridor of Green.

The National Landcare Program involves the provision of funds for land care and related tree planting and remnant vegetation conservation. Some protected areas cannot conserve biodiversity in the area available, so wildlife corridors are necessary across unprotected land, such as farmland. Landcare helps to achieve this, along with other programs such as One Billion Trees and Save the Bush.

Nationally, the Endangered Species Program seeks to protect endangered species and return them to secure status in the wild. In conjunction with the National Reserves System, the Program works to increase the representation of rare and threatened plants and animals in reserves.

Threatened species are listed under the *Endangered Species Protection Act 1992.* Under the Endangered Species Program, a series of recovery plans and other research programs has been implemented for threatened species (see Tables 7.2.3 and 7.2.4).

National projects, as defined under the Endangered Species Program, tend to have more of an emphasis on education and co-ordination, with the State and Territory programs dealing with more specific projects such as the rehabilitation of a single species.

Conservation of fauna

Action plans, detailing actions necessary for conservation, have been prepared for Australian freshwater fishes, reptiles, rodents, birds, Australasian marsupials and monotremes, and plans are in preparation for Australian seals, bats, cetaceans, dugongs and amphibians. There will eventually be a complete series of action plans for Australian terrestrial and freshwater animals and marine mammals.

Recovery plans describe actions needed to arrest the decline and enhance the recovery of an endangered or vulnerable species so that its long-term survival in nature can be achieved. Costs, responsibilities, time frames, goals and criteria for assessing success are included in a recovery plan. A recovery plan may also be adopted for the conservation of endangered ecological communities. (ANCA 1994, p. 47–48)

7.2.3 Projects under Endangered Species Program

Jurisdiction	*Ongoing*	*New 1995–96*
NSW	25	3
Vic.	21	4
Qld	21	6
SA	16	3
WA	35	7
Tas.	18	1
NT	8	
ACT	1	
National	8	5
Total	**153**	**29**

Source: ANCA 1995.

Conservation effort: Western swamp tortoise

Threats	Initially, a natural contraction of range due to increasing aridity of the continent.
	Loss of habitat to agriculture, industrial and urban use accelerated this decline, as did predation and fire, leaving only 30 wild tortoises.
Steps	Remaining habitat protected in fenced reserves;
	Water pumped in to prevent swamps drying;
	Some eggs taken from unsuitable sites in the wild and hatched under controlled conditions;
	Captive breeding program has produced over 140 tortoises. Some have been released into the wild.

Source: ANCA 1995.

Many of Australia's zoos have established captive breeding programs to breed endangered or vulnerable animals. These aim to maintain genetically diverse captive populations for an indefinite period, releasing animals into protected reserves if habitat is suitable and any threats are judged to be acceptable. Captive breeding has proven most successful with mammals.

7.2.4 Recovery plans under the Endangered Species Protection Act, at June 1995

Species	*Recovery plan prepared or in preparation*	*Recovery plan being implemented*	*Other actions if no plans, research etc.*
Mammals	15	11	19
Birds	17	10	7
Amphibians	17	22	3
Reptiles	9	1	3
Freshwater fish	9	26	7
Vascular plants	231	177	44
Invertebrates	13	1	2
Ecological communities	8	5	10
Total	**319**	**213**	**95**

Source: ANCA 1995.

There are problems associated with releasing captive bred animals, in particular:

- upsetting the genetic balance of wild populations, which are genetically the best suited to a location; and
- diminishing the genetic diversity of the population if the released animals are inbred.

However, if care is taken to prevent inbreeding, the animals put back into the wild may in fact increase the fitness and genetic diversity of the wild population. Other the advantages of captive breeding include:

- higher survival rate for the animals;
- faster growth and earlier maturity of animals which, combined with artificial insemination and other techniques, allow for increased reproduction rates;
- valuable sources of information on species by observation of captive-bred animals;
- opportunities for young to be adopted by unrelated adults; and
- prevention of parents harming their young.

Relocation is another conservation technique. In Western Australia, programs are determining the size and stability of island populations of certain species, and identifying causes of their decline on the mainland. The goal is to re-establish populations in protected parts of the mainland. For example, Burrowing bettongs have been moved to a peninsula in Shark Bay. Other animals being investigated include the Golden and Western-barred bandicoots, and the Rufous, Banded and Spectacled hare-wallabies.

As with captive breeding and release, relocation requires care. If a species is territorial, an animal should not be relocated into another's range, as this leads to stress. Animals must be released into a suitable habitat, at the right time of year, with sufficient food and shelter.

Among other programs to conserve fauna are bird and bat banding schemes. The information collected from these schemes is then used in the conservation of the animals. Bird banding is one of Australia's obligations under international migratory bird agreements (ANCA 1994 p. 52).

Threats posed specifically by introduced species are addressed in part by a Feral Pests Program. Projects under this program focus on the pests themselves and the animals to which they represent a threat (ANCA 1994).

With specific regard to marine species, there is a Marine Wildlife Program. Animals such as cetaceans (whales, dolphins, porpoises), seals, dugong, seabirds, sea snakes and turtles are protected in Commonwealth waters under the *National Parks and Wildlife Conservation Act 1975*. Important parts of the Southern Ocean Whale Sanctuary, including calving zones, fall within Australia's 200 mile Exclusive Economic Zone.

Conservation strategies have been developed for particular marine species. The Great Barrier Reef Marine Park Authority, for example, has strategies for turtles, dugong, seabirds and cetaceans.

Conservation effort: Burrowing Bettongs

Reasons for vulnerability	Agriculture and predation depleted the range of the bettongs until they were restricted to islands off WA.
Steps	Area of mainland, with similar climate and vegetation to the existing island habitat of the bettongs, was fenced.
	Exotic predators, particularly foxes and cats, were shot, trapped and poisoned with baits that are not harmful to native animals.
	Group of bettongs moved to a breeding enclosure on mainland.
	Some of the bettongs were released into the protected area.

Source: Beckmann 1990.

Conservation effort: Leadbeater's Possum

Reasons for vulnerability	Restricted to remnant patches of a specific type of forest (montane ash). The majority of this forest is still designated for timber production by clearfelling.
Steps	Conserving hollow-bearing trees.
	research and monitoring for habitat management.
	developing methods for captive breeding, reintroduction.
	Predator control.
	Acceleration of nest hollows.
	Nest boxes.
Further steps needed	Protection of habitat.

Source: ESD Working Groups 1991, p.76.

There is also a Crown-of-Thorns Starfish program, which monitors outbreaks of these starfish which regularly damage large sections of reef. Elsewhere, there is monitoring of the Drupella snail, which is damaging Western Australia's Ningaloo Reef in particular.

Legislation also applies to many of Australia's external territories. Oceanic reefs and islands, for example, are managed as complete protected units and provide safe breeding sites for birds, turtles and dugongs, as well as resting points for migratory birds.

Conservation of flora

Recovery planning, discussed in the section on conservation of fauna, is also a key approach for the conservation of flora. It is recognised in national and state legislation. Programs for threatened plants include: removing threats such as clearing, overgrazing, trampling, weeds, disease, feral plants and animals, recreational activities; and growing native trees for release into the wild.

The Australian National Botanic Gardens is involved with such work, and coordinates the Australian Network for Plant Conservation. The survival of many species of plants and animals depends on the protection of areas of remnant vegetation (ANCA 1993a, p. 2).

A system is being developed to prioritise conservation of threatened flora.

Conservation effort: Monarto Mintbush

Threats	Naturally restricted habitat in heathland, threatened by low numbers.
	Further threatened by clearing for agriculture, grazing by rabbits and stock, competition from weeds, quarrying and collecting.
Protection	Growing bushes and planting in the wild. Fencing existing populations and re-introduction sites to keep out rabbits and stock.

Source: ANCA 1993b.

Conservation effort: Sandhill Greenhood (orchid)

Threats	Restricted habitat in semi-arid grassland.
	Main threat is loss of habitat; further threatened by rabbit burrowing, grazing, weed encroachment and illegal collecting.
Protection	Existing populations fenced.
	New population established and fenced.
	Weed control.

Source: ANCA 1993b.

Conservation effort: Rose Mallee

Threats	Grazing, heavy weed and rabbit infestation.
Protection	Nature reserve declared on the private land where populations of the tree occur.
	Fencing to exclude rabbits and stock.
	Weed control.
	Seed collected and seedlings planted amongst the main populations.

Source: ANCA 1993b.

7.2.5 Some of Australia's international responsibilities towards conservation of species

Convention	*Date of entry into force generally*
International Convention for the Regulation of Whaling	1925
Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)	1975
Convention on Wetlands of International Importance (Ramsar Convention)	1975
China-Australia Migratory Birds Agreement (CAMBA)	1988
Japan-Australia Migratory Birds Agreement (JAMBA)	1981
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	1983
Convention on the Conservation of Nature in the South Pacific (Apia Convention)	1990
Convention for the Protection of Natural Resources and Environment of the South Pacific Region (SPREP Convention)	1990

Source: Department of Foreign Affairs and Trade 1995.

7.2.6 Some legislation relevant to protected areas and protected species

Jurisdiction	*Legislation*	*Provisions*
C'wealth	Environment Protection (Impact of Proposals) Act 1974	Provides that a number of matters relevant to the environment must be considered in the planning and carrying out of works to be undertaken by the Commonwealth or its agencies.
	National Parks and Wildlife Conservation Act 1975	Establishment and management of parks and reserves on Commonwealth land. Plan of management must be prepared. Conservation of wildlife.
	Australian Heritage Commission Act 1975	Provides for the identification and preservation at a federal level of aspects of the natural environment of national interest.
	Whale Protection Act 1980	Provides for conservation of all cetaceans.
	Wildlife Protection (Regulation of Exports and Imports) Act 1982	Furthers the protection and conservation of wildlife (both terrestrial and marine) by regulating the export and import of certain plants animals and goods.
	Endangered Species Protection Act 1992	Contains provisions that promote the recovery of listed endangered or vulnerable species and listed endangered ecological communities. Also prescribes key threatening processes which impact on endangered species and requires their management through the implementation of Threat Abatement Plans.
ACT	Land (Planning and Environment) Act 1991	Aims to conserve the natural environment of the ACT.
	Public Parks Act 1928–66	Declaration of public parks and reserves, some managed as natural areas.
	Nature Conservation Act 1980	Land in the ACT or Jervis Bay may be declared to be a reserved area.
NSW	National Parks and Wildlife Act 1974	Proclamation of parks and nature reserve; requires plan of management addressing conservation, natural values etc.
	Forestry Act 1916	Establishes a commission which is responsible for the protection of native fauna and certain plants throughout the state.
NT	Territory Parks and Wildlife Conservation Act 1977	Deals with the administration of parks, reserves and sanctuaries. A 1992 amendment enables the Minister to declare a plant, or class of plants to be protected.
	Conservation Commission Act 1980	Commission has responsibility for developing and administering a number of nature conservation plans and measures.
Qld	Nature Conservation Act 1992	Establishes a comprehensive regime of administration for the purpose of the conservation of flora, fauna and the natural landscape.
	Forestry Act 1959–87	Includes recommendations for the protection of watersheds and soil conservation.
	Marine Parks Act 1982	Provides for establishment of marine parks over tidal lands and tidal waters.
SA	National Parks and Wildlife Act 1972	Establishment of reserves for conservation of wildlife as well as public benefit.
	Fisheries Act 1982	Protects certain fish and aquatic habitats and restricts access and activities within an aquatic reserve.
	Native Vegetation Act 1991	Provides incentives and assistance to landowners in relation to the preservation and enhancement of native vegetation.
Tas.	National Parks and Wildlife Act 1970	Establishment of conservation areas. Wildlife and habitat protected, but other activities allowed unless specifically excluded by a management plan.
	Forestry Act 1920	Forest reserves can be set aside for conservation and protection.
	Threatened Species Act 1995	Provides for recovery planning and protection of threatened species.
Vic.	National Parks Act 1975	Outlines scope and policies for the management of the State's parks
	Crown Land (Reserves) Act 1978	Allows for land to be acquired and managed for the preservation or management of wildlife or wildlife habitat.
	Wildlife Act 1975	Aims to protect all wildlife for varied and future needs.
	Flora and Fauna Guarantee Act 1988	Protects the state's flora and fauna for varied and future needs, and provides for the establishment and management of State reserves, refuges and conservation area.
WA	Land Act 1933	Reservation of land for state reserves.
	Conservation and Land Management Act 1984	Provides for the management and protection of public lands and forests of the State, and for the conservation of flora and fauna.
	Wildlife Conservation Act 1950–80	Requirements for protection of flora and fauna.

Source: ANZECC 1994, Hooy and Shaugnessy 1991, ANCA pers.comm. May 1996.

International responsibilities

Alongside its commitment to the Convention on Biological Diversity, Australia is party to a number of other international agreements. Table 7.2.5 outlines some major agreements. Responsibilities under these agreements may be addressed as part of national programs. For example, responsibilities under the China-Australia and Japan-Australia Migratory Birds Agreements are dealt with as part of the Migratory Species Program within Australia.

Legislation

Various pieces of Commonwealth and State legislation relate to the protection of biota. States and Territories fulfill national commitments to conservation goals and also have their own conservation strategies. Table 7.2.6 lists legislation relevant to the conservation of biota and of habitat, lands and waters, as discussed in Section 7.1.

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Chapter 8 — Population conditions and processes

This chapter represents an overview of the Population stocks and Processes components of the PEP model. The aim of the chapter is to present statistics which serve as an introduction to the later chapters of Part 2, where the impacts of individuals on the environment are explored.

Two aspects of the population are explored in Chapter 8 as a prelude to the material in the rest of Part 3:

- Population conditions, change, distribution and density (Section 8.1);
- Components of population change and population projections (Section 8.2).

8.1 Population conditions, change, distribution and density

Population growth

To understand the human impact on the Australian environment, it is necessary to know how many people live here, and how they are distributed across the continent. Analysis of the economic impact on the environment is enhanced by knowing how many producers and consumers of economic and environmental resources there are across Australia.

It is important to recognise that not all individuals have the same level and type of impact on the environment. And that the impact people have is not restricted to where they live.

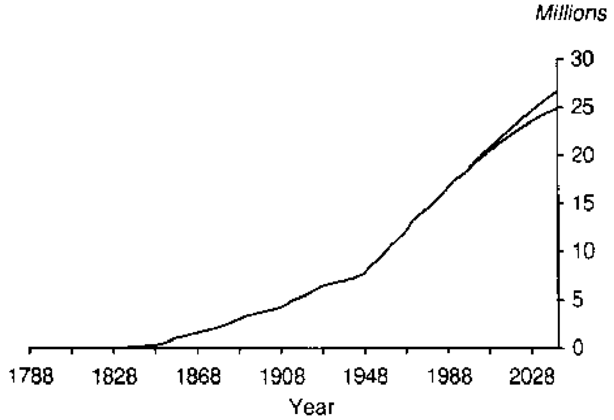
The parliamentary inquiry into Australia's Population 'Carrying Capacity' "rejects the view that Australia is close to its maximum population already and that an increase would lead to intolerable pressure on resources and lead to a sharp decline in health, increase in crime, pollution etc. There is no numerical population level beyond which the social fabric and environmental quality might be expected to go into precipitate decline." However, it went on to conclude that it is necessary to develop a population policy, "to have some idea of where we are going and/or where we want to go" (Australia, Parliament 1994, p.143).

In March, 1995 the resident population of Australia reached 18 million. The population is currently growing at just over 1% a year.

There are no accurate measurements of the indigenous population prior to European settlement. However, recent research has produced a preliminary estimate of 750,000 people, or around 4% of the 1995 population (Mulvaney & White 1987).

The population (excluding full-blood Aboriginal people until 1961) grew rapidly after 1788, especially after the end of the Second World War. Between 1950 and 1994 the population doubled, although by 2041 it is only expected to increase another 39–49% (see Figure 8.1.1).

8.1.1 Australia's population (a), 1788–2041



(a) Excludes Full blooded Aboriginal people till 1961. From 1995 to 2041, the population is projected to lie within a range determined by population projections using different assumptions.

Source: ABS 1996 (4102.0).

State populations

State boundaries tend not to correlate with any environmental regions. However, as much environmental management is done by State governments, States are important units of analysis for environmental data. In 1994, nearly 60% of the Australian population lived in New South Wales or Victoria. Adding Queensland increases this proportion to over 75%.

As shown in Table 8.1.2, over this century Australia has had an average growth rate of just over 2% per annum. Western Australia has had nearly double this rate, and so has increased from 5% to 9.5% of the national population. Tasmania, Victoria and South Australia have all grown at slower than the national average throughout the century.

8.1.2 Population (a) distribution

	Proportion of total population			Population	Average annual growth rate	
	1901	1947	1994	density	1901–94	1984–94
State	%	%	%	people/km²	%	%
NSW	35.9	39.4	33.9	7.5	2.05	1.14
Vic.	31.8	27.1	25.1	19.7	1.61	0.94
Qld	13.2	14.6	17.9	1.9	2.66	2.39
SA	9.5	8.5	8.2	1.5	1.64	0.78
WA	4.9	6.6	9.5	0.7	4.01	2.03
Tas.	4.6	3.4	2.6	7.0	1.38	0.77
NT	0.1	0.1	1.0	0.1	3.86	1.87
ACT	. .	0.2	1.7	125.4	. .	2.07
Aust.	**100.0**	**100.0**	**100.0**	**2.3**	**2.03**	**1.36**

(a) Data for 1901 and 1947 are Census counts, data for 1994 are estimated resident population.
Source: CBCS 1966; ABS 1994 (3201.0).

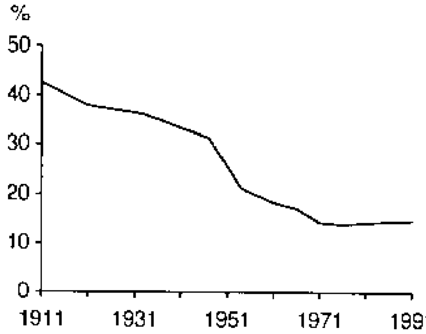
Urbanisation

Australia's population is highly concentrated in relatively small urban areas. This means that population pressures have a very high impact in these areas, but that the total area subjected to direct population pressure is relatively small.

During this century, Australia has become much more urbanised. In 1911, 42% of the population lived in rural areas. By 1976 this had fallen to 14% (see Figure 8.1.3, and Table 8.1.4 which provides a State breakdown). In this process the population lost much of the direct connection it had with many aspects of the environment.

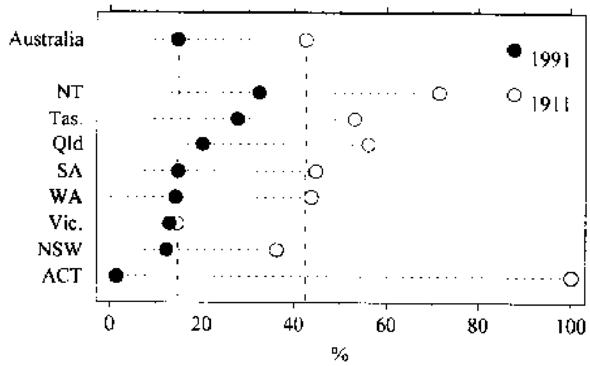
However, between 1976 and 1991 this trend was stopped, in that the proportion of people living in urban areas fell slightly. This is mainly due to people moving to rural areas surrounding the cities, especially Melbourne and Sydney, but still working, shopping etc in the city (O'Connor 1994).

8.1.3 Rural population of Australia



Source: ABS 1994 (1301.0); CBCS 1921; CBCS 1933.

8.1.4 Rural population of States and Territories



Source: CBCS 1921; ABS 1994 (2822.0).

Urban centres

While major cities contain most of the population, 678 of the 699 urban centres in Australia have less than 50,000 people (see Table 8.1.5). About 20% of the Australian population live in these centres.

Smaller urban areas often have less comprehensive environmental protection strategies, such as for sewage treatment, than larger cities. However, their much smaller populations mean that their total impact on the local environment is much smaller.

Largest cities

Australia has twenty cities with more than 50,000 people. These cities concentrate 65% of Australia's population into 0.1% of its area. This places great stress on these areas, and on the areas that service them, such as water catchments and leisure areas (Australia, Parliament 1994, pp. 95–97).

8.1.5 Size of urban centres

	Centres		Population		
	1981	1991	1981	1991	1991
Size (a) of urban centre	No.	No.	%	%	'000
1 000 000 and over	2	4	37.4	47.6	7 985.1
500 000–999 999	3	1	18.1	5.7	954.7
250 000–499 999	1	3	1.8	4.8	810.2
100 000–249 999	5	5	5.9	4.5	761.1
50 000–99 999	9	8	3.9	8.1	512.0
25 000–49 999	12	14	2.7	2.7	456.4
10 000–24 999	50	72	5.8	6.9	1 154.8
2 500–9 999	203	240	7.1	6.7	1 126.2
1 000–2 499	271	352	3.0	3.3	546.5
Total urban	**556**	**699**	**85.6**	**85.3**	**14 307.0**
Rural	. .	. .	14.2	14.6	2 456.2

(a) The data in this table are based on Census counts on a usual residents basis, and so differ slightly from the data in Table 8.1.2.
Source: ABS 1994 (2822.0).

The urban area of Sydney had over 3 million people in 1991. Adding to this population are many people who live in towns or rural areas such as the Blue Mountains, who commute to Sydney, or who use the city, and contribute to some of its environmental problems.

During the 1980s, Sydney grew outwards, and absorbed smaller towns and settlements into its urban area. While people living in these communities may not have moved during the decade, in 1981 they were not part of the Sydney population, but by 1991 they were. The non-urban land that had buffered them from Sydney had largely gone.

The parliamentary enquiry into Australia's Population 'Carrying Capacity' found "widespread concern over environmental problems in Sydney ... the ongoing degradation of the Hawkesbury-Nepean system is suggested as being a foretaste of the problems which will arise elsewhere with population growth." It also cited "problems of overuse of natural recreation areas near cities and overloading of water supply and waste disposal systems" (Australia, Parliament, 1994, pp. 95–97).

Increasing congestion and associated problems are often cited in relation to the continual growth of major cities. However "because of the emergence of multi-centred cities with each centre being somewhat self contained... [t]here are a large number of people who live in the suburbs who are 10 minutes from their work. They have matched up a suburban job and a suburban house... They have a very good quality of life" (Australia, Parliament 1994, p. 98).

Sydney has the largest population of any city in Australia (Table 8.1.6). However Melbourne covers a greater area than Sydney. This is partly because the topography of the cities enabled Melbourne to develop a better road system. Melbourne has 248km of freeway, more than twice the length in Sydney, so commuting distances in Melbourne can be greater than in Sydney.

8.1.6 Australia's largest cities

		Urban population (a)			*Urban area*	*Population density (b)*		
		1981	*1991*	*Increase*	*1991*	*1981*	*1991*	*Increase*
City	*State*	*'000*	*'000*	*%*	*km²*	*people/km²*	*people/km²*	*%*
Sydney	NSW	2 877	3 098	7.7	1 548	1 919	2 001	4.3
Melbourne	Vic.	2 579	2 762	7.1	1 643	1 594	1 682	5.5
Brisbane	Qld	943	1 146	21.5	1 006	1 067	1 139	6.7
Perth	WA	809	1 019	25.9	875	1 019	1 165	14.3
Adelaide	SA	883	957	8.5	671	1 352	1 428	5.6
Canberra-Queanbeyan	ACT–NSW	238	300	25.8	262	1 007	1 143	13.6
Newcastle	NSW	259	262	1.3	247	1 073	1 062	−1.0
Gold Coast-Tweed Heads	Qld–NSW	155	256	65.7	230	1 303	1 113	−14.6
Wollongong	NSW	209	211	1.3	175	1 093	1 209	10.6
Hobart	Tas.	129	127	−1.2	121	1 105	1 052	−4.9
Geelong	Vic.	125	126	0.8	80	1 457	1 573	8.0
Townsville-Thuringowa	Qld	86	101	17.7	139	na	730	na
Toowoomba	Qld	63	76	19.8	58	1 111	1 313	18.2
Darwin	NT	56	68	20.3	72	na	938	na
Launceston	Tas.	65	67	3.3	84	800	793	−0.8
Ballarat	Vic.	63	65	3.8	67	1 095	972	−11.2
Cairns	Qld	49	64	32.8	72	695	897	29.1
Albury-Wodonga	NSW–Vic.	53	64	19.5	90	692	704	1.7
Bendigo	Vic.	53	57	8.9	66	781	866	10.9
Rockhampton	Qld	50	56	11.1	45	na	1 231	na
Comparable cities (c)		**9 549**	**10 658**	**11.6**	**7 295**	**1 395**	**1 461**	**4.7**
Total cities (c)		**9 742**	**10 883**	**11.7**	**7 552**	**na**	**1 441**	**na**

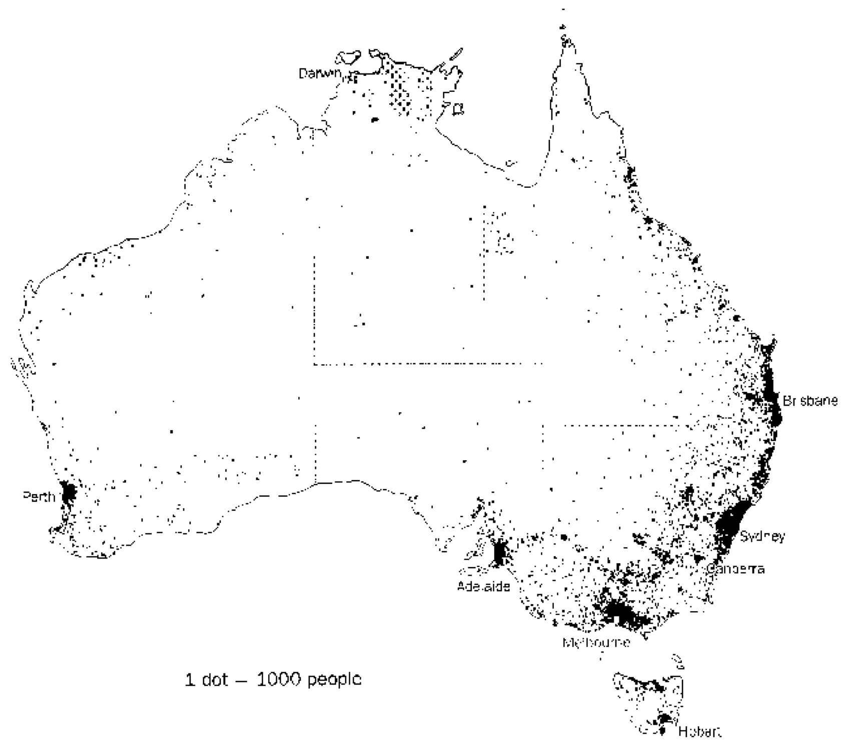
(a) Census count.

(b) Census boundaries are not designed to be used to compare the size of urban areas over time. Therefore these data should be regarded as indicative only.

(c) The urban areas of Townsville, Darwin and Rockhampton used in 1981 are not comparable with those used in 1991. Therefore they are excluded from the total. A separate total has been provided including these centres, but no data on area or density in 1981 have been presented.

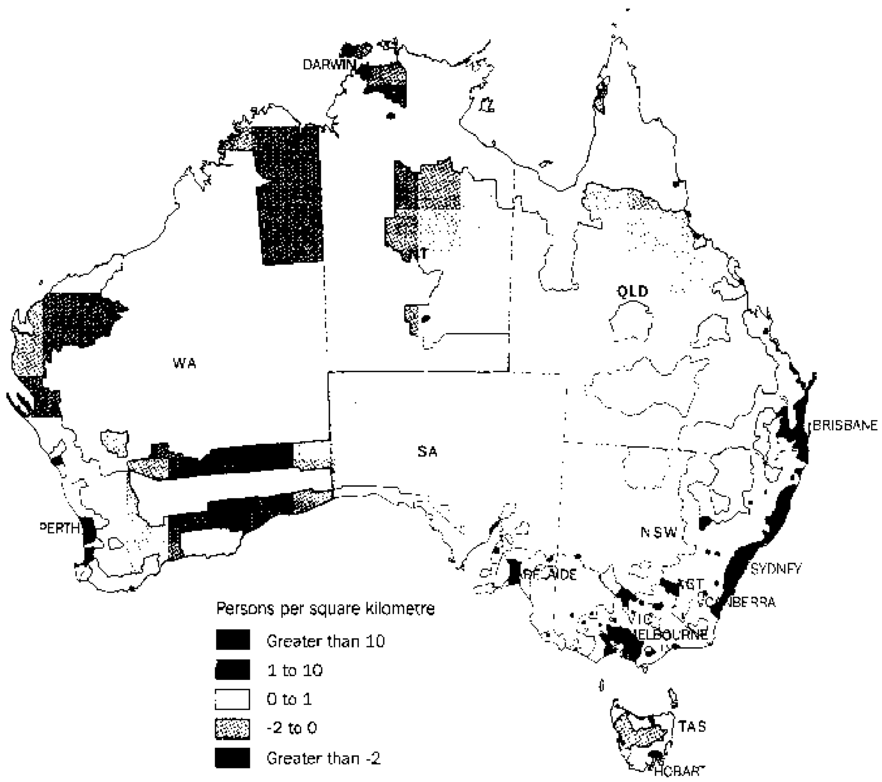
Source: ABS Census of Population and Housing 1991, unpub.; ABS 1994 (2822.0).

8.1.7 Population (a) distribution, Australia, 1993



Note: Based on Statistical Local Area boundaries.
(a) Estimated resident population.
Source: ABS 1993 (3227.0).

8.1.8 Change in population (a) density, 1988–93



Note: Based on Statistical Local Area boundaries.
(a) Estimated resident population.
Source: ABS 1993 (3227.0).

Perth and Canberra-Queanbeyan had population increases of 26% in the decade to 1991, but their area increased at a slower rate and, consequently, the density of these cities increased rapidly.

Australia's twenty largest cities on average increased their population density by about 5% over the decade (but see footnote (c) to Table 8.1.6). This reflects a trend towards urban consolidation, with increased high density living, and falling block sizes of separate dwellings.

During the 1980s Gold Coast-Tweed Heads nearly doubled in area. The population density fell dramatically as most of the increase in population was in less densely populated suburbs, rather than the more densely populated coastal belt.

Population distribution

Only four of Australia's twenty largest cities are inland cities. Figure 8.1.7 shows the extent to which the population is clustered around the coast. The rapid growth of the coastal belt, especially around Brisbane and Perth, indicates that this concentration is increasing.

Between 1986 and 1993, Australia experienced an average population growth rate of 1.4% per year. Despite this growth, Statistical Local Areas (SLAs) covering over half of the continent experienced population decline (see Figure 8.1.8).

Regional population growth and decline

Population growth in an area means that there is greater demand for and pressure on resources. It also means that there is a change in land use, either to higher density residential, or from non-residential to residential land use.

Increasing population density usually replaces vegetation with hard surfaces, increasing runoff and summer temperatures, as well as decreasing local biodiversity (Australia, Parliament 1994, p. 97). Changing land use patterns can have similar effects.

Local population decline may sometimes indicate that an area cannot support its population because of environmental or economic problems.

Most areas with rapid population growth are on the outskirts of capital cities (see Table 8.1.9). Most of Australia's capital cities are growing; with decline in inner urban population, this growth is concentrated on the outskirts of the cities.

Geographic classification

The Australian Standard Geographic Classification (ASGC) is designed to enable spatially classified statistics to be produced on a useful and comparable basis.

The primary geographic unit for the collection of Census data is the census collection district (CD). There are 30,000 CDs in Australia. These can be aggregated into 1,346 Statistical Local Areas (SLAs), which in turn can be aggregated to form 196 Statistical sub-divisions (SSDs). The SSDs aggregate to 67 statistical divisions (SDs) which then aggregate to the 8 States and Territories, without gaps or overlap.

There are a number of editions of this. This document primarily uses edition 2.1, which was current in the 1991 Census.

This section also aggregates CDs into other regions, such as urban areas, precipitation deciles, drainage divisions and bioregions.

Population counts

There are three main sources of data about population, all have been used in this analysis. The Census of Population and Housing produces counts of people based on where they spent Census night (place of enumeration) and where they usually live (Usual residents). Place of enumeration gives an indication of the number of people in an area at a point in time, including tourists etc. Census usual resident counts give an indication of the number of people who usually live in an area.

The ABS also produces Estimated Resident Population (ERP) for each SLA. As the census misses out on about 1.8% of the population, this is a better estimate of the population of an area, and data is available annually, rather than just five yearly, as with the Census.

There are other areas, outside the capital cities, experiencing rapid growth due to growth of local industries. For example, the Sunshine Coast had very rapid population growth in the late 1980s due to growth of tourism and related industries. The population growth in Dale in Western Australia was primarily due to growth in mining in the region.

Between 1986 and 1991, Queensland had the highest population growth rate in the country. Because of this rapid growth, 6 of the 10 fastest growing Statistical sub-divisions (SSDs) in Australia are in Queensland (see Table 8.1.9).

The areas with the most rapid population decline are shown in Table 8.1.10. Many of these areas have a narrow employment base. For example, in 1986, 34% of employed people living in Whyalla worked in the basic metal manufacturing. By 1991, employment in this industry had fallen by 44%.

Ageing of the population can lead to declining household size, as children leave home and as partners die. This is the main reason behind the decline in Weston Creek in the ACT, and in the inner city areas Northern Middle Melbourne and Northern Inner Melbourne.

8.1.9 Areas with highest population growth rate 1986–91

Statistical sub-division (a)	State	1991 Population '000	Population increase 1986–91 No.	Average annual growth rate, 1986–91 %	Population density, 1991 People/km²
Albert Shire (b)	Qld	111.5	40.9	9.6	109.3
Caboolture Shire (b)	Qld (c)	67.1	21.2	7.9	61.4
Tuggeranong	ACT (c)	74.4	22.9	7.6	463.7
Dale	WA	41.0	11.9	7.1	15.1
South-Eastern Outer Melbourne	Vic. (c)	174.1	50.7	7.1	98.3
Albert Shire (b)	Qld (c)	33.7	9.5	6.9	115.7
Redland Shire	Qld (c)	82.8	22.6	6.6	158.4
Sunshine Coast	Qld	119.3	32.0	6.4	176.3
Western Fringe Melbourne	Vic. (c)	110.5	26.5	5.6	98.7
Moreton (b)	Qld	121.5	24.2	4.5	7.3

(a) Only 153 Statistical sub-divisions with an estimated resident population over 25,000 have been included in this analysis.
(b) Part of.
(c) SSD is within the capital city Statistical Division.
Source: ABS 1993 (3227.0).

Regional population decline means that resources in those areas may be underused, putting greater pressure on resources in other areas.

Population density is closely related to population growth rates. High growth rates are associated with medium population density. Population decline is occurring both in the densely populated areas of the cities and in sparsely populated areas of rural and remote Australia. Of the 21 SSDs with population decline, only Latrobe Valley in Victoria had a population density between 3 and 600 people per km².

The low density SSDs with population decline are usually rural or remote areas with a small range of industries, usually mining or agriculture. Local declines in these industries cause declines in the population.

There has also been substantial decline in population density in inner city areas. Residential land use is being replaced with other commercial land use and, with an ageing population, household size has fallen. Despite some gentrification in these areas, their population has declined.

As in rural areas, declining population often leads to underused services, and inefficient allocation of services. However, in inner city areas, while population is falling it is being replaced by commercial and other land uses which may draw on these services.

8.1.10 Areas with greatest population rate of decline 1986–91

Statistical sub-division (a)	State	1993 Population '000	Population increase 1986–91 No.	Average annual growth rate, 1986–91 %	Population density, 1991 People/km²
Whyalla	SA	26.9	−2.0	−1.4	2.01
Flinders Ranges	SA	23.0	−1.3	−1.1	0.29
Lincoln	SA	26.8	−1.3	−0.9	0.72
Fortescue	WA	23.9	−1.1	−0.9	0.20
Far West	NSW	28.3	−1.2	−0.8	0.19
Weston Creek	ACT (b)	27.2	−0.9	−0.7	1 146.71
Northern Inner Melbourne	Vic. (b)	94.2	−2.9	−0.6	3 277.81
Northern Middle Melbourne	Vic. (b)	191.6	−5.5	−0.6	2 222.81
North Central Plain	NSW	31.7	−0.9	−0.5	1.02
Pirie	SA	28.0	−0.6	−0.4	0.58

(a) Only 153 Statistical sub-divisions with an estimated resident population over 25,000 have been included in this analysis.
(b) indicates that an area is within the State's capital city Statistical Division.
Source: ABS 1993 (3227.0).

8.1.11 Population distribution by precipitation area deciles, 1991

Area (a) ranked by average precipitation	Average precipitation	Pop. (b)	% of population	Annual growth rate 1986–91	Indigenous population	Employment in agriculture	Largest area		Largest population	
	mm	'000	%	%	%	%	State	%	State	%
Driest 10%	151–186	15.0	0.1	3.1	20.0	7.8	SA	100	SA	100
2nd decile	186–210	31.4	0.2	2.2	6.7	5.4	WA	67	WA	93
3rd decile	210–226	38.4	0.2	0.2	9.5	5.6	WA	70	NSW	62
4th decile	226–277	156.6	0.9	0.2	7.4	12.0	WA	36	SA	47
5th decile	277–303	72.6	0.4	0.0	10.0	17.0	WA	72	WA	51
6th decile	303–392	251.4	1.5	0.0	5.7	27.0	WA	30	SA	29
7th decile	392–503	835.8	5.0	0.6	2.8	12.0	Qld	38	SA	51
8th decile	503–680	2 837.2	16.9	1.2	1.2	5.0	Qld	34	Vic.	50
9th decile	680–881	4 635.10	27.6	1.6	0.9	3.4	Qld	51	Vic.	42
Wettest 10%	881–3300	7 947.9	47.2	1.9	1.5	3.2	Qld	46	NSW	52
Wettest 5%	1167–3300	2 857.9	17.0	2.5	2.1	3.9	Qld	41	NSW	46
Wettest 1%	1520–3300	888.4	5.3	3.6	3.9	6.4	Qld	48	Qld	61
Total Australia (c)	151–3300	16 821.4	100.0	1.5	1.6	4.5	. .	. .	. .	. .

(a) This table is based on Statistical Local Areas. These do not correlate perfectly with isobars, and so there is some introduced error. Any correlation found in this table would probably be stronger if perfect matching were used.
(b) Estimated resident population.
(c) Excluding migratory and offshore areas.
Source: ABS 1994 (2721.0).

Precipitation

There is no direct link between rainfall and population, except for people engaged in agriculture and in a few other industries. However, primarily for historical reasons, Australia's population is concentrated in the wettest part of the continent. As the ecology of Australia is also very strongly related to rainfall, the population concentration has a greater effect on some ecological areas than others. This is illustrated in Table 8.1.11.

10% of the surface area of Australia receives an average annual rainfall in excess of 881mm per year. 47% of the Australian population live in this area. This includes most of the populations of Brisbane and Sydney.

Half of Australia receives less than 303mm per year. This area contains less than 2% of the national population.

9% of the population in the driest half of the continent are Aboriginal or Torres Strait Islander peoples, compared to 1.6% nationally. Many of the indigenous peoples in these areas live a traditional lifestyle, and so interact with the environment in ways different to those of the non-indigenous population.

20% of employed people living in the driest 10% of Australia work in the mining industry, with another 8% in agriculture.

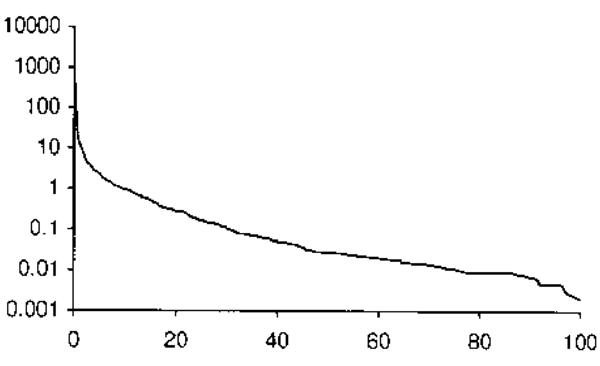
The most rapid population growth between 1986 and 1991 in Australia occurred in the wettest and driest areas of the continent, while those areas receiving between 277mm and 392mm a year (20% of the continent) experienced population decline.

The growth in the driest areas can mostly be attributed to growth of the mining industry in a few areas, which contain a large proportion of the population in these parts of the continent.

Growth in the wettest parts of Australia is largely due to the migration to coastal Queensland.

The 20% of the area of Australia around the median rainfall of 303mm (the fifth and sixth deciles) experienced population decline between 1986 and 1991. About half of this area is in Western Australia (72% of the 5th decile, and 30% of the 6th decile), and it is the area most dependent on agriculture. 24% of employed people living in these areas are employed in agriculture. Falling employment in agriculture, and in the towns supported by it, has had its greatest impact in these areas.

8.1.12 Population (a) density of SLAs, 1991



(a) Estimated resident population.
Source: ABS 1993 (3227.0).

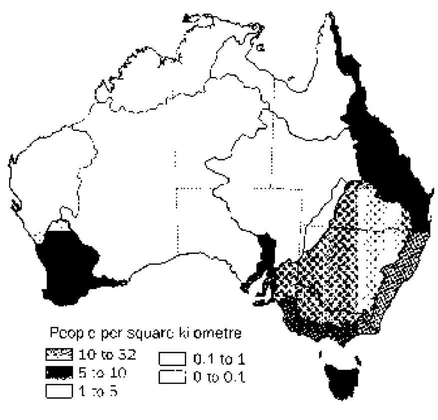
Population density

Half of Australia's land area comprises SLAs with a population density below 0.027 persons per km^2 (see Figure 8.1.12). This area contains only 0.3% of Australia's population.

The most densely populated 1% of Australia has an average population density of 189 persons per km^2, including park land, roads, shops etc in the SLA. This area contains 84% of the population.

Some areas within this have a much higher density. The most densely populated SLA in Australia is Waverley, around Sydney's Bondi Beach, which has 61,000 people living in just 8.6 km^2 (7,084 people/km^2).

8.1.13 Population density in Major drainage basins, 1991



Note: Based on Water Resources Council Drainage Division Boundaries
Source: ABS Census of Population and Housing 1991, unpub.

Drainage Divisions

The South-East Coast Drainage Division includes a lot of relatively short, unconnected river systems (see Figure 1.1.2 and Table 1.1.10 for the identity and location of Australia's Drainage Divisions). 52% of the Australian population live in this Drainage Division, east of the Great Dividing Range from the Glenelg river system in Victoria and South Australia to the Tweed River system in Queensland and New South Wales. The population density is the highest of any Drainage Division in the country, at 32 people/km^2.

Combined with the North-East Coast Drainage Division, the 10% of Australia east of the Great Dividing Range contains 68% of the population.

However, within these Drainage Divisions many of the individual drainage basins face much greater pressure. The ecology of the lower Yarra river has been altered significantly by the pressures from the population of Melbourne and from rural areas further upstream.

The Murray-Darling river system covers 13.7% of Australia, and includes 10.8% of the population (see Figure 8.1.13 and Table 8.1.14). However, as it supports a major food producing area of Australia, the population which directly or indirectly impacts on this river system is far greater. The biggest pressures on this system are water usage for agriculture, fertiliser and pesticide runoff into the river system, and salination of the river system (see Section 1.1).

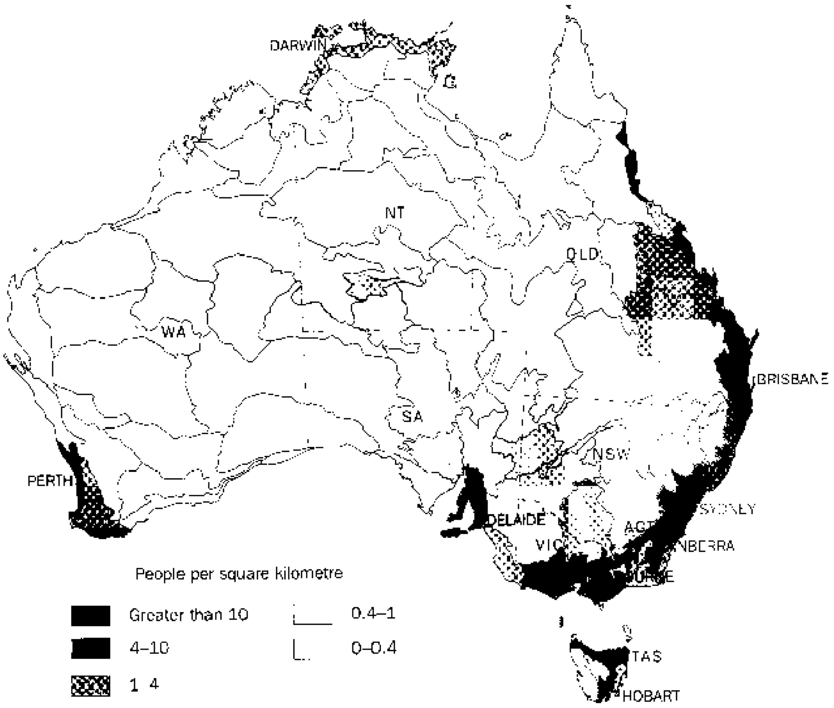
Direct population pressures also contribute to the state of the river system, although these are more noticeable in more highly densely populated drainage basins.

8.1.14 Population in major drainage basins, 1991

	Population		*Area*	*Density*
Drainage Division	*'000*	*%*	*Km²*	*People/km²*
South-East Coast	8 752	52.0	274	31.91
North-East Coast	2 732	16.2	463	5.90
Murray-Darling	1 823	10.8	1 063	1.72
South-West Coast	1 410	8.4	315	4.48
South Australian Gulf	1 210	7.2	82	14.85
Tasmania	452	2.7	68	6.62
Timor sea	144	0.9	547	0.26
Indian ocean	101	0.6	524	0.19
Western Plateau	82	0.5	2 496	0.03
Gulf of Carpentaria	62	0.4	650	0.10
Lake Eyre	55	0.3	1 150	0.05
Bulloo-Bancannia	1	0.0	98	0.01
Total Australia	**16 825**	**100.0**	**7 731**	**2.18**

Source: ABS Census of Population & Housing 1991, unpub.

8.1.15 Population density in Australia's biogeographic regions



Note: Based on Australian Nature Conservation Agency's Interim Biogeographic Regionalisation for Australia (IBRA), Version 4 1995.
Source: ABS Census of Population and Housing, unpub.

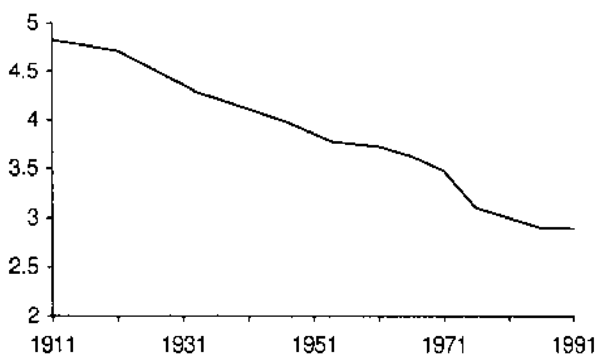
Biogeographic regions

Australia has been classified into 80 regions based on climate, geology, landform, vegetation, flora and fauna and land use. These range in size from Furneaux which covers under 2,400km^2, to the Great Victoria Desert, which covers 5.5% of Australia's landmass (see Table 7.1.9 and Figure 7.1.10 for the identity and location of Australia's biogeographic regions).

The region with the highest population density in 1991 was the Sydney basin with 118 people per km^2 (see Figure 8.1.15). This one biogeographic region contained 4.3 million people, or 26% of the national total. Of course, this population distribution is not even across the region, and with more than 10% of the region in reserves, most ecosystems in the area are relatively well preserved compared to other areas in Australia (Thackway & Cresswell 1995, p. 44).

South-east Queensland and south-east coastal plains both have populations in excess of 2 million (the former including Brisbane, the Gold Coast and the Sunshine Coast, the latter containing most of Melbourne, Geelong and the Latrobe Valley).

8.1.16 Average number of people per dwelling (a)



(a) Until 1976, data refers to people per occupied private dwelling From 1981 data refers to persons per household.
Source: CBCS 1954; CBCS 1971; ABS 1989 (2506.0); ABS 1988 (2502.0).

Dwelling density

As people within a dwelling share resources, the number of people within a dwelling has a significant impact on the effect the population has on the environment. For example, people in a dwelling share heating. So the greater the number of dwellings housing a given population, the greater their energy demands could be expected to be.

Between 1911 and 1991 the number of people per dwelling in Australia nearly halved (see Figure 8.1.16). Despite this, the actual size of the dwellings has increased. In 1911, Australian dwellings had an average of about 5.1 rooms. By 1981 this had increased to around 5.7 rooms.

Similarly, private houses built in 1983 had an average floor area of $167m^2$. By 1994 this had increased 15% to $192m^2$.

The growth of the population tells us something about the potential impact it has on the environment, but many other factors affect this interaction.

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8.2 Components of population change and population projections

Introduction

Section 8.1 looked at Australia's population growth, distribution and density; and dwelling and household size and growth. Much debate surrounds the extent to which population size and growth cause or contribute to environmental degradation; the pressures exerted on the environment by the population will be examined more closely in Chapter 9.. The present section examines those characteristics of the population which drive or influence its growth and distribution (see Tables 8.2.1 and 8.2.5), and which may also impact on current and future resource use — e.g. age structure and non-permanent population flows.

Table 8.2.1 and Figures 8.2.2 and 8.2.3 provide a historical overview of the various components of Australia's population growth. Tables 8.2.5, 8.2.6 and 8.2.8 examine some of the factors contributing to population pressures over recent years, at a regional level.

Components of growth

The main source of Australia's population growth this century has been natural increase. Since 1916, an increase of over 8 million people can be attributed to natural increase, with net migration contributing another 4.6 million to Australia's population.

Population numbers and their growth have been influenced primarily by immigration policies and major events. The relatively low population growth rate during the 1930s relates to the years of the Great Depression, an era which was followed by the post-World War 2 'Baby Boom' years which resulted in both high natural and immigration increases.

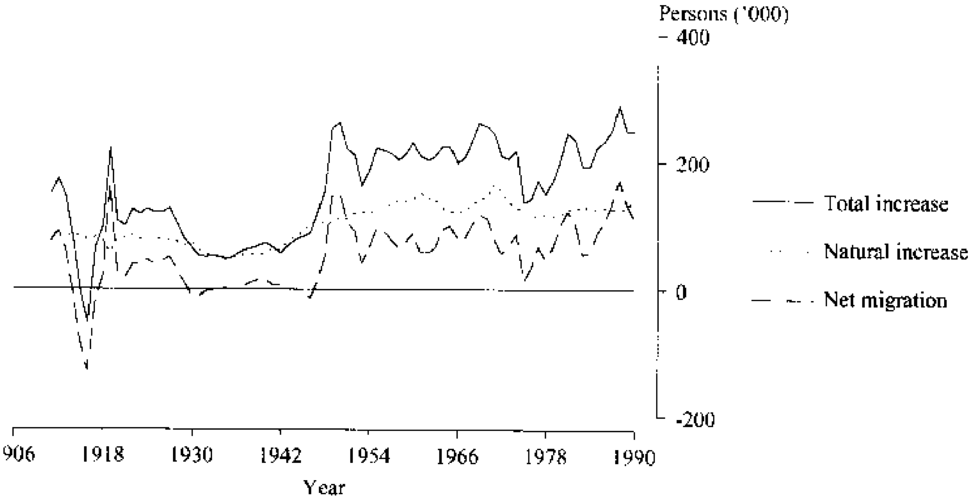
Between 1971 and 1981 the average annual growth rate dropped from almost 2% to 1.38%. In the 1980s the growth rate steadily increased due to increasing levels of net overseas immigration. Since this time a decline has been apparent, with immigration levels dropping in the early 1990s.

8.2.1 Components of growth

		Growth for five years ending				*Life Expectancy (e)*	
	Population (a)	*Annual growth rate*	*Natural increase (b)*	*Immigration (c)*	*Total Fertility Rate*	*Male*	*Female*
Year	*'000*	*%*	*'000*	*'000*	*TFR (d)*	*years*	*years*
1916	4 917.9	0.08	410.4	−66.2	na	na	na
1921	5 510.9	2.30	376.0	217.0	3.12	59.2	63.3
1926	6 124.0	2.13	402.0	210.6	2.85	na	na
1931	6 552.6	1.36	353.7	74.9	2.31	na	na
1936	6 810.4	0.77	253.4	4.4	2.18	na	na
1941	7 143.6	0.97	283.6	54.2	2.36	na	na
1946	7 518.0	1.11	412.0	−4.8	2.98	na	na
1951	8 527.9	2.55	539.9	470.1	3.06	na	na
1956	9 530.9	2.25	614.1	388.7	3.33	na	na
1961	10 642.7	2.15	704.9	365.9	3.55	67.9	74.2
1966	11 704.8	1.92	655.6	400.0	2.88	67.6	74.2
1971	12 908.2	1.98	711.9	491.7	2.87	67.8	74.5
1976	14 110.1	1.36	660.4	258.5	2.06	69.6	76.6
1981	15 054.1	1.38	593.5	408.1	1.94	71.2	78.3
1986	16 134.1	1.37	638.7	414.3	1.87	72.7	79.2
1991	17 284.0	1.54	660.6	617.3	1.86	74.4	80.3
1995p	17 843.3	1.13	683.2	322.2	nya	nya	nya

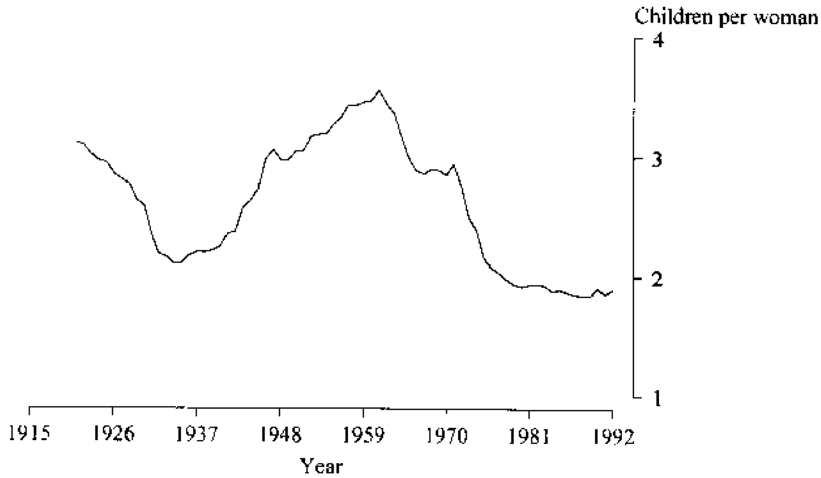
(a) Excludes full-blood Aboriginal people prior to 1962. Population at 30 June.
(b) Excess of births over deaths, for the five years ending at the year indicated.
(c) For the period September 1939 to June 1947 troop movements were excluded and deaths of defence personnel, whether in Australia or overseas, were included.
(d) Children/woman. See Explanatory Notes for definition.
(e) Figures refer to life expectancy at birth.
Source: ABS various years (3301.0); ABS various years (3302.0); ABS various years (3102.0); ABS various years (4101.0); ABS various years (3412.0); ABS various years (3101.0); Office of the Australian Government Actuary, various years.

8.2.2 Annual increase in population by components of growth, 1911–1991



Source: see Table 8.2.1.

8.2.3 Total fertility rate



Source: see Table 8.2.1.

Over the ten years from 1961 to 1971 the total fertility rate declined gradually from 3.6 to 2.9 children per woman. The rate then declined rapidly between 1971 and 1976 (from 2.9 to just over 2.0), and has remained at around 1.9 since the early 1980s.

Mortality rates are also falling, resulting in increased life expectancy for people in Australia. Since 1921, the life expectancy at birth has increased by over 15 years for males and 17 years for females.

All these factors have resulted in, and will continue to influence, changes in the age structure of the population.

8.2.4 Age profile of States

	1971					1981					1991				
	0–14	15–44	45–64	65+	Median	0–14	15–44	45–64	65+	Median	0–14	15–44	45–64	65+	Median
State	%	%	%	%	Years	%	%	%	%	Years	%	%	%	%	Years
NSW	27.6	43.4	20.6	8.5	28.4	24.5	45.4	20.0	10.1	30.3	21.6	46.8	19.8	11.9	32.9
Vic.	28.9	42.9	19.8	8.4	27.7	25.1	45.8	19.3	9.8	29.8	21.3	47.8	19.4	11.5	32.5
Qld	29.5	41.3	20.1	9.0	26.9	25.6	45.2	18.9	10.2	28.8	22.7	47.5	19.0	10.8	31.8
SA	28.9	42.2	20.4	8.5	27.5	23.9	45.5	20.1	10.5	30.4	20.7	46.6	19.8	12.9	33.6
WA	30.3	44.4	17.9	7.4	26.0	26.2	47.5	17.6	8.7	28.5	23.2	48.6	18.5	9.7	31.5
Tas.	31.1	41.5	19.5	7.9	26.2	26.2	45.4	18.7	9.8	28.8	23.1	45.9	19.1	11.9	32.4
NT	32.9	52.5	12.2	2.4	23.7	31.2	53.3	12.4	3.0	24.5	27.8	55.7	13.9	2.6	26.9
ACT	32.4	50.4	14.5	2.8	23.9	29.4	51.2	15.1	4.3	26.9	23.5	53.2	17.1	6.2	29.5
Aust.	**26.8**	**43.0**	**19.9**	**8.3**	**27.5**	**25.1**	**45.8**	**19.3**	**9.8**	**29.6**	**21.9**	**47.5**	**19.3**	**11.3**	**32.4**

Source: ABS various years (3201.0).

Age structure

Table 8.2.4 shows the median age of the Australian population to be steadily increasing between 1971 and 1991. In particular, the decline in fertility in the 1970s and the increased life expectancy has seen an increase in the percentage of elderly people (65+) and a decrease in the percentage of children under 15 over this period.

In the 20 years between 1971 and 1991, South Australia increased its percentage of people in the 65+ age group by over 4 percentage points to 12.9% of the State's population. In both the Northern Territory and the ACT, the percentage of the population over 44 years of age was considerably lower than for the rest of Australia over this period.

Migration

Population growth rates vary significantly between the States and Territories. Table 8.2.5 shows that Queensland grew much faster during the early 1990s than any other State.

The role of migration in the growth and redistribution of the population over recent years becomes immediately obvious. Table 8.2.6 shows the strong tendency for overseas immigrants to settle in the major metropolitan areas, particularly Sydney and Melbourne, although Perth also received a disproportionately high number of overseas immigrants. It is significant too that Sydney and Melbourne experienced substantial internal migration losses. The growth of these two cities is thus closely linked to net overseas migration levels during this period.

Overall, internal migration (i.e. combined inter- and intrastate movement) was the principal

8.2.5 Components of population change by State, 1991–1995 (a)

	Net estimated migration			Natural increase
	Overseas (b)	Interstate	Net migration gain (c)	
State	No.	No.	No.	No.
New South Wales	102 880	–62 796	40 084	176 329
Victoria	57 339	–106 416	–49 077	130 704
Queensland	28 221	185 821	214 042	102 379
South Australia	9 540	–14 778	–5238	32 906
Western Australia	29 983	6 834	36 817	58 840
Tasmania	705	–6 773	–6 068	12 286
Northern Territory	1 916	–4 857	–2 941	11 326
Australian Capital Territory	–734	2 965	2 231	13 321
Australia	**229 850**	..	**229 850**	**538 166**

(a) Figures for 1995 are preliminary.
(b) Includes an adjustment for 'category jumping'. Refer to ABS cat. 3101.0 for details.
(c) The sum of net estimated overseas migration and net estimated interstate migration.
Source: ABS various years (3101.0).

8.2.6 Migration as a component of change by State and selected regions, 1986–1991

State/Region	Total overseas arrivals	Net migration		Natural increase
		Interstate	Intrastate	
	No.	No.	No.	No.
Sydney	214 326	−71 087	−67 645	134 328
Hunter	6 247	−5 608	15 155	14 787
Illawarra	6 790	−5 719	14 449	13 627
South-Eastern	2 014	1 440	4 635	6 734
Richmond-Tweed	2 359	2 130	14 114	5 503
Mid-North Coast	2 203	−939	20 350	6 850
Total New South Wales	**242 800**	**−93 316**	. .	**213 859**
Melbourne (a)	145 308	−29 653	−29 029	113 565
Barwon	3 861	−2 131	7 108	7 402
Loddon-Campaspe (a)	1 184	−1 749	9 341	5 254
Central Highlands	1 285	−2 020	5 434	4 357
Goulburn	1 206	−2 398	4 057	6 580
Ovens-Murray	819	214	2 206	3 492
Gippsland (a)	1 530	−3 655	3 128	7 366
Total Victoria	**158 700**	**−45 217**	. .	**163 441**
Brisbane (a)	58 716	46 098	−2 658	48 491
Moreton (a)	22 620	50 087	20 610	14 559
Wide Bay-Burnett	2 305	12 722	1 744	5 597
Darling Downs	2 378	4 295	−1 152	7 179
Northern	3 966	2 761	−904	8 594
Far North	5 678	7 482	236	9 627
Total Queensland	**101 992**	**125 299**	. .	**114 181**
Adelaide	29 501	−438	3 757	27 995
Outer Adelaide	883	110	5 995	3 071
Total South Australia	**32 858**	**-4 250**	. .	**42 960**
Perth	78 598	12 934	4 603	49 565
South-West	2 569	1 608	9 910	6 125
Total Western Australia	**89 482**	**16 069**	. .	**77 266**
Greater Hobart	3 349	−327	3 808	5 988
Total Tasmania	**6 294**	**126**	. .	**16 021**
Total Northern Territory	**5 949**	**-3 791**	. .	**13 491**
Total ACT	**13 372**	**5 080**	. .	**16 589**
Australia	**651 447**	. .	. .	**657 808**

Note: Based on census counts on a usual residence basis. Excludes children aged less than 5 years at 6 August 1991. Excludes persons whose SLA of usual residence in 1986 was not stated.

(a) Boundary change as of 01-01-91.

Source: ABS 1991 Census of Population and Housing, unpub; ABS various years (3305.2); ABS various years (3306.2); ABS various years (3311.2); ABS various years (3312.3); ABS various years (3306.3).

mechanism of population redistribution within and between regions. Some 43% of the Australian population moved between 1986 and 1991 (Maher 1994). Nationally, there was a strong trend of population movement from the south-east northwards.

The contribution to population growth from interstate migration between 1986 and 1995 was greatest in Queensland and the ACT (see Tables 8.2.5 and 8.2.6). Queensland was in fact the only State or Territory to receive the bulk of its population increase through interstate migration. Western Australia was the only other State to maintain net interstate migration inflows over this period. The bulk of the net interstate migration outflows occurred in New South Wales and Victoria.

The net internal migration loss from New South Wales between 1986 and 1991 was a rise of more than 50% on the loss between 1981 and 1986. Conversely, the net migration loss from South Australia more than halved between 1981–86 and 1986–91 (Bell 1995). Table 8.2.5 shows net interstate migration loss from South Australia to be increasing again over recent years.

At the regional level, net internal migration gains were confined to selected coastal fringe Statistical Divisions, and the smaller metropolitan areas namely Brisbane, Adelaide, Perth and Canberra. By far the largest net gain occurred in south-east Queensland, with the Statistical Division of Moreton experiencing a net internal migration gain of 70,697 persons, followed by Brisbane. Wide Bay-Burnett also experienced substantial net internal gains, though these were considerably lower at 14,466 internal immigrants.

Net gains occurred in all coastal Divisions of New South Wales except for metropolitan Sydney.

These internal migration gains differed from those occurring in Queensland Divisions, in that they were almost exclusively the result of intrastate movements. Net intrastate immigration was also experienced by several inland Divisions of Victoria, the most significant occurring in Loddon-Campaspe, Ovens-Murray, Central Highlands, Goulburn, and the coastal Division of Barwon.

Beyond the south-eastern strip, significant net internal migration gains were experienced by Far North Queensland (primarily through interstate movement), Adelaide and Outer Adelaide, Perth and the South-West Statistical Division, and Greater Hobart.

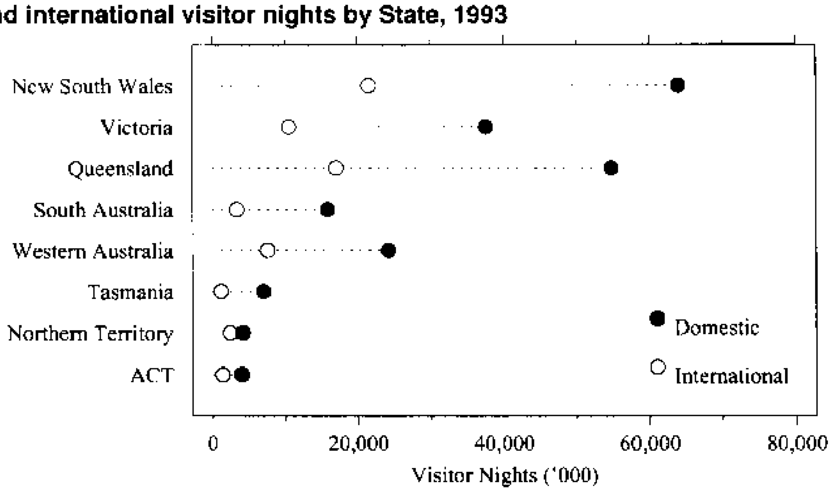
It is apparent from Tables 8.2.5 and 8.2.6 that the major determinant in population growth, for the Statistical Divisions and States experiencing the highest levels of growth, is the net impact of migration to the region, be it overseas, interstate or intrastate.

Non-permanent population flows

Data on permanent population flows do not, however, take into account the impacts of the many short-term residents placing pressure on Australia's natural environment. Table 8.2.8 shows total visitor nights to each of the States/Territories and selected regions over the five year period 1989 to 1993.

Although these regions do not correspond exactly with the Statistical Divisions discussed previously, it is apparent that many of the regions settled by permanent residents are attractive tourist destinations also.

8.2.7 Domestic and international visitor nights by State, 1993



Source: Bureau of Tourism Research, (BTR), Canberra, 1995 a–g.

8.2.8 Total visitor nights by domestic and international visitors, by State and selected regions, 1989–93(a)

	1989			1991			1993		
	Dom	*Int*	*Total*	*Dom*	*Int*	*Total*	*Dom*	*Int*	*Total*
Region	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*
Sydney	15 548	15 832	31 380	16 480	19 080	35 560	16 867	17 543	34 410
Hunter	6 064	492	6 556	5 320	896	6 216	5 660	576	6 236
New South Wales	**68 743**	**19 511**	**88 254**	**64 292**	**23 258**	**87 550**	**63 959**	**21 469**	**85 428**
Melbourne	12 127	7 535	19 662	12 541	9 696	22 237	12 572	8 980	21 552
Victoria	**41 672**	**9 128**	**50 800**	**36 293**	**11 323**	**47 616**	**37 551**	**10 506**	**48 057**
Brisbane	11 694	4 815	16 509	12 619	4 394	17 013	10 926	5 600	16 526
Gold Coast	9 763	2 265	12 028	10 759	3 040	13 799	11 016	3 920	14 936
Sunshine Coast	6 287	548	6 835	7 333	823	8 156	6 467	802	7 269
Far North	5 486	2 702	8 188	6 482	3 284	9 766	6 177	3 326	9 503
Queensland	**55 000**	**13 543**	**68 543**	**58 832**	**15 275**	**74 107**	**54 729**	**17 044**	**71 773**
Adelaide	7 646	2 932	10 578	7 275	2 855	10 130	6 236	2 739	8 975
South Australia	**17 392**	**3 541**	**20 933**	**17 600**	**3 365**	**20 965**	**15 827**	**3 312**	**19 139**
Perth	7 826	5 319	13 145	9 070	5 810	14 880	7 432	6 240	13 672
Western Australia	**25 465**	**6 570**	**32 035**	**24 627**	**7 203**	**31 830**	**24 185**	**7 606**	**31 791**
Hobart	1 748	298	2 046	1 940	424	2 364	2 110	620	2 730
Tasmania	**6 385**	**625**	**7 010**	**6 558**	**1 008**	**7 566**	**7 005**	**1 177**	**8 182**
Darwin	1 706	861	2 567	1 648	682	2 330	1 654	1 100	2 754
Northern Territory	**4 792**	**1 970**	**6 762**	**4 416**	**1 949**	**6 365**	**4 166**	**2 423**	**6 589**
Australian Capital Territory	**4 399**	**1 051**	**5 450**	**3 641**	**1 259**	**4 900**	**3 952**	**1 390**	**5 342**
Australia	**223 849**	**55 899**	**279 748**	**216 259**	**64 645**	**280 904**	**211 373**	**64 931**	**276 304**

(a) Domestic figures are for financial years not calendar years, as for the international figures.
Source: BTR, Canberra. 1995 a–g.

Just over three quarters of the total visitor nights recorded for Australia over this period are attributed to domestic tourism. Over recent years, New South Wales and Queensland have consistently been the most popular destinations for short-term visitors, as they have been for permanent residents also.

Next most popular as a tourist destination were Victoria, Western Australia then South Australia, with ACT and Northern Territory attracting the least numbers.

Outside the capital cities, Queensland was the only State to consistently attract significant numbers of domestic and international visitors to other regions of the State.

The most visited of these regions was the Gold Coast, the popularity of which has been increasing steadily with both domestic and international tourists between 1989 and 1993. Next most popular is the Far North, which, at about 36%, boasts a slightly higher proportion of international visitors than other areas.

8.2.9 Population projections by various assumptions

	A/B: Medium fertility, low overseas migration		C: High fertility, low overseas migration		D: Medium fertility, high overseas migration		Medium fertility, no overseas migration		High fertility, no overseas migration	
	Population	Annual growth rate (a)	Population	Annual growth rate (a)	Population	Annual growth rate (a)	Population	Annual growth rate (a)	Population	Annual growth rate (a)
Year	'000	%	'000	%	'000	%	'000	%	'000	%
1993	17 661.5	. .	17 661.5	. .	17 661.5	. .	17 661.5	. .	17 661.5	. .
2001	19 169.5	1.03	19 295.8	1.11	19 310.6	1.12	18 676.6	0.70	18 799.7	0.78
2011	20 952.4	0.89	21 376.0	1.03	21 452.2	1.06	19 583.8	0.48	19 981.7	0.61
2021	22 528.0	0.73	23 281.2	0.86	23 428.1	0.89	20 178.3	0.30	20 867.6	0.44
2031	23 874.0	0.58	25 093.5	0.75	25 212.6	0.74	20 459.1	0.14	21 555.4	0.33
2041	24 858.4	0.41	26 679.1	0.62	26 666.6	0.56	20 304.0	-0.08	21 910.3	0.16

(a) Average annual growth rate for period ending calculated using exponential rates of growth.
Source: ABS 1994 (3222.0).

Population and age projections

Australia's population growth rate is projected to fall to 0.6% or lower by the year 2041. In the early 1930s the growth rate was about 0.7%. At the projected growth rates reported in Table 8.2.5, Australia's population would increase to between 19.2 million and 19.3 million by 2001; 22.5 to 23.4 million in 2021; up to 26.7 million in 2041, depending on levels of fertility and overseas migration.

With the slowing of the growth rate there is a concomitant ageing of the population. Table 8.2.10 shows that the median age was 33.0 years in 1993, projected to increase to around 38 years in 2011, and up to between 39.4 and 41.8 years in 2041.

By 2041, South Australia and Tasmania are projected to have the oldest populations, with the median age lying between 42.2 and 44.8, and 41.9 and 46.8 years respectively.

The median population age of most other States is projected to be around three to four years younger than in South Australia and Tasmania, with the exception of the Northern Territory and the ACT, with median ages significantly lower again (see Table 8.2.10).

Population projections by State

Table 8.2.11 shows projections of populations and population growth rates for Australia and the States/Territories for 1993–2011 and 2011–2041. These figures show each State experiencing a decline in its rates of growth over this projection period. Each State, however, with the possible exception of Tasmania, is projected to experience an overall population increase.

8.2.10 Median age projections under various assumptions by State, 2011 and 2041

		2011				2041			
	1993	A(a)	B(b)	C(c)	D(d)	A(a)	B(b)	C(c)	D(d)
State/ Territory	Years	Years	Years	Years	Years	Years	Years	Years	Years
NSW	33.5	38.3	38.1	37.5	37.9	41.7	41.5	39.2	41.0
Vic.	33.2	38.5	38.3	37.8	38.2	42.6	42.1	40.0	41.9
Qld	32.4	37.3	37.6	36.6	37.1	41.2	41.8	39.1	41.0
SA	34.3	39.9	39.8	39.3	39.7	44.8	44.4	42.2	44.3
WA	32.3	37.1	37.3	36.4	36.8	41.0	41.3	38.7	40.6
Tas.	33.2	39.3	40.0	38.6	39.2	45.0	46.8	41.9	44.7
NT	27.6	31.5	31.6	30.6	31.5	34.8	35.0	32.4	34.8
ACT	30.0	34.6	35.0	34.0	34.5	39.1	39.7	37.2	38.9
Australia	**33.0**	**38.0**	**38.0**	**37.3**	**37.7**	**41.8**	**41.8**	**39.4**	**41.3**

(a) Medium level fertility; low level overseas migration; high interstate migration.
(b) Medium level fertility; low level overseas migration; low level interstate migration.
(c) High level fertility; low level overseas migration; high level interstate migration.
(d) Medium level fertility; high level overseas migration; high level interstate migration.
Source: ABS 1994 (3222.0).

8.2.11 Population projections under various assumptions by State, 2011 and 2041

		Medium fertility; low overseas & high interstate migration.		*Medium fertility; low overseas & interstate migration*		*High fertility; low overseas & high interstate migration*		*Medium fertility; high overseas & interstate migration*	
	Population 1993	*Population 2011*	*Growth rate (a)*	*Population 2011*	*Growth rate (a)*	*Population 2011*	*Growth rate (a)*	*Population 2011*	*Growth rate (a)*
State	*'000*	*'000*	*%*	*'000*	*%*	*'000*	*%*	*'000*	*%*
NSW	6 008.8	6 916.4	0.78	7 018.2	0.87	7 058.4	0.90	7 131.8	0.96
Vic.	4 462.1	4 934.4	0.56	5 024.5	0.66	5 035.4	0.67	5 064.3	0.71
Qld	3 112.6	4 242.2	1.74	4 128.1	1.58	4 324.9	1.84	4 311.5	1.83
SA	1 461.7	1 580.3	0.43	1 600.3	0.50	1 609.2	0.54	1 602.7	0.51
WA	1 677.6	2 138.7	1.36	2 092.7	1.24	2 182.3	1.47	2 190.8	1.49
Tas.	471.7	520.5	0.55	499.4	0.32	531.1	0.66	522.9	0.57
NT	168.3	221.3	1.53	210.6	1.25	227.5	1.69	224.0	1.60
ACT	298.9	398.5	1.61	378.6	1.32	407.2	1.73	404.2	1.69
Australia	**17 661.5**	**20 952.4**	**0.95**	**20 952.4**	**0.95**	**21 376.0**	**1.07**	**21 452.2**	**1.09**
		Population 2041	*Growth rate (b)*	*Population 2041*	*Growth rate (b)*	*Population 2041*	*Growth rate (b)*	*Population 2041*	*Growth rate (b)*
State		*'000*	*%*	*'000*	*%*	*'000*	*%*	*'000*	*%*
NSW		7 941.4	0.46	8 260.4	0.54	8 549.8	0.64	8 728.9	0.68
Vic.		5 282.2	0.23	5 636.8	0.38	5 688.8	0.41	5 750.8	0.42
Qld		5 853.8	1.08	5 419.3	0.91	6 237.4	1.23	6 101.2	1.16
SA		1 622.3	0.09	1 683.8	0.17	1 736.4	0.25	1 701.3	0.20
WA		2 786.2	0.89	2 651.4	0.79	2 983.0	1.05	2 973.5	1.02
Tas.		537.7	0.11	471.2	−0.19	581.1	0.30	546.4	0.15
NT		294.9	0.96	260.6	0.71	325.3	1.20	304.3	1.03
ACT		540.0	1.02	474.9	0.76	577.6	1.17	560.3	1.09
Australia		**24 858.4**	**0.57**	**24 858.4**	**0.57**	**26 679.1**	**0.74**	**26 666.6**	**0.73**

(a) Average annual growth rate 1993–2011.
(b) Average annual growth rate 2011–2041.
Source: ABS 1994 (3222.0).

Queensland is the most rapidly growing State, and is projected to overtake Victoria as the second most populous State by 2041, under various assumptions. With a projected population of 6.2 million under an assumption of high fertility, low overseas and high interstate migration, Queensland is the only State the population of which may double over this period (1993–2041).

8.2.12 Population projection for non-metropolitan coastal zone, by State, 2005

	Proportion of population in non-met coastal zone		*Change, 1990–2005*
	1990	*2005*	
State/Territory	*%*	*%*	*%*
NSW	22	24	2
Vic.	13	15	2
Qld	45	49	4
SA	13	11	−2
WA	32	34	2
Tas.	42	43	1
NT	68	65	−3

Source: Resource Assessment Commission 1993, p. 42.

Western Australia, Northern Territory and the ACT are projected to experience the next highest rates of growth over this period, with New South Wales, Victoria, South Australia and Tasmania projected to show a loss in the share of the national population living in these States.

Even so, regional projections suggest that most States, including New South Wales, Victoria and Tasmania, will experience an increase in the non-metropolitan coastal zone between 1990 and 2005 (Table 8.2.12).

The population pressures being placed on certain coastal areas have been highlighted in Section 8.1. If growth occurs rapidly there is a danger of inadequate infrastructure and environmental protection measures being put in place.

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Chapter 9 — Pressures from Individuals on the Environment

With the overview of the Australian population established in Chapter 8, this Chapter links the Population stock in the PEP model to the stock of Natural Assets. It presents statistics which indicate some of the pressures which are exerted on the natural environment by the human population, in the forms of:

- consumption patterns (Section 9.1);
- waste generation by households (Section 9.2);
- the introduction of non-native species (Section 9.3); and
- pressures from recreational and tourist activities (Section 9.4).

The impacts of the economy on the environment are explored in Chapter 12.

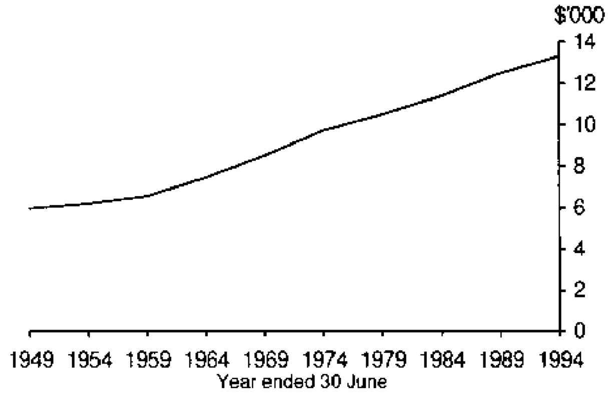
9.1 Consumption patterns

Introduction

Household consumption levels are often used as an indicator of the standard of living enjoyed by a nation. However, the level of consumption of goods and services also has implications for the environment, in relation to depletion of natural resources and generation of wastes and pollutants.

Since 1949 private final consumption expenditure (PFCE) per person has more than doubled, from $5,900 in 1949 to $13,300 in 1994 (at average 1989–90 prices) (see Figure 9.1.1).

9.1.1 Private final consumption expenditure per capita (a)



(a) At average 1989–90 prices.
Source: ABS 1994 (5204.0); ABS 1995 (3101.0).

At $US9,700 per capita, Australian PFCE in 1992 was less than two thirds that of the USA. It was also lower than that of Canada, Japan, the UK and the more heavily industrialised countries of Europe, but higher than for the Scandinavian countries and New Zealand (see Table 9.1.2).

The remainder of this section looks at some specific areas of consumption in Australia: housing; household energy consumption; passenger vehicles and fuel consumption; and apparent consumption of foodstuffs and nutrients. Consumption data are also presented in Sections 2.1 (pesticides); 3.1 and 6.2 (fish); 6.3 (wildlife); 6.4. (agricultural products); 6.5 (water); 6.8 (energy) and 12.1.2 (emissions to air e.g. greenhouse gas emissions).

The Organisation for Economic Co-operation and Development (OECD) and United Nations Commission for Sustainable Development, have identified the issue of consumption patterns as very important and strategic concerning policies about environmental issues. Various frameworks are being researched to compile information on this issue. the system of National Accounts is a framework for financial transactions about consumption and production, the Australian State of the Environment 1996 report introduces the concepts of metabolism model for human settlements (on which the report elaborates) ecological footprint. The final part of this section provides some information about the ecological footprint approach.

Housing

Since 1947 the number of dwellings has more than trebled, from 2 million in 1947 to 6.7 million in 1994. During this period the average number of persons per dwelling has declined from 3.9 to 2.7 (ABS 1995, 4102.0, p. 133); see also Figure 8.1.16, which showed that between 1911 and 1991 the number of people per dwelling nearly halved.

Housing size has increased. The proportion of dwellings with 4 or more bedrooms has increased from 13% in 1971 to 23% in 1994. In the same period the proportion of dwellings with one or less bedrooms has declined from 9.6% to 6.6%. Between 1984 and 1994 the average size of newly constructed private houses has increased 15% to

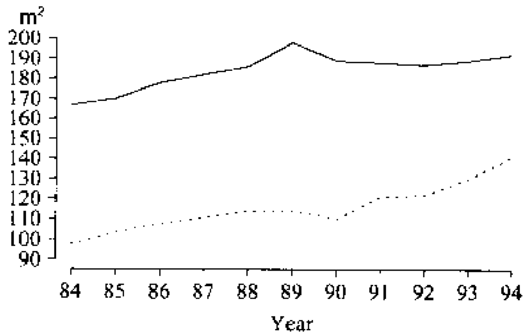
9.1.2 Private final consumption expenditure for selected OECD countries, 1992

	US$ 000/capita	US$ Billion (a)
USA	15.2	3 867
Canada	11.0	302
Germany (b)	11.0	713
Italy	11.0	635
France	10.9	627
Japan	10.3	1 275
Netherlands	10.2	155
UK	10.0	579
Australia	**9.7**	**169**
Denmark	8.8	46
Sweden	8.5	74
New Zealand	8.4	29
Norway	8.0	34
OECD (b)	**10.7**	**9 077**

(a) Per capita values are presented for the most recent year in billion US$ at purchasing power parity (PPPs). PPPs are defined as the ratio between the amount of national currency and the amount of a reference currency needed to buy the same bundle of consumption goods in the two countries.
(b) Data including the Federal Republic of Germany.

Source: OECD 1994.

9.1.3 Average size of newly constructed houses



Source: ABS 1995 (4102.0).

192 square metres, while the size of new public sector houses has increased by 44% to 141 square metres (see Figure 9.1.3).

The materials used in the outer walls and roofs, as well as the use of insulation, can have a significant effect on the amount of energy needed to heat or cool a house. The majority of Australian dwellings (65%) have outer walls made from brick, 16% have timber outer walls while 8% have outer walls made of fibro-cement. Most new dwellings constructed in Australia have single brick outer walls. Of new dwellings approved in 1993–94, 68% had outer walls of single brick and 20% had double brick outer walls (ABS 1995, 4181.0).

In 1994, half of all dwellings in Australia had roof insulation, 18% had wall insulation and 15% had both (see Table 9.1.4). There were wide variations across States and Territories, with Queensland and the Northern Territory having the lowest rates of roof insulation. They also had relatively low rates of wall insulation. This may be related to their warmer climates, but climate does not explain the particularly low rate of wall insulation in Western Australia. Average age of housing stock and the presence or absence of State legislation governing insulation in new houses could also contribute to variations between different regions of Australia.

Energy consumption

Residential energy consumption in Australia has increased by 16% in the last twenty years, from 17 to 19.6 gigajoules (GJ) per capita, and is projected to increase to 21.6 GJ per capita by 2009–10.

However, as a proportion of total energy use, residential consumption has declined slightly from 8.8% in 1973–74 to 8.4% in 1993–94 (see Table 9.1.5).

9.1.4 Insulation of dwellings, 1994

State	Walls only %	Roof only %	Walls and roof %	Total walls %	Total roof %	No insulation %	Not known %	Total '000
NSW	2.8	34.2	11.3	14.2	45.6	32.7	18.9	2 237.2
Vic.	1.6	43.2	25.4	27.0	68.5	14.9	15.0	1 657.6
Qld	5.5	16.8	8.2	13.7	25.0	46.6	22.9	1 194.1
SA	1.9	47.4	19.6	21.5	66.9	15.2	15.9	587.9
WA	1.1	47.7	5.3	6.5	53.0	31.9	14.0	640.7
Tas.	5.5	38.8	17.3	22.9	56.1	24.9	13.4	183.3
NT	* *	22.6	*9.0	10.7	31.6	28.4	38.3	66.5
ACT	* 1.6	52.7	22.1	23.7	74.8	9.3	14.3	110.6
Australia	**2.8**	**36.1**	**14.7**	**17.5**	**50.8**	**28.5**	**17.9**	**6 677.9**

Source: ABS 1995 (4181.0).

9.1.5 Residential energy consumption in Australia

	Energy consumption per capita	Total residential consumption	Proportion of total energy consumption
	GJ	PJ	%
1973–74	16.9	231.3	8.8
1993–94	19.6	349.3	8.4
2009–10(a)	21.6	459.7	8.3

(a) Projected.
Source: ABARE 1995.

Electricity is the main source of energy used in Australian households, accounting for 42.5% of total residential energy use in 1993–94 (see Table 9.1.6). A quarter of all electricity used in Australia is for residential purposes. The majority of wood and heating oil and practically all of the solar energy used in Australia are for residential purposes (see Table 9.1.7).

In 1993–94 wood and wood waste accounted for 23.4% of total residential energy use, down from 32.3% in 1973–74. Over the same period, the use of heating oil and coal has declined sharply, while electricity and natural gas have increased, as a proportion of total residential energy use. Use of solar energy has also increased but represented less than 1% of total residential energy use in 1993–94 (see Table 9.1.6).

In 1994, an estimated 306,900 or 5% of Australian households used solar energy as their main source of fuel to heat water, 31% used mains gas, while 61% used electricity.

Electricity was also the most popular choice for space heating. 37% of households used electricity as the main source of fuel to heat their dwelling, 29% used mains gas; and 17% wood or coal. Only 3% of households used oil as their main source of fuel for space heating (see Table 9.1.8).

9.1.6 Residential energy consumption

	1973–74	1993–94	2009–10 (a)
Fuel type	%	%	%
Electricity	30.7	42.5	44.6
Natural gas	10.2	28.3	35.2
Wood and wood waste	32.3	23.4	15.4
Heating oil	11.7	1.1	0.4
Solar	0.0	0.7	1.0
Other	15.1 (b)	4.1	3.3
Total	**100.0**	**100.0**	**100.0**

Note: percentages may not add due to rounding.
(a) Projected.
(b) Mainly coal and coal products.
Source: ABARE 1995.

9.1.7 Residential energy consumption in Australia for selected fuel types, 1993–94

	Residential consumption	Residential as a proportion of total consumption
Fuel type	PJ	%
Electricity	148.3	24.6
Natural gas	98.7	13.5
Wood and wood waste	81.6	76.2
Heating oil	3.9	83.0
Solar	2.4	100.0

Source: ABARE 1995.

Passenger vehicles and fuel consumption

In 1995 there were 8.4 million registered passenger vehicles, almost one car for every two people. The level of new vehicle registrations declined between 1985 and 1988 then stabilised at around 25 per 1,000 of the population up until 1993. In 1995 the level had increased to almost 29 per 1,000 of the population (see Table 9.1.9).

While some passenger vehicles are used for business, most use is for private purposes. In the year ended September 1991, 52% of the total 114,286 million kilometres travelled by passenger vehicles was for private discretionary purposes, while 25% of the total distance travelled was to and from work (ABS 1993, 9208.0).

9.1.8 Main sources of heating fuel used by Australian households, 1994

	Number of dwellings	Proportion of dwellings
Purpose/source	'000	%
To heat dwelling		
Electricity	2 457.8	36.8
Mains gas	1 917.0	28.7
Wood/coal	1 122.1	16.8
Oil	190.0	2.8
Bottled gas	212.2	3.2
Other	106.1	1.6
No heating	672.7	10.1
To heat water		
Electricity	4 044.8	60.6
Mains gas	2 055.9	30.8
Solar	306.9	4.6
Other	270.3	4.0
Total	**6 677.9**	**100.0**

Source: ABS 1995 (4181.0).

9.1.9 Passenger vehicles (a) in Australia

	Registered passenger vehicles (b)		*New passenger vehicles (c)*	
Year	*'000*	*per 1 000 population*	*'000*	*per 1 000 population*
1982	6 233.4	409.0	453.5	29.7
1985	6 734.2	426.0	510.9	32.6
1988	7 158.8	431.0	384.2	23.5
1991 (d)	7 861.5	453.0	430.9	25.0
1993 (d)	8 280.2	470.0	449.8	25.7
1995 (d)	8 391.5	591.0	528.5	28.6

(a) Motor cars and station wagons.
(b) Yearly basis as at 30 September or 30 June after 1991.
(c) For the financial year.
(d) Passenger forward control vehicles with less than 10 seats now included.
Source: ABS (9304.0) various years; ABS (9309.0) various years.

The vast majority of Australians travel to work by car, mostly alone. At the 1991 Census, 65% of Australian workers drove to work and a further 10% travelled to work by car as a passenger. Only 12.5% used public transport (see Table 9.1.10). Since the 1981 Census, the proportion of workers going to work on public transport or as a passenger in a car has declined while the proportion driving a car to work has increased.

In 1991 passenger vehicles travelled an average of 14,300 km per vehicle. This represents a break in the rising trend between 1979 and 1988, when the average rose from 15,100 km to 15,800 (Table 9.1.11).

On the other hand, the average fuel consumption rate in 1991 (12.3 litres per 100 km), represented a small rise, as against a falling trend between 1979 and 1988.

9.1.10 Method of travel to work, Australia, Census 1991

Method of travel (a)	*Number of people (b)*	*Proportion of people*	*Change 1981–91*
	'000	*%*	*%*
Train	372.1	6.3	– 4.7
Bus	310.5	5.3	– 16.9
Ferry / tram	50.3	0.9	– 32.5
Taxi	28.9	0.5	– 20.8
Car, as driver	3 827.4	65.3	16.1
Car, as passenger	573.6	9.8	– 6.7
Motor bike	63.0	1.1	– 33.9
Bicycle	92.5	1.6	13.9
Walked only	336.1	5.7	– 0.2
Other	86.6	1.5	. .
Worked at home	376.4	6.4	– 14.3
Total	**6 168.9**	**100.0**	**4.5**

(a) People may have more than one mode of transport. Therefore components do not add to totals.
Source: ABS 1992 (2821.0).

9.1.11 Passenger vehicles: distance travelled and fuel consumption, Australia

Year	*Average distance travelled* '000 km	*Average fuel consumption* litres/100km	*Total fuel consumed* million litres
1976 (a)	15.4	12.6	9 873.2
1979 (a)	15.1	12.7	10 727.0
1982 (a)	15.3	12.5	12 046.1
1985	15.5	12.1	12 916.6
1988	15.8	11.9	13 893.8
1991	14.3	12.3	14 035.5

(a) Excludes Commonwealth owned vehicles.
Source: ABS 1993 (9208.0).

Consumption of food and nutrients

Australia has a varied and abundant food supply. In 1992–93 nutrients available for consumption exceeded the recommended daily intake in all main categories, by margins ranging from 2% for calcium to 224% for vitamin C. On average, Australians were estimated to have consumed 12,986 kilojoules of energy per person per day, 40% more than the recommended daily intake (Table 9.1.12).

As Table 9.1.13 indicates, in 1992–93 Australians consumed 2.5 million tonnes of vegetables, 2.2 million tonnes of fruit, 1.8 million tonnes of meat and poultry, 1 million tonnes of bread and 0.9 million tonnes of sugar.

Since 1948–49 consumption patterns have changed. Apparent consumption of meat has declined to an average of 77 kg per person per year; consumption of grain products (including bread) has declined to 90.5 kg per person per year; consumption of sugars has declined to 50.7 kg and consumption of eggs has also declined to an average of 151 eggs per person per year.

9.1.12 Nutrients available for consumption in Australia compared with daily recommended dietary intakes (RDI), 1992–93

Nutrient	*Unit*	*RDI*	*Available*	*In excess of RDI* %
Protein	g	45.8	99.7	118
Calcium	mg	838.0	856.0	2
Iron	mg	9.2	12.7	39
Retinol equivalent	μg	686.0	2 178.0	218
Vitamin C	mg	34.0	109.0	224
Thiamin	mg	0.9	1.8	100
Riboflavin	mg	1.4	2.4	74
Niacin equivalent	mg	15.2	42.4	179
Energy	kJ	9 284.0	12 986.0	40

Source: ABS 1993 (4306.0).

9.1.13 Annual apparent consumption of selected foodstuffs

	Average 3 years ended						
	1948–49	*1958–59*	*1968–69*	*1978–79*	*1988–89*	*1992–93*	*1992–93*
Foodstuffs	*kg/capita*	*kg/capita*	*kg/capita*	*kg/capita*	*kg/capita*	*kg/capita*	*'000 tonnes*
Meat and meat products	103.0	112.4	98.8	102.0	82.8	77.0	1 353.6
Poultry	na	na	8.3	17.1	24.1	26.5	465.7
Seafood	4.1	4.5	5.6	6.4	8.3	9.7	170.5
Dairy products	22.3	22.1	25.4	22.1	23.8	23.1	405.5
Fruit and fruit products	80.9	72.2	86.5	91.0	111.6	122.8	2 159.5
Vegetables	129.7	117.1	124.3	122.5	148.1	145.3	2 554.2
Grain products	98.6	na	86.8	79.9	86.5	90.5	1 591.6
Bread	64.0	69.1	59.5	47.7	49.6	54.4	956.0
Nuts	6.0	6.5	8.6	5.0	5.6	5.4	94.8
Oils and fats	14.0	na	14.3	21.6	20.4	19.0	334.9
Sugars	56.8	53.0	51.9	54.5	48.3	50.7	891.9
	No./capita	*No./capita*	*No./capita*	*No./capita*	*No./capita*	*No./capita*	*'000 dozen*
Eggs and egg products (a)	255	206	222	220	146	151	220 621

(a) Equivalent number of eggs.
Source: ABS 1993 (4306.0).

Consumption of fruit and vegetables has increased. In 1992–93 Australians consumed an average of 145 kg of vegetables and 123 kg of fruit per person. Consumption of seafood has more than doubled, but remains a relatively small part of the Australian diet at 9.7 kg per person per year. Consumption of dairy products has remained fairly constant and was estimated to be 23 kg per person for 1992–93.

Human ecological footprint

This concept has been developed principally by a Canadian academic, William Rees as a way of aggregating a number of consumption indicators and expressing the result in a way that would be readily understood. Much of the research in the past has focused on what population or level of economic activity a particular region can support sustainably. However research undertaken by Rees 1992, and Rees and Wackernagel 1994 (cited in Simpson et al 1995) ask "how large an area of productive land is needed to sustain a defined population or economy indefinitely?" The theory is that as "most forms of natural income (resource and service flows) are produced by terrestrial ecosystems and associated water bodies" (with the exception of the ozone layer and hydrologic cycle both of which are purely physical forms of natural capital), estimations can be made of the area of land and water required to produce sustainably the quantity of any resource or ecological service used by a defined population or economy at a given level of technology. This area is referred to as the "ecological footprint" and defined as "the total area of productive land and water required to produce on a continuous basis all the resources consumed and to assimilate all the wastes produced by a defined population, wherever on Earth that land is located" (Rees 1995).

For example, large urban areas consume huge quantities of energy (electricity, gas etc), food (often transported long distances), materials (building and technological goods), land (for buildings and recreation) and water. At the same time these urban areas generate large amounts of waste (atmospheric, chemical, water borne, solid and organic). The aim of the 'ecological footprint' is to define how much land is required to support the region's population indefinitely at a given material standard (Rees 1992 cited in Simpson et al. 1995).

To calculate the total area of land required, five consumption categories are used:

- food;
- housing;
- transportation;
- consumer goods; and
- embodied resources in services received.

9.1.14 'Ecological footprints' for Australia per capita (a)

	Energy	*Built environment*	*Agricultural land (garden, crop, pasture)*	*Forest*	*Total*
	ha	*ha*	*ha*	*ha*	*ha*
Food	0.3	. .	1.1–1.4	. .	1.4–1.7
Housing	0.3	0.1 (b)	. .	0.4 (b)	0.8
Transport	0.9	0.1 (b)	. .	. .	1.0
Consumer goods	0.3	. .	0.2 (b)	0.2 (b)	0.7
Resources in Services	0.2	. .	. .	. .	0.2
Total	**2.0**	**0.2**	**1.3–1.6**	**0.6**	**4.1–4.4**

(a) This is a simplified version of the Land-Use-Consumption Matrix.
(b) From Canada, used as being representative of Australia.
Source: Simpson et al. 1995.

A number of land-use categories are also considered:

- fossil energy (non-renewable resources);
- built environment;
- gardens (includes land used for growing fruit and vegetables);
- crop land;
- pasture; and
- managed forest.

The consumption categories combine with land-use categories to form a Land-Use-Consumption Matrix, in which consumption data are expressed in hectares per capita. Energy is converted to land area on the (Canadian) assumption that one hectare of typical forest can assimilate 1.8 tonnes of carbon per year, which is equivalent to emissions produced by the consumption of 100 gigajoules of fossil fuel (Petroeschevsky A. 1996, pers comm.).

Research by Simpson et al (1995) produced estimates of the 'ecological footprints' for Australia, in terms of various broad consumption categories and in total (see Table 9.1.14). The authors state that their results are preliminary and that some of the calculations are currently based on Canadian assumptions due to the difficulty in obtaining data and the nature of the data collected. Table 9.1.14 indicates that for Australia 4.1 to 4.4 hectares of ecologically productive land are needed per person to sustain the population's standard of living. Similar research (see Table 9.1.15) showed that 4.3 hectares per person for Canada and 5.1 hectares per person for the USA. It should be noted that research in Canada has shown that these estimates are not uniform across socio-economic groups ranging from 2.6 hectares per person to 12 hectares per person) (Boothroyd et al. 1994, cited in Simpson et al. 1995).

9.1.15 Comparison of consumption per capita for selected countries, 1991

	Annual consumption						
	CO_2 emission	*Purchasing power*	*Paper consumption*	*Fossil energy use*	*Freshwater withdrawal*	*Ecological Footprint*	*Vehicles per 100 persons*
	Tonnes	*$US*	*Kg*	*GJ*	*m^3*	*Ha*	*No.*
Australia	15.5 (a)	na	156	215 (b)	1 306 (c)	4.4	58
Canada	15.2	19 320	247	241	1 688	4.3	46
USA	19.5	22 130	317	287	1 868	5.1	57
India	0.8	1 150	2	5	612	0.4	0

(a) Data as at 1989.
(b) Data as at 1990.
(c) Data as at 1975.
Source: Wackernagel & Rees 1995 quoted in Simpson et al. 1995.

The calculations for such tables are made under the following assumptions:

- current farming and forestry practices are assumed to be sustainable;
- only fossil energy is considered when calculating commercial energy consumption;
- appropriated water areas are not included;
- land used for, or damaged by, the absorption of waste is neglected; and
- only land which is biologically productive is considered.

On the basis of these assumptions, the true 'ecological footprint' is probably underestimated (Simpson et al. 1995). Also there are no allowances for potentially large efficiency gains or technological advances, though Rees and Wackernagel (1994) suggest that there is no guarantee that such advances will decrease consumption.

Table 9.1.15 compares the average consumption per capita in Canada, USA and India, with estimates for Australia. The estimates for India of 0.4 hectares per person indicates that a lot less is consumed and therefore imported. This table shows similar patterns of resource use by Australia, Canada and the USA.

In 1994, Rees and Wackernagel predicted that the minimal food-land requirements for the growth in the world's population each year (about 94 million) would require the equivalent of all the cropland in France (at 5 people per hectare, the current average productivity of world agriculture).

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9.2 Waste generation

There is an Australian and New Zealand Environment and Conservation Council (ANZECC) endorsed classification system of wastes which includes:

- municipal waste;
- commercial and industrial waste; and
- building and demolition waste.

The framework used in this publication, however, differs from the above classification system as this section deals specifically with waste generated by people in their capacity as private individuals. This includes household solid waste and personal litter. Information about other waste is contained in Sections 12.1.3 and 12.1.4.

Household solid waste

Estimates of the amount of household solid waste generated in Australia are generally based on the amounts collected at kerbside by, or under contract to, local government councils. As such they exclude waste which is stored, recycled, re-used, buried or burnt by the householder on the premises. They also exclude waste transported by householders or private collection agents to tips or recycling collection points, and household waste which has been dumped illegally.

Based on local council waste collection and disposal data in 1989 (see Table 9.2.1), it was estimated that private households generate about half of the total volume of solid waste in Australia. More recent data, collected for the Australian Waste Database (AWD), suggests that households generate about 40% of urban solid waste (Moore, S. 1996, pers comm.).

In 1989 councils collected an average of 370 kg of household waste per person in Australia. Waste collected in most State capitals ranged between 300 and 350 kg per person. In the Hobart region councils collected 577 kg of household waste per person, the highest rate in Australia, compared to a low of 136 kg in the ACT (see Table 9.2.1).

9.2.1 Household waste (a) collected by councils, 1989

	Household waste per person	*Household contribution to total waste disposed of by councils*
Region (b)	*kg*	*%*
Sydney	354	42
Melbourne	338	52
Brisbane	303	28
Adelaide	307	73
Perth	345	53
Hobart	577	86
Canberra	136	11
NT	312	34
Capital cities (b)	336	44
Other regions	427	53
Australia	**370**	**48**

(a) Household wastes data collected in this 1989 survey are not necessarily compatible with the ANZECC classification system shown in 9.2.2.
(b) Capital city regions for this collection based on Local Government Areas, and are slightly larger than Capital City Statistical Divisions. Excludes Darwin.
Source: Industry Commission 1991.

The contribution of household waste to the total solid waste disposed of by councils also varied markedly by region, from 86% in Hobart to 11% in the ACT. In addition to the different amounts of household waste collected, regional differences in the contribution of household waste to total waste disposed of by councils are influenced by differences in the amounts of self-carry, industrial and builders' waste disposed of. For example, the very low rate in the ACT (11%) was influenced not only by relatively small amounts of household waste collected, but also by relatively high amounts of builders' waste disposed of.

Table 9.2.2 shows the volume of domestic waste system which was collected in Sydney during 1994. Of this waste, 79% was disposed of

9.2.2 Sydney quarterly waste disposal, 1994

Description	Disposal route	*Jan.–Mar.*	*Apr.–Jun.*	*Jul.–Sep.*	*Oct.–Dec.*	*Total*
		tonnes	*tonnes*	*tonnes*	*tonnes*	*tonnes*
Domestic	Recycling	46 665	44 185	45 161	52 846	188 857
Domestic	Incineration	30 465	29 809	27 079	27 754	115 107
Domestic	Landfill	242 545	224 732	213 124	235 955	916 356
Other domestic	Landfill	65 291	50 272	44 102	53 294	212 959

Source: AWD 1996.

9.2.3 Domestic waste stream for the City of Mitcham, Adelaide, October and November 1995

		Annual waste generation	
		Per capita	Per household
Material type	Includes	kg	kg
Ferrous metal	Steel cans, white goods, packaging etc.	11.1	28.3
Glass	Jars, bottles, plate glass, etc.	23.9	61.1
Household hazardous	Paint, dry cell batteries, car batteries, fluorescent globes, etc.	1.9	4.9
Non-ferrous	Aluminium packaging, aluminium cans, copper brass, etc.	3.1	8.0
Organic compostable	Garden, Food/kitchen, other compostables.	178.5	456.0
Other	Ceramics (bricks tiles etc), dust, dirt, rock, soil, ash, etc.	10.2	26.1
Other organic	Textiles, wood, leather, rubber, oils.	9.5	24.3
Paper	Newspaper, writing paper, packaging, cardboard, milk cartons, etc.	91.2	233.0
Plastics	PET, HDPE, LDPE, plastic bags. polypropylene, polystyrene, etc.	25.1	64.1

Note: Survey of 302 households over 10 day period. Mitcham, in inner south Adelaide comprises 62,636 residents (using ABS 1994 data) and 24,600 households.
Source: City of Mitcham 1995.

to landfill, 8% was incinerated and 13% recycled (EPA, 1994). A study undertaken in the City of Mitcham (see Table 9.2.3) over a ten day period in October and November 1995, found that the estimated annual waste produced per capita is 354.5 kg. This consisted of 319.4 kg of garbage and 35.1 kg of recyclables. Each household produced an average of 17.4 kg of waste per week of which 15.7kg entered the garbage stream and 1.7kg the recycling stream.

Studies of the composition of household waste since the 1970s (Table 9.2.4) show that putrescibles (food scraps and garden waste) account for about half of the total weight. Paper accounts for about a quarter. Since the mid 1980s the proportion of glass and metal waste has declined and that of plastics has slightly increased. This may be a reflection of changes in packaging, particularly the substitution of lightweight plastic for glass and steel beverage containers. However, the recycling behaviours of householders may also be a factor, with more glass being taken to local recycling collection centres.

Product packaging and provisions for waste collection and recycling can vary considerably over time and between different parts of Australia. These differences may account for some of the differences observed in the composition of household waste as illustrated in Table 9.2.4.

Studies of household waste in Melbourne (see Table 9.2.5), show that the amount of glass packaging material found in regular kerbside collections in 1990–91 (0.31 kg per person per week) was less than half the amount collected in 1980–81 (0.69 kg per person per week). The amount of steel packaging has almost halved during the period while the amount of plastic

9.2.4 Household waste: composition by weight

		Putrescibles	Paper	Glass	Metals	Plastics	Other	Total
Metropolitan region	Year	%	%	%	%	%	%	%
Sydney	1973	34	38	13	9	3	4	100
Melbourne	1975	45	26	15	8	3	3	100
Melbourne	1985	43	21	16	6	10	4	100
Adelaide	1986	40	27	13	6	9	5	100
Sydney	1989	48	21	9	6	8	8	100
Brisbane	1989	42	30	7	6	12	3	100
Perth	1989	56	23	7	4	9	2	100
ACT	1989	44	19	14	5	10	7	100
Melbourne	1990	51	24	7	4	8	6	100
Adelaide	1991	47	24	8	5	7	9	100
Perth	1991	55	24	7	3	2	9	100

Source: DITC 1990, for 1973–1989; EPA Victoria 1991, for Melbourne 1990; EPA South Australia 1993, for Adelaide 1991; EPA Western Australia 1992, for Perth 1991.

9.2.5 Household waste per person per week, Melbourne selected years

	1980–81	1984–85	1990–91	1980–81	1984–85	1990–91
Type of waste	*kg*	*kg*	*kg*	*%*	*%*	*%*
Packaging						
Glass	0.69	0.58	0.31	17.5	15.5	6.6
Aluminium	0.02	0.02	0.03	0.5	0.5	0.6
Steel	0.22	0.17	0.13	5.6	4.6	2.8
Plastic	0.17	0.29	0.32	4.3	7.8	6.8
Paper	0.28	0.21	0.24	7.1	5.6	5.1
Total packaging	**1.38**	**1.27**	**1.03**	**34.9**	**34**	**21.9**
Other paper	0.50	0.57	0.88	12.7	15.3	18.7
Food	1.63	1.35	1.47	41.3	36.2	31.3
Garden	0.23	0.25	0.94	5.8	6.7	20.0
Other	0.21	0.29	0.38	5.3	7.8	8.1
Total	**3.95**	**3.73**	**4.70**	**100.0**	**100.0**	**100.0**

Source: EPA Victoria 1991.

packaging has almost doubled to 0.32 kg per person per week in 1990–91 (see Table 9.2.4).

Overall, the amount of packaging fell between 1980–81 and 1990–91, accounting for 22% of the total weight of household waste or 1.03 kg per person per week in 1990–91.

The total amount of household waste has increased, particularly garden waste and paper. Much of the increase in paper waste shown in Table 9.2.5 may be related to the closure of many local paper recycling schemes since 1989 (EPA 1991). Paper recycling was however improving during 1995 with the commissioning of the Albury newsprint recycling mill. Although prices are still volatile, a number of those involved in recycling have established markets in Asia (Moore, S. 1996, pers comm.).

Hazardous wastes

Melbourne Water reported that hazardous waste disposed into the sewerage system from households totalled 89,576 kgs between the period October 1990 to September 1992. These wastes included arsenical compounds, poisons, heavy metals, organochlorines and other pesticides, oils, paints, solvents, acids and alkalis (Melbourne Water cited in SoE 1996).

The State of the Marine Environment Report for Australia (1995) states that each year around 10,000 tonnes of phosphorus and 100,000 tonnes of nitrogen are discharged through sewage. Sewage and stormwater run-off are the major sources of nutrients in urban areas. High levels of nutrients in sewage and run-off have resulted in blooms of harmful algae in estuaries and bays (Zann 1995).

Types of hazardous wastes found in kerbside collections are demonstrated by the data collected by the City of Mitcham in South Australia during 1995. From this sample survey (see Table 9.2.6) it can be seen that paint represented 69% and batteries 20% of the hazardous waste collected (City of Mitcham 1995).

Further data on hazardous and special wastes are provided in Section 12.1.4.

Personal litter

The effects of litter (solid waste material that has not been properly contained or disposed of) range from the degradation of the aesthetic qualities of an area to serious pollution and danger to the health of wildlife and humans.

Analysis of regular litter surveys shows that litter comes from seven main sources: pedestrians, motorists, household waste, commercial waste, uncovered loads, construction sites, and loading

9.2.6 Household hazardous waste, City of Mitcham, Adelaide, 1995

	Hazardous waste per household	Total city	Proportion of hazardous waste
Waste	*kg/year*	*t/year*	*%*
Paint	3.4	83.3	69
Fluorescent globes	0.4	8.8	7
Dry cell batteries	0.5	12.7	10
Car batteries	0.5	12.1	10
Pharmaceuticals	0.2	4.2	3
Total	**4.9**	**121.1**	100

Source: City of Mitcham 1995.

9.2.7 Composition of polystyrene litter collected on Clean Up Australia day, 1993 and 1995

	1993	*1995*
Item	*%*	*%*
Polystyrene foam pieces	36.4	30.7
Fast food containers	27.3	28.1
Cups and plates	17.7	22.4
Polystyrene packaging	16.3	16.9
Other	2.3	1.8
Total polystyrene items	**100.0**	**100.0**

Source: Clean Up Australia1993; Clean Up Australia 1995.

and unloading operations (SA Department of Environment and Land Management 1993).

Most, although not all, litter is personal waste, dropped or left by individuals while travelling or pursuing recreational activities. Some of the areas most affected by this type of litter, and where ongoing attention to cleaning up is most required, are roadways, beach and coastal areas, parklands and waterways (Clean Up Australia 1993).

Plastic is a major component of litter. On Clean Up Australia Day, 1995, plastic and polystyrene items accounted for 30% of all rubbish counted while in 1994 plastic and polystyrene accounted for 42% (Clean Up Australia, 1995). Most of the common types of plastic litter and polystyrene are associated with take-away foods and beverages (Tables 9.2.7 and 9.2.8). Further information on Clean Up Australia Day can be found in Section 13.3.

9.2.8 Ten most common items of plastic litter collected on Clean Up Australia Day, 1995

	Proportion of total plastic items collected
Item	*%*
Plastic chip/confectionary bags	12.3
Supermarket bags	11.1
Plastic straws	11.0
Plastic bottle caps and lids	10.1
Water and soft drink bottles	8.0
Cling wrap, wrapping, packaging	7.0
Pet bottoms (Rocket bottoms)	5.7
Food bags	3.9
Polystyrene fast food containers	3.2
Polystyrene pieces	3.5
Ten most common items	75.8
Other plastic items	24.2
Total plastic items	**100.0**

Source: Clean Up Australia 1995.

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9.3 Introduced flora and fauna

Introduction

The floral and faunal communities of Australia have one of the highest number of introduced species in the world. Recent records indicate that about 20 mammals, 30 birds, 21 fish, several amphibians, 500 invertebrates and 1500 plants have been introduced, and have subsequently become naturalised, in Australia (Denny 1992, Humphries, Groves & Mitchell 1991,). The vast majority of these species have been introduced either deliberately or accidentally over the last 200 years and, in the process, have instigated many changes to the natural environment.

Given that there is a very large number of introduced species in Australia, this section will only focus on a subset of key introduced species. Those selected form self-perpetuating populations within native habitats and are currently causing (or have the potential to cause) severe impacts on several native species in the process.

Biogeographical origins, place, timing and methods of introduction

European settlement of Australia, starting with the First Fleet in the late 1700s and increasing rapidly and widely during the 1800s, is primarily responsible for the large number of introduced species. As Tables 9.3.1, 9.3.2 and 9.3.3 illustrate, many introduced species have a Eurasian origin and were deliberately introduced in the 1800s. The reasons behind such introductions vary greatly. They include: food production (e.g. pig and honeybee); an aid to food production (e.g. pasture plants such as Mission Grass and Buffel Grass); game (e.g. rabbit, fox and carp); domestic companionship (cat); ornamental gardening (e.g. Giant Sensitive Plant, Rubber Vine and Blue Thunbergia) or other aesthetic reasons (e.g. the Common starling); and biological control (e.g. Cane toad and Mosquito fish).

Several introductions, however, have been accidental. In certain circumstances, accidental introductions may reflect inadequate quarantine procedures in place at the time. Terrestrial examples are the European wasp, the house mouse and the black rat. The first named was initially transported into Australia within sawn timber imports and the latter two within ship cargoes. The introduction of marine fish, invertebrates, plants and algae is another serious

9.3.1 Introduction of selected exotic vertebrates

Common name	*Species name*	*Biogeographical origin*	*Where introduced*	*When introduced*	*Initial method of introduction*
Pig (feral) (a)	*Sus scrofa*	Eurasia	Nth Qld, Sydney	1770	Deliberate: Food.
Cat	*Felis catus*	Eurasia	Sydney, Nth Aust.	late 1700s, possibly earlier in Nth Aust.	Deliberate: Pet and pest control.
Red fox	*Vulpes vulpes*	Eurasia	Sydney, Melbourne.	mid 1800s	Deliberate: Hunting and skins.
Rabbit	*Oryctolagus cuniculus*	Eurasia	Many areas in Eastern Australia	early 1800s	Deliberate: Food, fur and skins.
Goat (feral)	*Capra hircus*	Eurasia	Inland Australia and islands	late 1700s	Deliberate: Milk and meat.
Black rat	*Rattus rattus*	Middle East	Coastal Australia	late 1700s, but possibly earlier	Accidental: Ship stowaway.
Mouse/House mouse	*Mus musculus or Mus domesticus*	Eurasia	Coastal Australia	late 1700s	Accidental: Ship stowaway.
Common starling	*Sturnus vulgaris*	Eurasia	South-eastern Australia	mid 1800s	Deliberate: Aesthetic reasons.
Cane toad	*Bufo marinus*	Caribbean	Sugarcane districts, North Queensland	1930s	Deliberate: Control of sugarcane beetle.
Carp (also referred to as European carp)	*Cyrprinus carpio*	Asia	Sydney, Gippsland Murrimbidgee Irrigation Area	mid 1800s	Deliberate: Food.
Mosquito fish (also referred to as Gambusia)	*Gambusia holbrooki*	Mozambique	Brisbane Sydney Cairns Perth Darwin	1925 1926 1929 1934 1940	Deliberate. Control of mosquito larvae.

(a) Celebos Wild Boar possibly introduced prior to European Settlement

Source: Denny 1992, Wilson et al. 1992, Pollard 1989, Williams et al. 1995, Gehrke, Dr. P. 1996 (pers. comm.).

9.3.2 Introduction of selected exotic invertebrates

Common name	*Species name*	*Biogeographical origin*	*Where introduced*	*When introduced*	*Method of introduction*
Honeybee	*Apis mellifera*	Eurasia	South-east Australia	early 1800s	Deliberate: As source of honey and wax; and for pollination services.
European wasp	*Vespula germanica*	Eurasia	Sydney	1960–70s	Accidental: As part of sawn timber imports.
Northern Pacific Seastar	*Asterias amurensis*	Japan	Tasmania	1980s	Accidental: As part of ships ballast water.
European shore crab	*Carcinus maenus*	Europe	Port Phillip Bay, Victoria	early 1900s	Accidental : As part of hull-fouling communities aboard ships.
Sabella worm	*Sabella spallanzanii*	Asia	Port Phillip Bay, Victoria	1980s	Accidental: As part of hull-fouling communities aboard ships.

Source: Denny 1992.

quarantine problem. About one quarter of the introduced fish, invertebrates and algae in Australian marine waters are either from the off-loading of ballast water by international ships in Australian waters or through hullfouling communities often found on such ships. Examples of the former include the Northern Pacific Seastar, Sabella worms, and Japanese Kelp; the European shore crab is an example of the latter.

9.3.3 Introduction of selected exotic plants

Common name	*Species name*	*Biogeographical origin*	*Where introduced*	*When introduced*	*Method of introduction*
Bitou Bush/Boneseed (shrubs)	*Chrysanthenoides monilifera rotundata/ C.m.monilifera*	South Africa	Newcastle harbour	1850s	Accidental: Through seeds dumped as part of ballast water. Deliberately: As an ornamental and binder of coastal soils.
Blue Thunbergia (vine)	*Thunbergia grandiflora*	North India	Tropical Nth Queensland	believed to be 1950s	Deliberate: As ornamental plant.
Bridal Creeper (vine)	*Myrsiphyllum asparagoides*	South Africa	Western Australia	1870s	Deliberate: As ornamental plant.
Buffel Grass (groundcover)	*Cenchus ciliaris*	Middle East	Kimberley Region	1950s	Deliberate: For erosion control and as pasture.
Giant Sensitive Plant (Semi-aquatic small tree/ shrub.)	*Mimosa pigra*	Central and South America	Botanic Gardens, Darwin	late 1800s	Deliberate: As an ornamental plant.
Mission Grass (ground cover)	*Pennisetum polystachion*	West Africa	North Australia	early 1900s	Deliberate: As potential pasture plant.
Parkinsonia (small tree/shrub)	*Parkinsonia aculeata*	North and South America	North Australia	early 1900s	Deliberate: As a shade tree.
Prickly Acacia (small tree/shrub)	*Acacia nilotica*	Middle East	West Queensland	1890s	Deliberate: As shade and fodder tree.
Rubber Vine (terrestrial weed)	*Cryptostegia grandiflora*	Madagascar	North Queensland	1870s	Deliberate: As an ornamental plant.
Salvinia (water weed)	*Salvinia molesta*	Sri Lanka	North Queensland	1940s	Deliberate: As an ornamental plant.
Tamarisk (small tree)	*Tamarix aphylla*	Eurasia	Finke River, Nth Australia	early 1900s	Deliberate: As a shade tree.
Para Grass (semi-aquatic weed)	*Brachiaria mutica*	Tropical Africa and Brazil	NT tropical wetlands	1980s	Deliberate: As a pasture plant.
Water Hyacinth (aquatic)	*Eichhornia crassipes*	Brazil	Far North Queensland	1890s	Deliberate: As an ornamental plant.
Japanese Kelp (marine kelp)	*Undaria pinnatifida*	Japan	East coast of Tasmania	1982	Accidental: Via ballast water of Japanese woodchip cargo vessels.

Source: Humphries et al. 1991, et al. 1994, Brown, J.1996 (pers. comm.).

Distribution and abundance of introduced species, and major influences affecting them

Tables 9.3.4 and 9.3.5 present summary information on what is known about the distribution and abundance of the key introduced species listed in Tables 9.3.1 and 9.3.3. Where possible, the major limits to their distribution and the major factors affecting their abundance are also given.

Two overall trends emerge from these tables. Firstly, each species is either currently distributed or has the potential to distribute itself across a wide geographic area that generally, though not always, includes a large range of habitat types.

9.3.4 Distribution and abundance of selected exotic vertebrates

Common name	*Present distribution*	*Potential future distribution*	*Estimates of abundance*	*Major factors affecting distribution and abundance*
Pig (feral)	Widely throughout Qld, NT, NSW and ACT. Isolated populations elsewhere including islands	Wider distribution through Eastern NT and Western Qld, and Southern Tablelands	9.3–23.5 million. Tropical & sub-tropical wetlands and seasonally-inundated floodplains (10–20/km^2). Drier temperate Eucalyptus woodland, forests and grazing lands (av. 1/km^2).	Available water (streams, ponds and floodplains), and forest shade (because of poor thermal tolerance) and fresh vegetation. Predation by dingo.
Cat	Australia wide, including islands	Australia wide	0.03–10 per km^2, depending on habitat.	Available prey species, especially rabbits, kittens subject to predation by fox etc.
Fox	Southern 2/3rds of Australia, not Tasmania	No change	Temperate rangelands (4.6–7.2/km^2), semi-arid grazing areas (0.6–2/km^2) and rainforests (av. 0.2/km^2).	Available prey species, particularly rabbits.
Rabbit	Southern 2/3 of Australia, including Tasmania. Common south of latitude 25º, rare north of latitude 25º	Expected decrease in short term due to introduction of Rabbit Calicivirus Disease (RCD)	Estimates for arid zone range from 2–97/ha, average 3/ha.	Principally fresh herbage and suitable burrow terrain. Myxomatosis, RCD, foxes and cats at lower densities.
Goat (feral)	Widespread semi-arid pastoral and isolated areas in montane forests also islands such as N. Goulburn and some isolated patches in Tasmania	No change	About 2.3 million in Australia.	Presence of fresh herbage and their nutritional quality, the availability of water and cover (dense scrub or rocky overhangs) the presence of natural (e.g. wedgetail eagle) and human predators.
Black rat	Coastal Australia and agricultural lands	No change	Low numbers, trapping rates less than 5%.	Water, disturbed land.
Mouse	Australia-wide	No change	Up to 2500/ha during plagues.	Fresh vegetation especially seeds.
Common starling	Mainly south-east Australia	Moving westward and northward	Range from 0.31–2.5 birds per ha.	Fresh water, open land.
Cane toad	Coastal Qld, Northern Territory and northern NSW	Moving further north, south and west	As high as 5 000 per ha.	Extremes of temperature and need for fresh water ponds for tadpole cycle.
Carp (also referred to as European carp)	All States except NT, widespread in Murray-Darling River System and south-east coast drainage divisions	All of non tropical Australia	Known to reach or exceed 650kg per ha in some water bodies and 80–100% dominant catch in some areas.	Linkage of river systems, cold water temperatures, high salinity and fast flowing waters.
Mosquito fish (also referred to as Gambusia)	North-east coastal, south-east coastal, Murray Darling, south Australian gulf and south-west coastal drainage divisions, Lake Eyre, Timor Sea and Western Plateau drainage division	Throughout Australia except in coldest streams	Figures of 100 fish per m^2 are not uncommon on a very small scale — dominant catch in many areas, especially in degraded water ways, paddy fields etc.	Linkage of river systems, cold water temperatures, high salinity and fast flowing waters.

Source: Denny 1992; Pollard 1989; Williams et al. 1995; Newsome 1991; Wilson et al. 1992; Menkhorst 1995; Brown, J. 1996 (pers. comm.);

9.3.5 Distribution and abundance of selected exotic plants

Common name	*Present distribution*	*Potential future distribution*	*Major factors affecting distribution*
Bitou Bush/ Boneseed	A variety of coastal habitats from foredune grasslands and heathlands to littoral forests in south-east Qld, NSW, south-west Vic., south-east SA.	Nth Qld and south-west WA.	Dry conditions and animal vectors.
Blue Thunbergia	Isolated patches in lowland rainforest of the wet tropics in far Northern Qld.	Continuing spread through the wet tropics.	Low temperatures and low rainfall.
Bridal Creeper	A range of habitats through southern Vic., SA and NSW and south-west WA; Lord Howe Island.	Continuing spread through southern Australia.	Requires a five month growing season.
Buffel Grass	Moist and high nutrient habitats near streams etc in the arid zone (central Australia).	Throughout inland Australia.	Dry conditions, nutrient poor soils and low temperatures.
Giant Sensitive Plant	Isolated moist, open areas in the tropical wetlands and floodplains in a 500km arc around Darwin.	Northern Australia from Katherine to Arnhem land, Gulf of Carpentaria and Cape York.	Rainfall less than 750mm, closed canopies (e.g. undisturbed rainforests).
Mission Grass	Monsoonal forest and woodlands around Darwin and the gulf region of NT.	Through Gulf of Carpentaria, Cape York and Ord River system.	Frost and low rainfall (less than 3000 mm per year).
Parkinsonia	Tropical rangelands, ephemeral wetlands of the semiarid zone throughout NT, WA, Qld and Northern NSW.	Continuing rapid spread through these areas.	Frost, and absence of drought-flood cycle to stimulate seed production and spread.
Prickly Acacia	Moist habitats of NW Qld, including 500,000ha of Mitchell grass (Astrebla spp.) downs country.	Gulf of Carpentaria through Channel Country to Lake Erye.	Frost.
Rubber Vine	Isolated patches in dry rainforest and monsoonal streamside habitats in the 400–1400 mm per year rainbelt of North Qld. About 350 000 sq km.	Throughout Katherine, Gulf of Carpentaria, Cape York, north central Qld regions.	Absence of drought-flood cycle to stimulate seed production and spread; frost; fire; too high or low rainfall; absence of disturbance.
Salvinia	Isolated tropical and subtropical nutrient-enriched freshwater bodies.	Throughout eastern and northern coast of Australia.	Low temperature, low nutrient levels, biological control.
Tamarisk	Several hundred kms along Finke River (largest arid zone river system in Australia).	Todd, Ross and Palmer Rivers in NT, north west Qld and other watercourses of the arid zone.	Frost, high rainfall, spread in flood events.
Para Grass	Wetlands and streams in the tropics and sub-tropics areas.	Throughout northern Australia.	Frost and low humidities.
Water Hyacinth	Isolated tropical and subtropical nutrient-enriched freshwater bodies.	Throughout eastern and northern Australia.	Low temperature, low nutrient levels. Invades open waters.
Japanese Kelp	East Tasmania.	Entire coastline from Cape Leeuwin, WA to Wollongong NSW.	High water temperature.

Source: Humphries et al. 1991.

The major limits to the distribution of these species are generally temperature, rainfall and, for terrestrial plants, also soil conditions.

Secondly, where the data are available, each species displays an enormous range of population numbers (or, in the case of some plants, biomasses) across the various habitats which have been surveyed. Although a wide range of ecological factors influence these abundances, the most important factor is probably food availability which is ultimately affected by both rainfall and temperature. Thirdly, the population data vary in quality, with those for vertebrates generally being the best and those for plants the poorest.

The success of the above introduced species within the Australian environment has been facilitated by i) their ecophysiology; and ii) the biophysical structure (trophic structure, nutrient levels) of the habitats under threat (Bomford 1991; Denny 1992; Humphries et al. 1991). These two aspects are discussed in greater detail below.

Ecophysiological attributes of successful introduced species

Successful animal and plant exotics possess one or more of the following biological attributes:

- wide climate or physical tolerance;
- high net reproductive rates and/or reproductive flexibility;
- excellent dispersal ability and/or flexibility;
- nutritional generalism; and
- excellent competitive ability.

Each of these five attributes is illustrated below.

Several introduced animals have behaviours that increase their tolerance to a range of climatic conditions. Examples are the warren building behaviour of rabbits and the fanning behaviour of European wasps and honeybees which assist with thermoregulation. Several plant examples exist. These include the flood and drought tolerating ability of the Giant Sensitive Plant, and the comparatively long root systems of semi-aquatic weeds and Tamarisk Tree. The latter can also tolerate extremely salty conditions (Humphries et al. 1991).

All introduced species listed in Tables 9.3.4 and 9.3.5 have high net reproductive rates, either through higher fecundity or effective survival mechanisms or both. Examples of animals with extraordinarily high fecundity are the house mouse, rabbit, Cane toad, and the Northern Pacific Seastar (Denny 1992). Under favourable environmental conditions, rabbits can increase their population density by 500% in a single year (Williams et al. 1995). Plants with very high rates of seed production include Giant Sensitive Plant, Bitou Bush, Mission Grass and Buffel Grass. Rubber Vine, Blue Thunbergia and Water Hyacinth are examples of plants with great vegetative growth potential as they each expend little energy on supportive structures. Water Hyacinth can double its mass and area every five days during warm periods. Japanese kelp and toxic dinoflagellates also have phenomenal spore production capabilities. Japanese Kelp can release millions of spores per plant per day (Humphries et al. 1991)

Examples of effective survival mechanisms in animals are: the wide environmental tolerances of mosquito fish to a range of water salinities from dystrophic swamps to salt lakes; the poison glands of the Cane toad; and the social behaviour of the pig, rabbit, fox, starling, European wasp and honeybee (Denny 1992). For plants they include: the thorns of the Prickly Acacia; the prickly and unpalatable Giant Sensitive Plant; the tillering system of growth of Mission Grass and Buffel Grass which greatly increases their tolerance to grazing pressure; and the salt tolerance of Tamarisk Tree and Parkinsonia. The bioconcentration of salts by the latter two species into their leaves gives an additional advantage of deterring animal herbivory (Humphries et al. 1991).

Reproductive flexibility in plants is well exemplified by those plants that can be produced either by seed or vegetatively such as Water Hyacinth; and those plants that produce seeds which can withstand long dormancies during drought, for example, Giant Sensitive Plant, Rubber Vine, Parkinsonia, Prickly Acacia and Tamarisk Tree. Furthermore many animals listed in Table 9.3.2 have the physiological ability to produce many more offspring when resources are plenty and many fewer offspring during resource-poor conditions (Humphries et al. 1991).

Nearly all species listed in Tables 9.3.4 and 9.3.5 have good dispersal ability, enabling them (or their propagules in the case of plants) to exploit other resource patches, and to escape threatening processes such as decline in food availability, fire, drought or flood. Often, the dispersal ability of a particular introduced species is improved markedly by human activities. For example, regular vehicle movements between particular localities have unintentionally aided the spread of the seeds of Giant Sensitive Plant and Prickly Acacia (Humphries et al. 1991) and colonies of the Argentine Ant which has relatively limited flight abilities (Majer 1993). Scallop fisherman in Port Phillip Bay are thought to have accidentally assisted the spread of Sabella worm to new locations by discarding the adult worms caught in their nets over the side of the boat (Wilson, R. 1995, pers. comm.). The translocation of carp (Roberts, J. 1995, pers. comm.), and the mosquito fish (Arthington, A. 1995, pers. comm.) to different streams are examples of deliberate assistance with dispersal.

Most of the animals listed in Table 9.3.4 have broad diets, enabling them to persist through periods of low food availability and exploit otherwise good periods. In fact, several are omnivorous. A good example of this is the fox, which prefers rabbit. However, in places where there has been effective control of rabbits through the actions of the myxomatosis or there have been drier conditions, the fox can easily switch to eating native mammals, birds and even plant material. Many of the plants listed in Table 9.3.5 have broad nutrient gradients, although they exhibit their most vigorous growth in nutrient-enriched areas (Humphries et al. 1991).

Many introduced plants outcompete native vegetation by growing quickly to smother surrounding vegetation (e.g. Rubber Vine and Blue Thunbergia) or by leaching into the soil allelochemicals that are toxic to surrounding vegetation (e.g. Tamarisk Tree and Bitou Bush) (Humphries et al. 1991). There are many examples of introduced animals with good competitive abilities. These include good resource competitors such as the Argentine Ant (Majer 1993) and the rabbit (Williams et al. 1995).

Attributes of native habitats vulnerable to introduced species

Native habitats that are vulnerable to invasion by an introduced species invariably lack the suite of biotic and abiotic factors that usually regulate populations of the exotic species within its home range. Depending on the particular exotic species in question, vulnerable habitats may have some combination of the following environmental conditions: absence of strong competitors; absence of specialist natural enemies (such as predators, parasitoids, parasites and diseases); increased food availability; increased shelter; and a more benign climate (Denny 1992; Humphries et al. 1991).

These environmental conditions may have arisen because of Australia's evolutionary history, or through the effects of human activities. These two points are illustrated below by using those species listed in Tables 9.3.4 and 9.3.5.

Effect of Australia's unique evolutionary history

The evolution of the natural environment in Australia has taken place in relative isolation from other continents, since the initial breakup of the Gondwana supercontinent over 100 million years ago. As a consequence, there is generally very little similarity between native ecological communities and those from which introduced species have originated over the past 200-odd years (Denny 1992; Humphries et al. 1991). As Tables 9.3.4 and 9.3.5 show, none of the populations of introduced species listed are affected to any major extent (and hence, possibly regulated) by natural predators or parasites. This is because Australia has almost no species of natural enemy that specialise on any of these introduced species. The rabbit and the Giant Sensitive Plant are two cases in point.

Although Australia has a few species of vertebrate predator (e.g. Wedge-tailed Eagle and Tiger Quoll), none of these specialise on rabbits in the same way that mustelids (e.g. ferrets and weasels) do in Europe and North America. Furthermore, the effectiveness of the few specialised diseases and parasites that accompanied the rabbit to Australia (and which are normally transmitted by mosquito), is drastically reduced in rangelands which usually experience frequent cycles of drought. This also applies to the introduced myxomatosis virus which has been spectacularly successful in controlling rabbit numbers in wetter rather than drier habitats where mosquitoes are less abundant (Williams et al. 1995).

In its home range of Mexico, the Giant Sensitive Plant is used by over 200 species of insect and fungi for food. It is thought not to be a problem weed there because of its heavy use as a food plant. However in Australia, few insects and even fewer vertebrate herbivores find the weed palatable.

Effect of human activities

Habitat modification through human activity has frequently exacerbated or even created some of the above conditions that favour an introduced species surviving and becoming established in a particular habitat. Furthermore the above biological attributes of successfully introduced species not only assist them to become established in native habitats, but also promote their ability to persist in habitats modified by human activity, where often many native species cannot survive (Denny 1992; Humphries et al. 1991). The major forms of human-induced disturbance to native habitat are:

- agriculture;
- forestry;
- urbanisation;
- mining;
- fires; and
- introduced exotic plants and animals.

(Environmental Science Project Committee 1994, p. 465).

Examples of this are set out below.

All of the plants listed in Table 9.3.5 are 'opportunistic colonisers' of disturbed habitats which provide both extra space and light to initiate growth. Their growth rates in these habitats, given the right environmental conditions, are often spectacular. Much of the severely fragmented nature of native habitats within much of eastern, southern and south-western Australia has been caused by land clearing. For instance, nearly 90% of temperate woodlands and mallee, and 50% of the rainforests have been cleared, with more than 48% of the Australian continent either significantly or substantially disturbed (Graetz, Wilson & Campbell 1995). Habitat remnants are more prone to invasion by introduced plant species because they usually possess a high edge to area ratio, they tend to be relatively isolated from larger source populations of native species and, depending on their locality, they are more susceptible to disturbances such as fires and changes to nutrient levels of soils and water (Humphries et al. 1991). Many of the animals listed in Table 9.3.4 may also be classified as 'opportunistic colonisers' of disturbed habitats. Good examples are rabbits (Williams et al. 1995) Argentine ants (Majer 1993) and Northern Pacific Seastars (Morrice & Wolf 1994).

Over-grazing and soil disturbance by rabbits, pigs and other introduced animals has led to the replacement of native perennial plants by introduced annual species that are either more tolerant of grazing pressure or generally promoted by disturbance (Humphries et al. 1991).

Many introduced plants are promoted by fire because fire creates bare areas which can be quickly colonised by these plants. Good examples are Rubber Vine and Blue Thunbergia. Decreases in fire frequency in schelophyllous habitats, on the other hand, may lead to introduced plants outcompeting native plants that rely on fire for seed germination and so on (Humphries et al. 1991).

Native plants are adapted to soils that are naturally low in nitrogen and phosphates. However, extensive applications of superphosphate compounds (as a fertiliser) and nitrogenous compounds (either as a fertiliser or through nitrogen-fixing plants such as legumes), into Australian soils as part of agriculture, have meant that, in some areas, introduced flora are able to outcompete native flora (Humphries et al. 1991).

Human-induced disturbances to aquatic habitat associated with the successful establishment of introduced species such as Mosquito fish and the Carp include: impoundment, diversion and channelisation of rivers, desnagging, loss of riparian vegetation, bank erosion and sedimentation, water pollution and the presence of introduced aquatic plants (e.g. Water Hyacinth) (Roberts, J. 1995, pers. comm. and Arthington, A. 1995, pers. comm.).

The construction of dams and weirs has also encouraged the 'year-round' persistence of noxious aquatic weeds like Water Hyacinth. This is because such impoundments frequently contain high levels of dissolved phosphates and nitrates through runoff from upstream settlements or other sources (Humphries et al. 1991).

The rapid spread of the Northern Pacific Seastar in the Derwent River may have been facilitated by the increase in unidentified micro-organic pollutants being discharged into this area (Morrice & Wolf 1994).

Many species of introduced terrestrial animals also use agricultural produce. Notable examples include the fox (lambs), the house mouse (cultivated grain crops, and stored grain) and the pig (lambs and calves, grain, sugar and fruit crops). These animals are also classified as economic pests in most agricultural districts around Australia. Undoubtedly, their increased presence in some of these districts must also place increased pressure on native habitat remnants within these districts.

The spread of the Argentine Ant in the south west of Western Australia has been facilitated by habitat disturbance in certain areas. Examples of such activities are urbanisation, market gardening and mining (Majer 1993).

Certain introduced species are vectors for the dispersal of seeds of exotic plants, or the spread of exotic diseases and pathogens. For example, foxes and rabbits are attracted to the fruits of the introduced Bitou Bush and Boneseed. Another example is the possible introduction of parasites and diseases into native fish communities via introduced fish such as Carp and Mosquito fish (Roberts, J. 1995, pers. comm. and Arthington, A. 1995, pers. comm.).

Ecological impacts of selected introduced species

Tables 9.3.6, 9.3.7 and 9.3.8 document lists of native flora and fauna affected by each of the key introduced species selected. The lists presented here are by no means exclusive, and can be extended with further research effort, particularly towards introduced invertebrates on native flora and fauna, and introduced plants on native fauna.

As Tables 9.3.6, 9.3.7 and 9.3.8 show, each introduced species can either directly or indirectly impact upon a large number of species of native flora and fauna.

Direct impact processes for introduced animals are: herbivory on native flora; predation of native fauna; competition with native fauna; and poisoning of native fauna. Competition with native flora is the principal direct impact by introduced plants.

Indirect impacts of exotic plants or animals occur via an (often negative) interaction with other species or the surrounding physical environment. For example, overgrazing by rabbits of native flora not only threatens particular plant communities (e.g. the Mitchell Grass biome in

9.3.6 Range of native flora and fauna affected by selected exotic vertebrates (a)

	Fauna		*Flora*	
Common name	*Main species affected*	*Mode of impact*	*Main species affected*	*Mode of impact*
Pig	Lord Howe Is Woodhen, Providence Petrel, Cassowary, crocodiles, ground-nesting birds and frogs.	Directly by preying on eggs and young. Indirectly by changing composition of the plant communities leading to loss of food and shelter for native animals.	Wetland & riparian vegetation, tubers and bulbs.	Removal as food and by trampling.
Cat	Antarctic Tern, Red-fronted Parrot, Macquarie Is Rail, White-fronted Petrel, Bilby, Antarctic Prion, Bettongs, Banded Hare-wallaby, Ground Parrot, Orange-bellied Parrot, Turquoise Parrot, Long-footed Potoroo, Eastern Barred Bandicoot, Little Tern, Fairy Tern, White-faced Storm Petrel, Eastern Quoll, Rufous Hare-wallaby, Numbat.	Predation, competition and possibly transferring disease.	None.	None.
Fox	Mallefowl, Rufous Hare-wallaby, Parma wallaby, Rothschild's Rock-wallaby, brush-tailed wallaby, Yellow-footed wallaby, Long-necked tortoise, Broad-shelled River Turtle, Murray Turtle, Eastern Barred Bandicoot, species of marine turtles, ground nesting birds, quolls, Tammar wallaby.	Predation and competition.	Not known.	Will eat fruit and some plants.
Rabbit	Little penguin, wedge-tailed shearwater, Fleshy-footed shearwater, White-faced Petrel, Bilby, Booby, Regent Parrot, Eastern Barred Bandicoot, Malleefowl, Gould's Petrel.	Competition for food and shelter with medium sized native herbivores. Indirect effects from changes in composition of the plant communities leading to loss of food and shelter for these native animals. Providing food for foxes and cats.	Many species of grasses, forbs (e.g. *Stipa* spp and *Danthonia* spp) and seedlings of *Acacia* spp (e.g. mulga) and *Eucalyptus* spp (e.g. mallee). Also bluebush, cypress pine, she-oaks and mallee seedlings.	Direct grazing plus indirect effects caused by grazing such as increased soil erosion, increased competition from subsequent colonisation by exotic weeds.
Feral goat	Yellow-footed Rock Wallaby. Peregrine falcon.	Resource competition limited succulent feed and summer shelter. Change composition of plant communities and increase soil erosion. Destruction of nesting habitat on cliff ledges.	Arid and semi-arid vegetation.	Grazing plus indirect effects such as increased soil erosion, competition from subsequent colonisation by exotic weeds; especially on islands.
Black rat	Bush rat, species of Betong, Boobie, Crested Tern, Lord Howe Is Woodhen, Wedge-tailed Shearwater, Sooty Shearwater, three species of rodent on Christmas Island, Common Noddy, five species of Lord Howe Is Bird.	Predation of juveniles plus indirect effect of reducing ground cover vegetation of plant communities inhabited by native animals.	Unknown.	Grazes on a variety of fruit and seeds.
Mouse	An unknown range of small granivorous mammals.	Competition for food and nesting burrows Indirect effect by providing more food for foxes & cats.	An unknown range of grasses and so on.	Seed grazing of an unknown range of native grass and tree species.
Common starling	Eastern Rosella, Green Rosella, Blue-winged Parrot, Orange-bellied Parrot, Gang-gang cockatoo.	Resource competition for food and nesting space.	Unknown.	Grazes on a variety of fruit and seeds.
Cane toad	Frogs, snakes, quoll, goanna, and an unknown range of carnivorous mammals and an unknown range of predators.	Resource competition and poisoning of predators.	Unknown.	Unknown.
Carp (European carp)	An unknown range of fish, waterbird and freshwater gastropods.	Indirect through their mudsifting behaviour changing water turbidity and sedimentation levels which reduce aquatic vegetation.	Shallow rooted and soft-leaved aquatic species.	Increase turbidity and direct distribution of habitat.
Mosquito fish (Gambusia)	Freshwater fish e.g., rainbow, e.g. Galaxias, Pygmy Perch, Honey Blue-eye, Red-finned Blue-eye, Gudgeon, Green and Golden Bell-frog. Possibly also affect beetles, & mayflies.	Competition for food (zooplankton and phytoplankton) and space, interference competition (e.g. fin nipping) & predation.	Unknown aquatic vegetation.	Changing the physiochemistry of the water.

(a) It must be recognised that other ecological factors may also contribute to the pressures affecting Australia's native flora and fauna.

Source: Denny 1992; Pollard 1989; Williams et al. 1995.

Western Queensland) (Humphries et al. 1991) but, in extreme cases, can also lead to a reduction of available habitat for small native mammals (Williams et al. 1995). An example of a more subtle interaction is the way foxes and feral cats have proliferated in those areas in which there are abundant supplies of rabbit (and house mouse). When populations of the introduced prey inevitably go into sharp decline (as food resources are stripped), these introduced predators invariably switch to include more native prey in their diet (Newsome 1994). A final example is the case where the Giant Sensitive Plant is overgrowing wetlands in the Northern Territory. This is not only reducing the productivity of these areas for native plants but, as a consequence, for native animals also (Lonsdale, Miller & Forno 1989).

As Tables 9.3.6, 9.3.7 and 9.3.8, indicate, a number of the native species impacted by introduced species are currently rated as listed in Schedule 1 of the Endangered Species Act 1992. It is possible to broadly categorise these endangered native species as those with one or more of the following attributes: long-lived with relatively low fecundities; limited dispersal abilities; narrow nutritional strategies; and restricted habitat or bioclimatic ranges, especially those species living on islands or in fragmented habitats (Denny 1992; Humphries et al. 1991).

At present, however, it is generally not possible to quantify the degree to which a particular introduced species is causing the decline in a particular native species because little or no data exist in this regard. This is understandable given the enormous range of flow-on effects that complex natural ecological systems often display when perturbed; and the fact that introduced species are only one of many perturbing factors affecting natural systems. As illustrated above, vegetation clearing, changing fire regimes, farming, overfishing and overhunting also contribute to the decline of native species (Newsome 1994; Environmental Science Project Committee 1994). Furthermore, previous research on the impact of introduced species has tended to concentrate on their effects on agricultural productivity rather than natural ecosystem productivity (Braysher 1993, p. 58).

Present and future management of introduced species

The management of introduced species involves two essential components. These are: monitoring of populations and impacts; and the application of control techniques (Denny 1992; Humphries et al. 1991).

Tables 9.3.9 and 9.3.10 present summary information on the present management of each of the key introduced species in terms of these two components. They also summarise future management strategies, in terms of priorities for further research on or the further development of each of these components. Where possible, this information has been gathered from the published opinions of relevant scientific experts and land managers.

A consistent trend obvious from these tables is that the future management of each introduced species will need to consider i) more effective monitoring of both populations and

9.3.7 Range of native flora and fauna affected by selected exotic invertebrates

Common name	Fauna		Flora	
	Main species affected	*Mode of Impact*	*Main species affected*	*Mode of Impact*
Feral Honeybee	An unknown range of bees, wasps and nectivorous birds (e.g. honeyeaters), possums, cockatoos, green parrot	Resource competition for pollen and/or nectar; resource competition for tree-hollows.	An unknown range of angiosperms that rely on pollinators for reproduction.	Indirect through reduction of native pollinator directly through inefficient pollination behaviours and possible spread of disease, e.g. dieback.
European wasp	An unknown range of terrestrial invertebrates.	Predation.	Unknown.	Unknown.
Argentine ant	An unknown range of ants.	Resource competition.	An unknown range of plants that rely on myrmechory (ant transportation of seeds).	Indirect through reduction of myrmechorus ant numbers.
Northern Pacific Seastar	An unknown range of invertebrates such as mussels, oysters etc. Also dead fish.	Predation and resource competition.	None.	None.
European shore crab	An unknown range of species.	Predation and resource competition.	None.	None.
Sabella worm	An unknown range of sessile marine invertebrates e.g. gastropods.	Resource competition for space.	An unknown range of macroalgae.	Resource competition for space.

Source: Denny 1992; CSIRO 1996 (pers. comm.).

9.3.8 Range of native flora and fauna affected by selected exotic plants

	Fauna		*Flora*	
Common name	*Main species affected*	*Mode of impact*	*Main species affected*	*Mode of impact*
Bitou Bush/ Boneseed	Unknown.	Changes in plant communities and loss of foraging habitat.	A range of coastal heath, and littoral rainforest species.	Resource competition for space, and nutrients. Contest competition — allelochemical poisoning.
Blue Thunbergia	Unknown.	Changes in plant communities and loss of foraging habitat.	A large range of tropical lowland rainforest species, some of which are in World Heritage Listed areas (e.g. Daintree).	Severe resource competition for space, light, and nutrients as it completely smothers vegetation.
Bridal creeper	Unknown.	Changes in plant communities and loss of foraging habitat.	An unknown range of groundlayer and shrub species.	Resource competition for light, space and resources.
Buffel Grass	An unknown range of herbivorous mammals and associated predators.	Reduction in forage and habitat.	A range of native grasses including *Anguillaria dioca*, *Stylidium inaequipetalum*, *Ophylyoglossum* spp. & *Isotes* spp. around Uluru — Kata Tjuta Nat. Parks. Some *Acacia* spp.	Resource competition for light, space, and nutrients. Indirectly through altered fire regimes (hotter and more frequent).
Giant Sensitive Plant	A range of animals including Magpie geese and crocodiles.	Reduction in nesting sites and habitat.	A range of tropical wetland species.	Severe resource competition for light, space and nutrients as it forms impenetrable thickets.
Mission Grass	Unknown.	Reduction in habitat.	A range of native grasses and shrubs.	Resource competition for space, and nutrients. Indirectly through altered fire regimes (hotter and more frequent).
Parkinsonia	A range of waterbird species in several lakes in the Barkly Tablelands.	Reduction in habitat.	A range of tree species including Coolibah and River Red Gum along watercourses and grass specie in the Downs country	Severe resource competition for space, light and nutrients as it forms impenetrable thickets.
Prickly Acacia	Unknown.	Changes in plant communities and loss of foraging habitats.	A range of native grasses including Mitchell grass.	Severe resource competition for light, space and nutrients as it displaces vegetation.
Rubber Vine	Purple-crowned Fairy wren, white-browed Robins, Rufous Owl, and Bower's Shrike-thrush.	Reduction in habitat.	A large range of 'dryland' rainforest species.	Severe resource competition for light, space and nutrients as it completely smothers vegetation.
Salvinia	Deep water diving birds e.g. some ducks.	Reduction of habitat and dissolved O_2 levels.	A range of aquatic vegetation species.	Resource competition for nutrients and light. Reduction of dissolved O_2 & pH plus increase in dissolved CO_2 through organic decomposition after heavy infestations.
Tamarisk	A range of animals including birds and reptiles, and soil invertebrates.	Reduction of habitat, increase in soil salinity.	A range of shrubs and trees including River Red Gum and less salt-tolerant grasses.	Resource competition for space and nutrients; lowering water table & increasing soil salinisation.
Para Grass	Magpie geese.	Overgrowing nesting sites.	Range of semi-aquatic vegetation.	Resource competition for nutrients (e.g. dissolved oxygen), and space.
Water Hyacinth	Resource competition for nutrients and light. Reduction of dissolved O_2 & pH plus increase in dissolved CO_2 through organic decomposition of heavy infestations.	Reduction of habitat and dissolved O_2 levels.	A range of aquatic vegetation species.	Resource competition for nutrients and light. Reduction of dissolved O_2 & pH plus increase in dissolved CO_2 through organic decomposition n of heavy infestations.
Japanese Kelp	Abalone and sea urchins.	Reduction of String Kelp which acts as a substrate for these two species.	A range of marine kelps (and algae) including String Kelp.	Resource competition for light and space.

Source: Humphries et al. 1991; Humphries et al. 1994.

9.3.9 Recommendations for management of and research on selected vertebrates

Common name	*Present management*	*Future management (including key further research and new control recommendations)*
Pig (feral)	1. Monitoring populations and environmental impacts using aerial surveys, ground surveys (e.g. trapping), and pig 'activity' (e.g. soil rooting) surveys. 2. Control through shooting, poison baiting (e.g. 1080, Warfarin) and trapping by local land managers. Also recreational shooting and electric fencing.	1. More base-line research in wet tropical rainforests on pig reproductive biology, feeding ecology and population dynamics. 2. More research on quantifying environmental damage, particularly native vegetation loss and native fauna predation, in relation to feral pig densities. 3. Biological control. More research needed on. viruses (e.g. Pig swine virus) and immunocontraceptives. Proposed vectors for these are unknown 4. Increased involvement of land management groups (e.g. Landcare) and local conservation authorities to address ameliorating habitat modifications that promote feral pig numbers.
Cat	1. Monitoring populations and environmental impacts using ground surveys. 2. Control through poisoning, shooting and trapping by local land managers.	1. More base-line research on cat population numbers and food sources, and movements of rural domestic and feral cats. 2. More research on quantifying environmental damage, particularly native fauna predation, in relation to cat densities. 3. Biological control. More research on immunocontraceptives 4. Increased involvement of land management groups (e.g. Landcare) and local conservation authorities.
Fox	1. Monitoring populations and environmental impacts using ground surveys. 2. Control through poisoning, shooting and trapping by local land managers.	1. More research on quantifying environmental damage, particularly native fauna predation, in relation to fox densities. 2. Biological control. More research on immunocontraceptives. 3. Increased involvement of land management groups (e.g. Landcare) and local conservation authorities.
Rabbit	1. Monitoring populations and environmental impacts using ground surveys (e.g. warren counts, spotlighting), and rabbit 'activity' (e.g. droppings, grazing) surveys. 2. Myxomatosis virus, fumigation and ripping of warrens, rabbit-proof fencing, and poison baiting (e.g. 1080 and anticoagulants), Rabbit Calicivirus Disease (RCD) following trials on Wardang Island and spread of disease onto mainland 1995.	1. More base-line research on standardising assessments of rabbit abundance. 2. More research on quantifying environmental damage, particularly, native vegetation loss in relation to rabbit densities. 3. Biological control. More research needed on ameliorating buildup of resistance to myxomatosis, on effective vectors of myxomatosis (e.g. fleas) and use of myxomatosis strains that cause long survival time to death thereby increasing infection rates; rapid haemorrhaging virus; and immunocontraception techniques. Proposed vectors for the last two are unknown. 4. Increased involvement of land management groups (e.g. Landcare) and local conservation authorities to address ameliorating habitat modifications that promote rabbit numbers.
Goat (feral)	1. Monitoring populations and impacts by ground and aerial surveys. 2. Control though shooting, trapping and mustering.	1. More baseline research on standardising assessments of goat abundance 2. More research on quantifying environmental damage, particularly to isolated native plant and animal populations.
Black rat	1. Monitoring populations and impacts by trapping. 2. Control by shooting, trapping, poisoning.	1. More research on population estimates, ecology, non-plague refuge characteristics and impacts on native fauna. 2. Research on impacts on non-target animals by control methods.
Mouse	1. Monitoring populations and impacts by trapping. 2. Control by trapping and poisoning, mouse proof barriers, manipulation of habitats, prediction of plagues.	1. More research on population estimates, ecology, non-plague refuge characteristics and impacts on native fauna. 2. Biological control. More research on immunocontraceptives, parasites, etc. 3. Research on impacts on non-target animals by target methods.
Common starling	1. Monitoring of populations and impacts by direct observation. 2. Control by shooting, poisoning exclusion netting and scare tactics.	1. More research on impacts upon native species, particularly those using nest hollows. 2. More research on control methods.
Cane toad	1. Monitoring of populations and impacts by direct observation. 2. Control by removal of animals from areas.	1. More research on long-term impacts and niche occupancy. 2. Research into biological control methods e.g. parasites and infectious diseases known from country of origin.
Carp (European carp)	1. Monitoring of populations and impacts by direct observation. Assessment of changes to habitat after carp introduction. 2. Control by commercial fishing, electro-fishing and poisoning.	1. More research into biological control e.g. virus, release of sterile males. 2. Research into commercial and recreational uses of carp.
Mosquito fish (Gambusia)	1. Monitoring of populations and impacts by surveys of fish and aquatic invertebrates in affected areas. 2. No control methods currently used.	1. More research into the use of native fish in artificial habitats for mosquito and midge control. 2. Research into biological control of mosquito fish e.g. release of sterile males or use of a virus such as *Rhabdovirus carpio*.

Source: Denny 1992; Pollard 1989; CSIRO & BRS 1995; NSW Fisheries 1996.

Table 9.3.10 Recommendations for management of and research on selected plants and algae

Common name	*Present management*	*Future management (including key further research and new control recommendations)*
Bitou Bush/Boneseed	Monitoring of populations and impacts by direct observation. Control by direct removal, herbicides, fire and biological control (moth).	Research rehabilitation methods. Establish seed bank for revegetation. Investigate impact of current control methods on native communities.
Blue Thunbergia	Monitoring of populations and impacts by direct observation. Control by direct removal and herbicides.	Eradication of breeding populations. Declare compatible strains a prohibited import. Establish biological control programme. Remove from commercial sale. Initiate public awareness campaign.
Buffel Grass	Monitoring of populations and impacts by direct observation. No current control methods used.	Resolve conflict of interest between pasture/soil stabilisation objectives and conservation objectives.
Bridal Creeper	Monitoring of populations and impacts by direct observation. Some biological control attempted.	More research into ecology of creeper. More research into biological control.
Giant Sensitive Plant	Monitoring of populations and impacts by direct observation. Control by direct removal and herbicides.	Research into post control regeneration methods. Monitor and avert spread to new areas. Fund surveillance of Aboriginal land. More research into biological control.
Mission Grass	Monitoring of populations and impacts by direct observation. No current control methods used.	Identify agents of spread and constraint on spread. Clarify taxonomic confusion with P. pedicellatum. Research impacts on native communities.
Parkinsonia	Monitoring of populations and impacts by direct observation. Control by direct removal, herbicides and biological control.	Monitor ephemeral wetlands to establish threat to waterbird habitat. More research into biological control.
Prickly Acacia	Monitoring of populations and impacts by direct observation. Control by direct removal and herbicides.	Reserve and manage representative areas of Mitchell grasslands for conservation. Research impacts of grazing on prickly acacia for defining conservation management strategies. Basic research into ecology of plant.
Rubber Vine	Monitoring of populations and impacts by direct observation. Control by direct removal and herbicides.	Establish priorities and develop management plans for conservation of dry rainforest and gallery forests of high conservation value. Map distribution and monitor spread in key areas. Define relationship between grazing, fire and rubber vine establishment for integrated management. Restrict grazing in Forty Mile Scrub. Monitor and avert spread to NT and high conservation areas of Qld. Research into autoecological studies, including seed dispersal mechanisms and seed longevity.
Salvinia	Monitoring of populations and impacts by direct observation. control by direct removal, biological control and herbicides.	More research into biological control. Continue public awareness campaign.
Tamarisk	Monitoring of populations and impacts by direct observation. No current control methods used.	Initiate biological control programme. Declare a noxious weed in all States. Survey homestead plantings and remove plants from any areas where they could escape into natural conditions Investigate taxonomic. confusion.
Semi-aquatic weeds *(Hymenache amplexicaulis, Brachiaria mutica and Echinoloa polysachya)*	Monitoring of populations and impacts by direct observation. No current control methods used.	Review planting policies. Develop strategy to control spread into non-target areas. No further introductions of these species.
Water Hyacinth	Monitoring of populations and impacts by direct observation. Control by direct removal, water management, biological control and herbicides.	Maintain integrated control programmes More research into biological control.
Japanese Kelp	Monitoring of populations and impacts by direct observation. No current control methods used.	Research into ecological impacts. Prevention of further introductions from ship ballast. Monitor spread.

Source: Humphries et al. 1994.

environmental impacts; and ii) a broader range of control options than is presently employed.

Two important Federal legislative Acts exist for curtailing the future importation of animals and plants. These are the Wildlife Protection (Regulation of Imports and Exports) Act 1982 and the Quarantine Act 1908. The former regulates the importation of species which pose a threat to the natural environment, while the latter relates mainly to primary production, especially in relation to exotic pests and diseases.

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9.4 Pressures from recreational and tourist activities

Introduction

Australia's natural qualities have long been valued by locals and visitors alike. The main attraction for overseas visitors continues to be Australia's unique and diverse environments. The growing ecotourism industry specialises in promoting areas that are rare, special or fragile. These are generally priority areas for conservation, or "hotspots, because of their high biodiversity, high endemism, and rapid rates of habitat conversion" (World Bank 1992 cited in Hohl & Tisdell 1993, p. 3). Hotspots only cover about 0.5% of the earth but it is estimated that they contain 20% of its species (ibid).

Australia is placed in "the fastest growing tourism region in the world", the Asia Pacific (ACF, ACTU & DEET 1994, p. 161). Over 70% of international visitors to Australia have identified as the main reasons for their visit the unique flora and fauna, and the open landscape (ATC 1993 cited in ACF, ACTU & DEET 1994, p. 163). Total visitor nights from selected regions over recent years are shown in Table 8.2.8.

A number of State-wide and regional studies are underway into the impacts of specific recreational activities on the environment. However, few studies to date have produced quantitative data on the impact of recreation and tourist activity. The problem for such studies, especially those done on a large scale, is that Australia's environment is so varied. Most studies looking at recreational impacts have been primarily concerned with developing frameworks for measuring and managing impacts. A nationwide measure of impacts on the Australian environment by any recreational activity is yet to be completed.

The nature and intensity of environmental impacts from recreational and tourist activity depend on the type, level and seasonality of that activity. The activity must be considered in relation to the ecosystem's response; that is, the latter's sensitivity to and response to the activity, and activity thresholds (see Figure 9.4.1). Existing information is largely in the form of case studies and anecdotal observation.

Therefore, it is critical that each activity be examined, along with its supporting infrastructure and the context of the environment in which it occurs. Initially we can approach this by looking at biogeographic regions; identifying areas that are inherently sensitive and looking at

9.4.1 Erosion (a) of a walking track in Southwest national park, Tasmania, Nov 1993

(a) Erosion in many areas has been hastened by water flow.
Source: PWS unpub.

these areas in relation to tourist activity. This section uses case studies as a way of highlighting the types of impacts one might expect in specific regions. This is useful as it provides an overview of potential impacts and responses to those impacts. Each of the case studies looks at the biogeographic nature of the area, the tourist activity, the potential or actual impacts, the effects of these impacts, and the management strategies designed to reduce these impacts where applicable.

Tourist activity as an indicator of pressures

Only those recreational activities that involve the use of nature have been included in the analysis in this section. Activities such as gardening and cricket become equally as valuable an indicator of pressures as do more traditional environmental recreation activities such as bushwalking and scuba diving. Kenchington (1993, p. 5) defined a number of environment conditions and described the recreation-based impacts (see Table 9.4.2). Kenchington's definition of wilderness is more restrictive than those used by agencies such as the Australia Heritage Commission, the Wilderness Society and the Parks and Wildlife Service (Hawes 1996 pers. comm.). These organisations consider that low level evidence of human activity, such as walking tracks and huts, is acceptable in defining wilderness. There are further definitions that specify the degree of wilderness quality; Kenchington's definition does this to a degree in defining levels of naturalness. Although definitions vary, there is a consensus that wilderness must satisfy the criteria of naturalness and remoteness; that is, that the area is in a largely natural state and evidence of technological activities is absent.

9.4.2 Relationship between Environment condition and recreational impacts

Condition	*Description*
Wilderness (a)	No detectable human works or impact. No visitation other than for the purposes of management monitoring or approved scientific research.
Natural/ hardened	Minimal works, conducted to harden or protect the environment from nature-based recreation. Examples include pathways to prevent erosion and barriers to keep visitors away from critical sites.
Natural/ facilitated	Limited works, conducted to improve access for nature-based recreation. Examples include jetties for rocky shore landings, steps in rough terrain, walking tracks and access for disabled visitors.
Natural/ enhanced	Limited works, conducted to enhance the nature-based recreation experience. Examples include signing and labelling, interpretive display and visitor centres.
Environmental Park	Works to facilitate nature-based recreation. Examples include jogging tracks, cross-country ski-trails, roads and boat ramps.
Environmental Sports Park	Substantial works to modify environmental structure to the minimal extent necessary to provide for structured sports. Examples include ski-lifts, recreational harbours and marinas.
Synthetic	Substantial works to create an environmentally pleasing setting for leisure. Examples include golf courses, sports fields, swimming pools, boating lakes and tennis courts.
Alienated	Substantial works to create recreational facilities unrelated to the local natural environmental structure. Examples include fantasy parks, indoor sports facilities, casinos and shopping centres.

(a) Definitions of 'wilderness' vary; however, there is the consensus that wilderness must satisfy the criteria of naturalness and remoteness. The Australian Heritage Commission and other organisations include low-key evidence of human activity in determining their definitions of wilderness (Hawes 1996, pers. comm.).

Source: Kenchington 1993, p. 5.

Tourist activity is not a complete indicator of pressures from recreational activities as it does not account for those activities undertaken by locals. However, tourist indicators are useful as the available data are reasonably reliable, and it is an area of increasing interest.

Recreational activities, such as cricket, golf and gardening, also impact on the environment. The degree to which they impact depends upon the environment in which they take place. Fertilisers and irrigation can both have a deleterious effect on the local environment. However, as runoff from playing fields and gardens cannot be measured separately, it is difficult to measure and attribute impacts to such recreational activities. The usefulness of attributing degrees of impacts to activities that are an aspect of urbanisation is debatable.

The pressures that gardening can have on the environment are reflected in the attitudes that recreational gardeners have towards the environment. While most recreational gardeners would change their behaviour to reduce weed infestation of local bushland, around 7% of gardeners would not change their behaviour (see Figure 9.4.3).

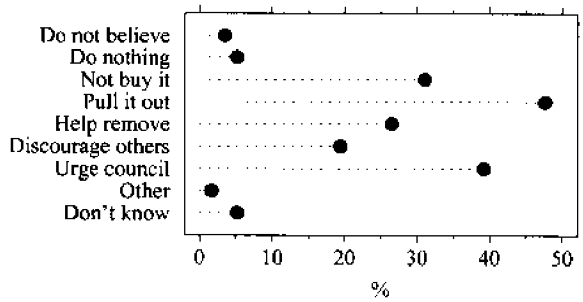
Hall (1994, p. 144) identified that an area missing in the focus on ecotourism has been the impacts of tourism "on host communities and their relationship with the environment". By linking the environment to economic imperatives, the cultural and social importance of natural areas may be lost. Existing data in relation to the environment and recreational and tourist activities focuses on the economic benefit derived from the environment.

Identifying areas of sensitivity

The Australian Nature Conservation Agency (ANCA) developed an Interim Biogeographic Regionalisation for Australia (IBRA) in 1995 in order to plan National Reserves Systems (NRS). IBRA integrates existing State and Territory regionalisations together with data sets and field knowledge. It is considered that "regionalisations provide a useful framework for focussing attention, summarising patterns, aggregating information, and allocating resources and priorities in nature conservation" (eds Thackway & Cresswell 1995, p. 1). IBRA is important because it is concerned with looking at biogeographic regions and is not constrained by State borders.

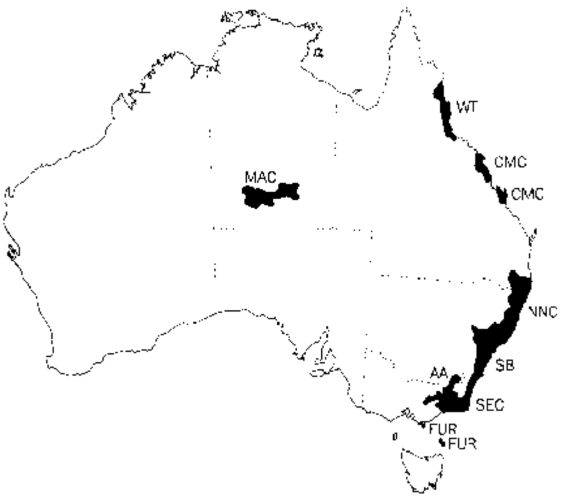
As part of the formulation of the IBRA, general categories were identified that indicated constraints to the planning of NRS. The

9.4.3 Attitudes of recreational gardeners (a) to weed infestation in native bushland, Victoria, 1994



Note: Respondents may have given multiple responses.
(a) People who garden at least monthly, and who enjoy gardening.
Source: ABS Population Survey Monitor 1994, unpub.

9.4.4 IBRA regions identified as having tourism as a major impact



Source: eds. Thackway & Cresswell 1995.

constraints identified were regarded as those activities, or factors, that had the greatest adverse impact on the biodiversity of the region. Therefore it is useful to look at those areas where tourism was considered to be a dominant limiting factor. IBRA is an interim measure undertaken to identify gaps within data sets and should not be thought of as a definitive regionalisation; however, it is the most comprehensive. A full map of the IBRA can been seen in Section 7.1.

Map 9.4.4 shows the areas considered to have tourism as a dominant limiting factor in the region. They are the MacDonnell Ranges, the wet tropics, the Central Mackay coast, the New South Wales north coast, the Sydney Basin, the south-east corner, the Australian Alps, and Furneaux (the Corner Inlet, Vic. and the Bass Strait Isles). IBRA is only an indicator of the dominant impacts. For some regions, tourism may be impacting adversely, but at the time of the field work other impacts were considered to be more dominant. The absence of it as a factor may simply mean that tourism has not been studied as an impact in the region.

An area that illustrates this limitation is the region covering the west and south-west of Tasmania. Much of Tasmania is part of a World Heritage Area; the dominant threatening processes are identified as mining and forestry (eds Thackway & Cresswell 1995, p. 55). While this is true it overlooks the indirect threats such as damage to viewfields and reducing the remoteness of the wilderness area.

Studies undertaken by the Parks and Wildlife Service (PWS) of Tasmania have identified several areas that have been severely degraded as a direct result of tourist activities in the area. This will be discussed in more detail later in this section.

Different types of impacts occur in different ecosystems. This is due to the nature of the ecosystem and the activities that occur in that region. IBRA is useful in identifying areas sensitive to tourist activities and further identifying areas that are biogeographically similar. The threshold of recreational activity and tourist activity for a region can be gained from looking at the activities in relation to the region's environment.

Impacts are summarised in Table 9.4.5; this is not an exhaustive list of impacts to which tourism contributes, but an indicator of general impacts expected.

The *State of Environment Reporting by Local Government* (EPANSW 1993, p. 8) suggests that indicators of areas of environmental sensitivity should measure changes in the condition of various types of ecosystems, such as wetlands, bushland and rivers. In order to do this, baseline measures are needed of these ecosystems. This is

9.4.5 Environmental impacts to which tourism may contribute

Disturbance type	Impacts on flora and fauna
Common impacts to most environments	Clearance and damage to vegetation at accommodation/shelter sites, along transport and service links.
	Introduction of exotic species.
	Nutrient impact on vegetation.
	Increase fire risk/frequency.
	Barriers to wildlife movement and migration of some species to other areas
	Shooting/killing/destruction of wildlife.
Critical impacts	
Aquatic	Anchor damage to coral reefs.
	Potential loss of fish breeding grounds and death from contamination.
Coastal	Impacts on migratory birds and fish.
	Loss of mangrove swamps and coastal wetlands.
Alpine	Increase fringe effect on alpine forests.
	Magnitude of impacts increase because of short growing/germination season.
	Seasonal impacts.
National parks	Increase fringe effects.
	Greater sensitivity to imported/exotic species.
Forest/ woodland	Increase fringe effect on forest area.
Semi-arid/arid	Short germination/breeding season — greater sensitivity to external shocks.
	Seasonal use means ecosystem has to withstand greater shocks.

Source: Ecologically Sustainable Development Tourism Working Group 1991.

another aspect for which data have been lacking. Some National Parks have data on the state of the environment in the park, but this measurement has only recently commenced, and there is no reliable measure of the pristine state of these areas.

As impacts on the environment occur at a regional level, case studies are at present the most useful way of determining impacts on an area. This section has taken four areas in Australia where tourism and recreation may have an impact. In looking at the pressures it is valuable to examine the management strategies undertaken that have helped rehabilitate impacted areas, and also to note areas where these activities have had a positive effect on the environment.

The impact of ecotourism is a sensitive issue as the industry derives its assets from the apparent pristine nature of a region. However, Kenchington (1993, p. 2) has pointed out that "recreation through tourism can provide economic and social logic to fund management". The impetus for environmental management and conservation often comes from the amenity values.

Case study 1 — Southwest National Park, Tasmania

Thackway and Cresswell (eds 1995, p. 71) describe the west and south-west biogeographic region of Tasmania as:

> "Perhumid cold lowlands, low hills and low ranges, comprising a complex mosaic of rainforest, scrub and buttongrass moorlands. Soils generally oligotrophic acid peat. Principal land uses are conservation, mining and forestry."

The Western Arthur Range is part of this biogeographic region. The area, while not appearing on maps, is recognised by park managers and walkers alike.

The environment throughout much of the range is inherently fragile. As the vegetation is fragile, recovery rates are slow in the alpine areas of the range. The soils are mainly organic and waterlogged. Underlying this, the subsoil consists of materials such as gravel which erode easily, especially on slopes and when subjected to water flow. Soil accumulation rates are slow at all altitudes, and once substantial erosion occurs the chance of recovery is low. Any impacts are accentuated as the environment has an extremely slow recovery rate.

The area is part of the Southwest National Park, which has been part of the Western Tasmania Wilderness National Parks World Heritage Area (WHA) since 1982 (Driml 1994, p. 37). The Tasmanian alpine ecosystem is special as the majority of its endemic species are of Gondwanan origin (DEST 1994, p. 36).

Tasmania's wilderness area has long been regarded as a Mecca for those seeking to experience pristine wilderness. It is regarded world-wide as one of the few remaining true wilderness areas (PWS Tasmania 1995, p. 1).

The increasing number of walkers in the area "has led to a rapid deterioration in the condition of walking tracks" and areas surrounding tracks (ibid). Track inventories have highlighted the fragility of the area as extensive damage has occurred in some parts despite relatively low usage. The *Walking Track Management Strategy (Penultimate Draft) (1994)* includes a summary of findings on degrees of walker induced damage under a number of criteria.

Tracks were measured for:

- trampled pad (visibly trampled but with intact vegetation);
- vegetation removed;
- moss/litter cover;
- mud of depth >10cm and >25cm;
- erosion of depth >10cm and >25cm; and
- track braiding (PWS 1994, p. 12).

9.4.6 Track conditions in the Western Arthur Range (a)

Track condition	*% of track* %	*Length* km	*Projected length (b)* km
No Pad	7.8	4.4	3.7
Pad (trampled vegetation)	6.6	3.8	3.3
Moss/Litter	5.6	3.2	3.2
Bare	88.2	50.3	51.9
Mud >10cm	15.3	8.7	14.2
Mud >25cm	5.0	2.9	4.7
Erosion >10cm	56.2	32.1	39.9
Erosion >25cm	29.6	16.9	27.9
Local braiding	5.2	3.0	na

Note: totals exceed 100% due to track experiencing more than one condition.
(a) Including access tracks, total length of track measured is 57km.
(b) Projected over 20 years where usage continues at current levels.
Source: PWS 1996 unpub.

9.4.7 Current estimated annual usage, Western Arthur Range

Section	*Visitors*
Western end: Moraine A — Lake Oberon	500
Central traverse: Moraine K — Lake Oberon	150
Eastern end: Moraine K — Lake Rosanne	75

Source: PWS 1996 unpub.

The Inventory did not measure those tracks for which track management plans had already been implemented. This was acknowledged as an oversight, as between 5 and 10% of the track system was excluded from the Inventory (Hawes pers. comm. 1996). These were sections of the Overland Track, the Port Davey Track, the western half of the South Coast Track, the Southwest Cape Circuit, and parts of the Anne Range. It is estimated that, had these tracks been included in the Inventory, the total length track erosion deeper than 25cm would be 200km (ibid), compared to 120km of the WHA measured to be deeply eroded (PWS 1994, p. 16).

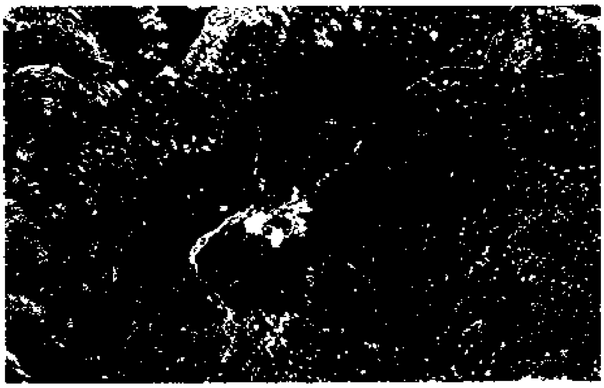
There are 57km of track in the Western Arthur Range. 56% of the track is moderately eroded, while 32% is heavily eroded (see Table 9.4.6). Rainfall in the region in the late 1980s was below average; had there been normal rainfall in the time preceding the inventory, track conditions may have been considerably worse (PWS 1994, p. 15).

In addition to track erosion and damage, there is the risk of introduced soil pathogens. Of particular concern is the soil pathogen *Phytophthora cinnamomi* which can be spread in the mud of walkers' boots, tent pegs and other kit. This pathogen affects a wide range of plant species and can cause permanent changes to moorland, heathland and dry sclerophyll floristics. A major access route to the Western Arthurs is infected with *P cinnamomi*. The PWS has introduced a number of measures to control

9.4.8 Illustration of campsite degradation: High Moor

Source: PWS unpub.

9.4.9 Aerial view of unplanned tracks and campsite degradation: High Moor



Source: PWS 1996 unpub.

the infection. These include walker education and the installation of washdown stations on the border of uninfected areas, usually at creeks which flow into infected areas, with scrubbing brushes and hardened platforms so that walkers can wash the mud from their boots and gaiters (Hawes 1996, pers. comm.).

The Parks and Wildlife Service has divided the Arthur Range into sections, and has estimated usage in those sections (see Table 9.4.7). High Moor is a remote campsite located in the Central traverse. The campsite is estimated to have less than 150 visitors each year, most of whom use the area in summer. It is only in the last twenty years that any measurable number of walkers have been using the site yet Figure 9.4.8 shows significant erosion. The aerial view (see Figure 9.4.9) clearly illustrates the problem of unplanned tracks around campsites. The photograph also illustrates the impact on the campsites; the white patches are campsites from which the original peat has been eroded, exposing sand and gravels. There are four major campsites in the Arthur Range, all of which are suffering from extensive damage (PWS, unpub.), and over six minor campsites, some of which are used only occasionally. Within the WHA there are 265 campsites listed on the campsite inventory (see Table 9.4.10). It is suspected that there are more campsites with a Frissell rating of 1 or higher that have not yet been included in the inventory.

The Western Arthur Range falls within the Bureau of Tourism Research (BTR) division known as the South-West; the breakdown of this region offers the most recent valid data available. The South-West Division includes Port Davey and Strathgordon. In 1990–91 it was estimated that 34,000 domestic visitor nights were spent in the area, with 6,000 international visitor nights in 1991 (BTR 1995b, p. 9).

9.4.10 The impact status of listed (a) campsites in the Tasmanian World Heritage Area

	Number of campsites	*Proportion of campsites*
Frissell Rating (b)	*No.*	*%*
1 or 1+	63	24
2 or 2+	64	24
3 or 3+	82	31
4 or 4+	42	16
5 or 5+	11	4
No rating recorded	3	1
Total	**265**	**100**

(a) Campsites listed in the Parks and Wildlife Service inventory.
(b) Indicates the degree of impact on a scale of 1–5; 1 is nearly pristine, 5 is heavily impacted. This rating scheme was devised in 1978 by S. S. Frissell and has been modified by the PWS for Tasmanian conditions.
Source: PWS 1996, unpub.

The Parks and Wildlife Service has projected costs over twenty years and has submitted strategies to implement a permit system and stabilise existing tracks in the Western Arthur Range. It estimates that, even with restricted access through a permit system, it would cost $1.7 million to stabilise tracks in the Western Arthurs, rising to $2.5 million if there was no permit system implemented (PWS 1996, unpub.). In the longer term, further expenditure may be required to stabilise the entire track system.

The PWS has developed management strategies including track and campsite hardening; track and campsite relocation, modifying user behaviour and restricting user numbers. In the Western Arthurs some of these strategies have already been implemented. The PWS considers that an absence of publicity of sensitive areas is another key to preserving the wilderness qualities of the Southwest National Park.

Case study 2 — Great Barrier Reef, Queensland

"The Great Barrier Reef (GBR) is the most managed environmental region in Australia" (Bowen 1994, p. 234). The reef stretches from the Cape York Peninsula to Bundaberg; it adjoins the Wet Tropics and Cape York Peninsula IBRA regions. The Wet Tropics comprise "wet coastal ranges and plains; rainforest and forests" (Thackway & Cresswell 1995, p. 71), while the Cape York Peninsula is described as having "low hills and plains, woodlands and having a tropical humid/maritime climate" (ibid, p. 64). Tourism has been identified as causing a major adverse impact on biodiversity of the area (ibid, p. 55). These areas are of environmental significance, and on the World Heritage List (Coveney 1993, p. 29). In looking at the GBR it is essential to consider the area surrounding the Reef. This is the area that supports the tourist activity generated by the Reef. Most damage to the Reef is through nutrient enrichment from surrounding settlements (Kelleher and Dinesen 1993, p. 52)

In 1975 the Great Barrier Reef Marine Park (GBRMP) was established (Benzaken 1995, p. 5). Since its inception into the World Heritage List in 1981, the popularity of the GBR as a tourist destination has grown. BTR surveys indicate that, while there have been fluctuations, tourism has continued to increase (see Table 9.4.11). Tourism has been, and continues to be, a growing industry in the region, especially surrounding Cairns. These tourists undertake a number of recreational activities, each varying in its impact. Kelleher and Dinesen (1993, pp. 48–9) outline the actual and potential impacts from tourism on the Reef:

- anchor damage to coral (reef);
- removal of mangroves and other natural features for tourism developments;
- land reclamation;
- excavation and dredging;
- effects of fixed and moored structures on corals and fish communities;
- recreational fishing and collecting;
- damage to coral from intensive diving and reef walking;
- waste discharge and littering from vessels;
- effects of fish feeding on fish communities; and
- amenity impacts (displacement of 'low key' recreational use of sites by more intensive tourism; andcultural impacts, particularly in relation to Aboriginal and Torres Strait Islander peoples.

9.4.11 Tourist nights, Far North Queensland

Domestic tourist nights		*International visitor nights*	
Year	*'000*	*Year*	*'000*
1989–90	5 486	1989	2 702
1990–91	4 535	1990	3 404
1991–92	6 482	1991	3 284
1992–93	5 975	1992	3 312
1993–94	6 177	1993	3 326

Source: BTR 1995a, p. 8.

9.4.12 Recreational activities permitted in the zones of the Great Barrier Reef Marine Park

	General Use		*Marine National Park*				
Activity	*Zone A*	*Zone B*	*A Zone*	*Buffer Zone*	*B Zone*	*Scientific research Zone*	*Preservation Zone*
Boating	Yes	Yes	Yes	Yes	Yes	No	No
Collecting (e.g. shells, coral, fish)	Permit	Permit	No	No	No	No	No
Diving, snorkelling, swimming	Yes	Yes	Yes	Yes	Yes	No	No
Line fishing (hand held)	Yes	Yes	Yes	No	No	No	No
Netting	Yes	Yes	Permit	No	No	No	No
Trolling	Yes	Yes	Yes	Yes	No	No	No
Spear fishing (not with scuba)	Yes	Yes	No	No	No	No	No
Traditional fishing	Yes	Yes	Yes	Permit	Permit	Permit	No

Source: ACIUCN 1986 cited in Coveney 1993, p. 74.

Studies on the impacts of anchor damage to the GBR are currently under way but as yet no data are available. Preliminary research has highlighted the types of impacts expected on the Reef; the extent of each of these impacts is yet to be measured.

The city of Cairns is one of the major tourism centres outside the capital cities. Cairns experienced population growth of 1.5% between 1993 and 1994, compared to 1% for Australia (ABS 1995, 3227.0). Much of this growth can be attributed to the close proximity of Cairns to the Reef. Since the introduction of high speed passenger catamarans, reefs previously inaccessible have been opened up to tourists.

Recreation on the Reef may comprise the enjoyment of nature and the scenery, swimming, fishing, snorkelling, diving, or boating. The GBRMP has been divided into seven zones (see Table 9.4.12), each of which has defined boundaries on recreational use in the park. Tourist operations take place in all zones except the scientific research zone and the preservation zone.

The main impacts from tourism on the Reef are considered to be from development on the mainland to provide supporting tourism infrastructure (Kelleher & Dinesen 1993, p. 49).

The Queensland Fisheries Management Authority's sub-program 'Recreational Fisheries' is currently collecting information on recreational fishing activities on a State-wide basis in order to gain a comprehensive picture of the state of Queensland's fisheries.

DPI Queensland's preliminary survey (1995) into small mackerel catches gathered some general information into the behaviour of recreational boat-based fishers in Queensland. The survey asked people with registered boats (vessels with engine capacity of 4hp and greater) to recall their fishing activities for the previous twelve months. Of those registered boat owners approached, 84% responded to the survey. The results are summarised in Table 9.4.13.

In the preceeding 12 months, 68.1% of respondents had used their vessel for fishing.

9.4.13 Areas most frequented by boat-based recreational fishers, Queensland 1993–94 (a)

Statistical Division	*Tidal rivers, estuaries, bays* %	*Offshore reefs, openwater* %	*Other (b)* %	*Average length of outing* hours
Brisbane	78.2	9.0	11.0	5.2
Moreton	70.2	14.7	14.7	4.6
Wide Bay – Burnett	72.7	12.8	14.0	4.7
Fitzroy	59.3	21.2	19.2	5.1
Mackay	51.3	33.6	15.1	5.0
Northern	58.8	27.5	13.7	5.3
Far Northern	47.9	32.0	15.0	5.4
Total	**67.4**	**17.6**	**14.8**	**5.0**

Note: percentages may not add due to rounding.
(a) Survey period was from May– October 1994; respondents were required to recall their fishing activity for the previous 12 months.
(b) Other may include: freshwater rivers and dams, or a combination of tidal rivers, estuaries, bays, offshore reefs and openwater.
Source: DPI Queensland unpub.

Respondents from the Fitzroy, Mackay, Northern and Far Northern regions would all have a potential impact on the reef (Cameron 1996, pers.comm.). In the Far Northern region (Cairns and north), 66.5% of respondents had used their boat for recreational fishing in the last twelve months. Of those, 32% did most of their fishing in offshore reefs and open water. The average time spent fishing in the region was 5.4 hours, as compared to the Queensland average of 5 hours for each fishing day.

The potential impacts from recreational fishing on the Reef are:

- anchor damage on the reef;
- water quality issues (turbidity and boat exhaust); and
- biodiversity concerns.

The GBRMPA allows hand held line fishing in three of the seven zones and trolling is allowed in four of the seven zones (see Table 9.4.12). Monitoring of biodiversity shows that fishing is not a major issue in looking at the impacts on the Reef. The Authority considers the major impacts to be "from mainland-derived water quality changes", specifically nutrient enrichment, "and perhaps from fishing" (Kelleher & Dinesen 1993, p. 52). In the same paper Kelleher and Dinesen (p. 7) point out that, by raising people's awareness of the issues, tourism has the potential to positively impact on protection of the park's qualities.

Case study 3 — Fleurieu Peninsula and Kangaroo Island, South Australia

Kangaroo Island and the Fleurieu Peninsula are in the Lofty Block IBRA region. This region is described as "temperate"; "well-defined uplands" from the Cambrian geological period, with marine sediments from the late Proterozoic period; "eucalypt open forests and woodlands and heaths on mottled yellow and ironstone gravely duplex soils in the wetter areas and red duplex soils in drier areas", now largely cleared for urban and agricultural development (Thackway & Cresswell 1995, p. 67). The region contains lakes and wetlands; the plateau is 300–400 metres above sea level (ABS 1996, 1301.4, p. 291). Kangaroo Island is a geological extension of the Mount Lofty-Flinders Ranges System. The island has some of the world's most impoverished soil (ABS 1994, 1301.4, p. 313). The region encompasses the mouth of the Murray River, Hindmarsh Island, Victor Harbour, Goolwa, Flinders Chase National Park annexe, Little Sahara and Seal Bay.

The Fleurieu Peninsula and Kangaroo Island region is a useful case study as it attracts well over 1 million tourists each year (see Table 9.4.14), mostly in summer. The region is a major summer holiday destination for people from Adelaide. The area offers a wide range of activities to tourists. Kangaroo Island in particular has a wide range of environments that support many nature-based recreational activities.

As the region is close to Adelaide it receives a high proportion of day trippers. There are a number of potential impacts on the environment of a coastal town that has high tourist-based population variation.

They include:

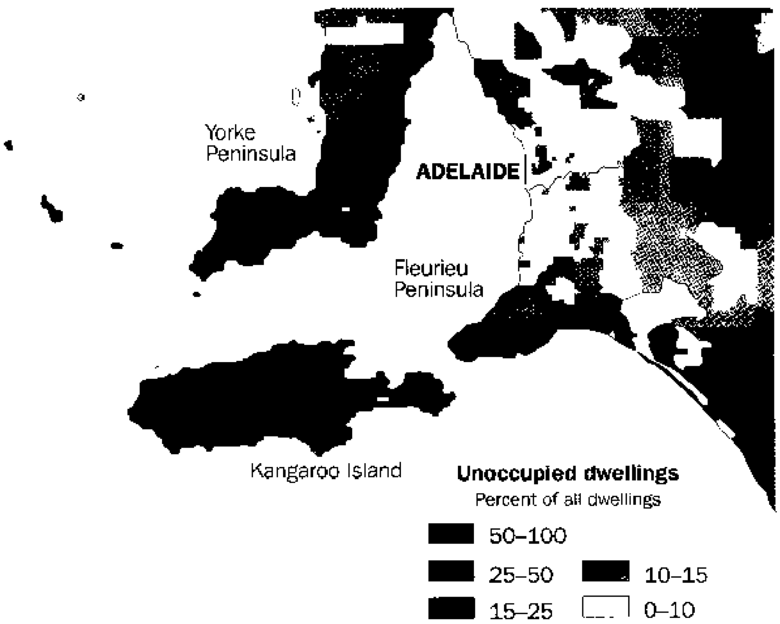
- clearance/damage to vegetation at accommodation/shelter sites, along transport and service links;
- water quality issues arising from water-based recreational activities and from seasonal stresses on facilities;
- dune destabilisation;
- barriers to wildlife movement and migration of some species to other areas;
- impacts on migratory birds and fish

9.4.14 Tourist nights, Fleurieu Peninsula and Kangaroo Island

Fleurieu Peninsula (a)				*Kangaroo Island*			
Domestic tourist		*International tourist*		*Domestic tourist*		*International tourist*	
Year	*'000*	*Year*	*'000*	*Year*	*'000*	*Year*	*'000*
1990–91	1 364	1990	19	1990–91	167	1990	30
1991–92	1 276	1991	26	1991–92	388	1991	37
1992–93	866	1992	10	1992–93	338	1992	34
1993–94	1 003	1993	14	1993–94	361	1993	33

(a) Includes Adelaide Hills.
Source: BTR 1995c, p. 8.

9.4.15 Unoccupied dwellings, Fleurieu Peninsula and Kangaroo Island (detail), 1991



Source: ABS Census of Population and Housing 1991, unpub.

- pressures on coastal wetlands; and
- slow recovery rates and heightened sensitivity in arid and semi-arid areas.

(Ecologically Sustainable Development Tourism Working Group 1991).

The Murray Mouth estuary is listed as "Ramsar Wetland of International Importance" (Edyvane et al 1996, p.i); therefore, it is protected under international law. However, the need exists for management planning processes that include a zoning framework. (Edyvane et al 1996, p. v-vi). "Coastal development, ... and boaters have the potential to significantly affect both wetland habitats and species" (ibid). Boating in particular has the potential to impact heavily upon aquatic plant communities. Murray Watch is a community inititative, by councils along the Murray, aimed at lifting community involvement in the care and protection of the river and its wildlife. People are urged to report incidences such as effluent discharge, the taking of protected or undersized fish, and inappropriate action in national parks (Murray Watch, brochure).

In 1983-84 a statewide survey was conducted into recreational fishing (Philipson et al 1986). The survey found that the Fleurieu Peninsula attracted between 4.8% and 8.4% of fishing effort each quarter; when limited to boatfishing only, the area attracted between 5% and 10.6% (Philipson et al 1996, p. 11). Kangaroo Island attracted between 1 and 3.3%. A more recent study of the Fleurieu Peninsula extimated that 76, 000 hours were spent fishing over a twelve month period until March 1995 (Kinloch & McGlennon, 1996, unpub.). The main species caught by recreational fishers during this period were; garfish, King George whiting, calamary, and Australian herring.

The dunes of the Fleurieu Peninsula have also been impacted by recreational and tourist activity. Dune destabilisation from urban development has occurred on the Fleurieu Peninsula. Much of this development is for holiday homes (see Figure 9.4.15). Building of these homes on the primary dunes of towns such as Goolwa, Victor Harbour, Port Elliot and Middleton has led to serious dune erosion. A number of strategies have been implemented in Goolwa to 'reclaim' the dunes (District council of Port Elliot and Goolwa 1996, unpub.).

The *Kangaroo Island Sustainable Development Strategy 1995/96* outlines the need for data on limits of acceptable change (LAC) (p. 51). As the area continues to receive increasing tourist numbers, the measures of LAC will become fundamental to preserving the amenity values of the region.

Case study 4 — Kosciusko National Park, New South Wales

The Kosciusko National Park (KNP) covers 690km^2 of the Australian Alps (Driml 1994, p. 43). This alpine region consists of a high undulating plateau, which has evolved over a long geological time period (Good 1995, p. 251).

9.4.16 Length of stay for visitors to the 'High Country' of the NSW Southern Alps

Length of Stay	Winter 1994 %	Summer 1994/95 %
1 day	45	20
1–3 nights	25	37
4+ nights	33	43

Note: Figures may not add due to rounding.
Use caution in viewing these data due to the small sample size and seasonal variation in this size.
Source: NSW PWS 1995, p. 80.

Due to deep soil cover over most of the Alps there is a high plant endemism (ibid). The Alps are dominated by herbfields, other treeless communities, snow gum and montaine alpine ash forests growing below the snow line (Thackway & Cresswell 1995, p. 63).

A visitor study conducted for the New South Wales Parks and Wildlife Service looked at the winter and summer comparisons of visitor behaviour in State National Parks. In looking at the 'High Country', of which KNP is a part, the study found that in winter 45% of visitors visited the region only for the day compared to only 20% in summer. Table 9.4.16 shows the breakdown of length of stay between summer and winter.

The survey collected information on the number of people participating in various activities. It found that, of those sampled in winter, 69% participated in ski and snow activities. Of those sampled in summer, 68% went walking for two or more hours. Table 9.4.18 indicates the extent of participation in the various activities. From this inferences can be drawn about the levels of potential impact from these activities.

The Kosciusko National Park is special in that pressures from recreational and tourist activity are exerted on the environment throughout the year, though the activities differ in the nature and scale of their impact. In the winter, most activity and associated impacts are concentrated in the resorts. In the summer activities are more free ranging over a larger area, but less concentrated.

9.4.17 Tourist Nights: Snowy mountains

Domestic tourist		International tourist	
Year	'000	Year	'000
1990–91	1 529	1990	158
1991–92	1 588	1991	103
1992–93	1 688	1992	101
1993–94	1 557	1993	153

Source: BTR 1995d, p. 6.

9.4.18 Participation in activities, 'High Country' NSW, 1994–95

Activities (a)	Winter 1994 %	Summer 1994–95 %
Birdwatching/Nature activity	10	35
Cycling	1	7
Fishing	6	16
Four Wheel Driving	5	6
Getting away from it all	30	64
Horse riding	1	1
Looking at scenery	66	91
Overnight walk	2	5
Picnic/BBQ	18	31
Rock climbing/canyoning	2	3
Ski and snow activities	69	5
Walk for under 2 hours	7	35
Walk for over 2 hours	5	68
Water activities	1	7
Visiting caves	21	10

Note: Due to small sample size these data should be viewed with caution.
(a) People may have participated in one or more activities.
Source: NSW PWS 1995, p. 81.

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Chapter 10 — Reducing the Pressures by People on the Environment

Chapter 9 presented statistics on a range of pressures which individuals exert on the environment, showing the impact of the Population on the stock of Natural Assets in the PEP model. This chapter maintains the same perspective. Section 10.1 considers the actions individuals take to reduce the pressures on the environment.

10.1 Actions by individuals

The ABS has conducted two household surveys (in May 1992 and June 1994) which examined the actions of people to reduce their impact on the environment.

The topics examined in the 1992 survey included the recycling activity of households, their use of environmentally friendly products, donations of time or money to environmental protection, and membership of groups involved in environmental protection. The 1994 survey provided data on conservation of water, both within dwellings and in its use on gardens, and the incidence of insulation in dwellings.

Recycling

Of the items surveyed as recycled by households the main item was old clothing and rags (ranked as such for 63% of households surveyed), followed by glass, paper and garden waste, as illustrated in Table 10.1.1. Respondents for 15% of households surveyed reported that their households were not involved in any recycling activity. For those respondents who gave a reason why their households either did not recycle more items or recycle at all, the main reason given for 19% of such households was that they believed they did not have enough suitably recyclable materials, as shown in Table 10.1.2. This was followed by the absence of services or facilities for recycling.

Recycling activity was most prominent among households of more than one person, being highest for households consisting of a couple with dependent child(ren), the main item recycled being old clothing and rags, as illustrated in Table 10.1.3. This household type also recorded the lowest incidence of not engaging in any recycling activity.

10.1.1 Items recycled by households, States and Territories, May 1992

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Australia*
	%	%	%	%	%	%	%	%	%
Paper	57.5	67.1	37.2	43.4	59.5	38.4	26.7	64.0	54.7
Glass	51.3	70.0	43.3	56.1	56.9	47.2	15.0	55.6	55.3
Cans	39.5	53.7	34.3	52.4	54.2	26.0	20.8	28.7	44.1
Plastic	33.6	47.9	34.6	33.4	35.1	30.2	14.3	33.2	37.3
Motor oil	8.0	8.7	10.0	7.5	10.6	11.1	*6.7	17.6	8.9
Kitchen or food waste	30.1	40.6	34.2	39.5	36.7	46.4	37.4	41.2	35.6
Garden waste	41.3	52.1	51.1	47.9	45.7	53.6	49.5	52.9	47.3
Old clothing or rags	58.9	66.8	62.9	62.9	69.3	63.7	52.3	73.7	63.3
No recycling	17.6	10.5	18.1	16.0	12.7	19.0	27.6	12.1	15.3
	'000	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*
Total households (a)	**2 085.0**	**1 571.8**	**1 049.3**	**556.0**	**595.7**	**170.5**	**49.9**	**97.3**	**6 175.4**

(a) Totals do not equal the sum of items in each column because more than one item may be recycled.
Source: ABS 1993 (4602.0).

10.1.2 Reasons for not recycling, States and Territories, May 1992: households not fully recycling(a)

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Australia
Reason	%	%	%	%	%	%	%	%	%
No services or facilities	15.0	11.3	28.5	14.7	17.5	18.8	21.7	* 2.8	16.6
Inadequate services or facilities	10.1	5.9	9.1	7.4	12.9	9.4	* 5.3	* 4.8	8.7
Uncertain of services or facilities	4.4	4.7	3.6	4.5	3.6	* 3.1	* 3.6	* 6.4	4.3
Distance	1.6	0.8	2.4	2.0	* 1.3	* 2.9	* 0.9	* 2.0	1.6
Personal reasons	2.8	2.1	2.4	2.1	2.3	* 3.3	* 4.1	* 8.0	2.5
No storage area	5.4	3.2	3.0	4.3	2.4	4.6	* 4.4	* 3.6	4.0
Not interested	9.0	7.0	7.5	10.3	11.3	11.8	* 9.9	13.5	8.7
Not enough recyclable materials	21.2	23.7	14.0	13.4	17.6	12.2	15.9	36.6	19.5
Other	2.2	2.1	1.9	2.0	3.6	* 2.3	* 2.0	* 2.6	2.2
No reason	42.3	47.0	39.3	48.8	38.8	42.5	41.9	31.9	43.1
	'000	'000	'000	'000	'000	'000	'000	'000	'000
Total households	**2 029.7**	**1 506.2**	**1 023.5**	**538.5**	**573.9**	**164.6**	**49.9**	**93.6**	**5 979.8**

(a) Totals do not equal the sum of reasons in each column because more than one reason may be given by households.
Source: ABS 1993 (4602.0).

10.1.3 Items recycled and recycling method, May 1992: households recycling(a)

	One person	Couple only	Other households with all members over 15	Couple with dependent child(ren)	One parent, dependent child(ren)	All other households	Total
Item recycled	%	%	%	%	%	%	%
Paper	51.1	58.0	58.0	56.0	46.1	50.7	54.7
Glass	47.2	60.3	58.6	58.8	44.9	51.7	55.3
Cans	31.3	46.5	46.7	52.2	39.8	41.0	44.1
Plastic	28.3	37.6	40.4	42.8	36.6	35.6	37.3
Motor oil	4.1	12.0	10.4	10.9	3.6	6.9	8.9
Kitchen or food waste	24.1	41.8	37.6	42.9	29.1	26.5	35.6
Garden waste	29.8	56.1	54.0	55.5	36.7	37.0	47.3
Old clothing or rags	46.2	65.2	68.9	73.5	64.1	57.5	63.3
Recycling method							
Central collection point	39.1	54.1	58.0	60.8	52.1	46.3	52.5
Collection from house	47.2	50.2	54.3	49.2	41.7	49.6	49.4
Special areas at dump	4.3	10.9	11.1	13.4	7.8	7.3	9.7
Compost or mulch	30.0	52.7	49.2	52.5	33.6	36.2	44.9
Re-use within household	28.0	43.8	43.2	52.0	41.8	37.5	41.9
Other	2.1	2.9	2.1	3.5	3.4	2.2	2.8
No recycling	25.6	12.1	12.5	9.6	19.1	19.1	15.3

(a) Totals do not equal the sum of items in each column because more than one item may be recycled.
Source: ABS 1993 (4602.0).

10.1.4 Households that use environmentally friendly products (a), May 1992

	Unbleached paper products			*Recycled paper products*			*Phosphate-free cleaning products*			*Re-fillable containers*		
	Yes	*No*	*Don't know*	*Yes*	*No*	*Don't know*	*Yes*	*No*	*Don't know*	*Yes*	*No*	*Don't know*
	%	%	%	%	%	%	%	%	%	%	%	%
NSW	60.8	33.4	5.8	67.2	27.8	5.1	36.4	36.9	26.7	62.3	35.3	2.4
Vic.	62.6	31.8	5.6	66.1	29.0	4.9	36.4	34.3	29.4	60.5	37.0	2.5
Qld	65.1	31.5	3.4	68.6	28.2	3.2	40.4	31.6	28.0	67.0	31.9	1.1
SA	65.7	30.0	4.3	69.6	26.4	4.0	36.2	31.1	32.7	63.9	34.6	1.5
WA	70.0	27.3	2.8	73.7	22.7	3.6	40.8	32.9	26.3	65.9	33.0	* 1.1
Tas.	62.7	35.2	* 2.1	62.4	33.8	* 3.8	41.6	34.3	24.1	66.7	32.4	* 1.0
NT	56.2	43.1	* 0.7	64.4	32.9	* 2.7	38.3	40.8	20.9	62.0	38.0	* *
ACT	63.3	33.5	* 3.2	72.7	24.6	* 2.7	37.5	31.6	30.9	66.2	31.5	* 2.3
Aust.	**63.4**	**31.9**	**4.7**	**67.9**	**27.7**	**4.4**	**37.7**	**34.3**	**28.0**	**63.3**	**34.8**	**1.9**

Source: ABS 1993 (4602.0).

10.1.5 Reason environmentally friendly products are not used: households not using products, 1992

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
Reason product is not used	%	%	%	%	%	%	%	%	%
More expensive	23.4	22.4	24.7	26.2	24.7	23.9	* 33.2	* 19.9	23.8
Always buy same brand	31.2	27.9	27.2	27.0	19.9	25.3	* 20.2	28.7	27.9
Inferior quality	24.6	23.7	25.0	23.5	27.8	28.7	* 19.6	* 22.5	24.7
Not convinced about less impact claims	7.3	6.4	4.3	* 3.9	* 3.4	* 4.9	* 4.4	* 8.2	5.8
Not interested	15.8	17.7	15.2	17.0	17.8	17.6	* 11.6	* 17.6	16.5
Other	17.3	16.0	19.0	17.6	22.3	18.4	* 21.1	* 18.7	17.9
	'000	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*	*'000*
Total households	**617.3**	**454.3**	**300.4**	**162.5**	**176.9**	**52.1**	**18.3**	**30.8**	**1 812.7**

Source: ABS 1993 (4602.0).

Environmentally friendly products

Table 10.1.4 shows that of the environmentally friendly products surveyed, recycled paper products dominated (ranked highest by 68% of household surveyed), followed closely by unbleached paper products and refillable containers. Use of phosphate-free cleaning products was reported by 38% of households surveyed.

Of those households reporting that they did not use environmentally friendly products, the principal reason identified was their preference for always purchasing the same brand of product (28% of these households), followed by those households considering that the environmentally friendly products they had experienced were of inferior quality and lower performance compared to the products usually used (Table 10.1.5). Six per cent of responding households indicated that they were not convinced by claims that a product had less environmental impact than alternative products.

Donations towards environmental protection

Table 10.1.6 shows that, in the May 1992 survey, 28% of respondents indicated that they had donated time or money to an activity which

10.1.6 Involvement in environmental protection, 1992

	Donate time or money	*Member of environmental group*
State	%	%
NSW	25.1	4.7
Vic.	26.4	5.8
Qld	30.8	5.4
SA	30.8	7.8
WA	33.7	7.5
Tas.	26.1	4.9
NT	38.6	10.0
ACT	36.4	8.4
Aust.	**28.0**	**5.7**

Source: ABS 1993 (4602.0).

10.1.7 Involvement in environmental protection, 1992

Age	Donate time or money %	Member of environmental group %
18–24	26.8	5.6
25–34	31.9	5.8
35–44	36.0	8.1
45–54	28.4	6.3
55–64	22.5	3.9
65 and over	15.7	3.2
Total	**28.0**	**5.7**

Source: ABS 1993 (4602.0).

helped protect the environment. Only 6% of respondents indicated that they were members of groups whose main activity was protection and conservation of the environment.

The incidence of respondents donating time or money towards protecting the environment was highest for those aged between 35 and 44 (8%). There were also more respondents in the younger age groups making donations, while the incidence was lowest among respondents aged 65 and over (3%), as illustrated in Table 10.1.7.

Water conservation

Within households surveyed in June 1994, the most prominent water conservation action was turning off and repairing dripping taps (24% of households), as illustrated in Table 10.1.8. The next most common actions were using full loads when washing clothes, and taking shorter showers. 39% of responding households indicated having a dual flush toilet, 22% a reduced flow shower head.

Whereas 54% of households reported taking no water conservation steps within their dwellings, only 16% of households with gardens reported taking no measures to conserve water in their garden (Table 10.1.9). Of all responding households with gardens, 68% reported conserving water by watering at the cooler times of the day. Mulch was used to conserve water by 53% of responding households, while 38% reported planting native shrubs and trees for that purpose.

10.1.8 Methods of conserving water in the dwelling, States and Territories, June 1994

Conservation measure	NSW %	Vic. %	Qld %	SA %	WA %	Tas. %	NT %	ACT %	Aust. %
Dual flush toilet	30.5	50.8	31.5	48.2	46.6	31.0	41.6	33.2	39.0
Reduced flow shower head	19.5	21.2	22.5	26.1	26.1	20.6	14.6	28.6	21.8
Recycle/reuse water	13.3	9.0	16.5	13.2	19.5	11.9	*7.7	12.3	13.3
Full loads when washing	16.3	15.9	15.1	10.5	22.1	18.5	19.0	16.8	16.1
Shorter showers	16.7	13.3	15.3	12.5	21.9	16.7	13.5	15.9	15.7
Turn off/repair dripping taps	25.3	21.1	29.7	13.1	20.8	23.5	24.5	29.5	23.5
Brick in toilet cistern	2.3	1.1	1.4	1.6	2.2	1.8	**	*2.5	1.8
Other	8.9	5.7	10.7	7.2	10.8	5.1	*5.2	15.0	8.4
Suds saver used	16.8	10.6	12.6	22.5	15.0	13.8	12.6	15.7	14.7
No water conservation methods	54.6	60.3	47.2	62.6	43.4	55.8	61.6	45.3	54.3

Source: ABS 1995 (4602.0).

10.1.9 Water conservation measures by households with gardens, June 1994

Conservation measure	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Aust.
	%	%	%	%	%	%	%	%	%
Plant native shrubs/trees	35.5	32.7	42.0	45.6	41.2	33.1	48.3	44.8	37.6
Mulch used on plants	48.0	53.5	59.2	53.9	51.4	56.3	60.6	62.8	52.9
Water early morning/late evening	63.5	65.0	67.2	75.2	84.6	61.5	87.8	78.6	68.1
Other	2.9	2.1	2.8	2.9	3.1	1.8	*0.6	2.9	2.7
No water conservation steps	19.3	18.1	14.9	11.8	5.9	19.3	*6.9	8.9	15.9
	'000	'000	'000	'000	'000	'000	'000	'000	'000
Total households	**1 755.3**	**1 463.6**	**996.3**	**513.9**	**576.7**	**167.4**	**35.1**	**96.7**	**5 605.1**

Source: ABS 1995 (4602.0).

10.1.10 Dwellings with insulation installed, States and Territories, June 1994

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Australia
Insulation	'000	'000	'000	'000	'000	'000	'000	'000	'000
Roof/ceiling	927.5	1 100.7	298.6	398.8	314.6	109.4	19.9	79.8	3 249.3
Walls	250.5	306.8	83.9	100.4	20.3	29.9	4.9	25.8	822.4
Floor	*6.6	*8.4	*2.3	*1.1	* *	*1.1	*0.4	*1.1	20.9
Other	*3	*1.2	*1.3	*1.7	*1.9	*0.3	* *	*0.3	9.7
Dwelling not insulated	1 197.5	489.7	817.5	157.5	293.1	67.0	25.9	21.3	3 069.6
Total dwellings(a)	**2 157.7**	**1 606.4**	**1 142.7**	**567.3**	**610.6**	**179.9**	**46.2**	**103.6**	**6 414.5**
	%	%	%	%	%	%	%	%	%
Roof/ceiling	43.0	68.5	26.1	70.3	51.5	60.8	43.1	77.1	50.7
Walls	11.6	19.1	7.3	17.7	3.3	16.6	10.5	24.9	12.8
Floor	*0.3	*0.5	*0.2	*0.2	* *	*0.6	*0.8	*1	0.3
Other	*0.1	*0.1	*0.1	*0.3	*0.3	*0.2	* *	*0.3	0.2
Dwelling not insulated	55.5	30.5	71.5	27.8	48.0	37.3	56.1	20.5	47.9

Source: ABS 1995 (4602.0).

Insulation

The presence of insulation in a dwelling reduces the rate of transfer of heat from the interior to the exterior of a house, and vice versa, depending on the season, and has the potential to save significant quantities of energy. As Table 10.1.10 shows, the June 1994 survey revealed that almost half of the households surveyed had dwellings with no insulation. Of those that did, the main locations for insulation were the roof and ceiling (51% of reporting households) and the walls (13%).

An Australian National Opinion Polls (ANOP) survey on environmental issues conducted in September 1993, also referred to in Sections 2.3 and 3.3, found that recycling was the main action taken by individuals to help the environment (reported as such by 67% of respondents). Conservation of water and of energy were identified as such by 8% and 5% of respondents respectively, as illustrated in Table 10.1.11.

10.1.11 Main actions by individuals, 1993

Main action	%
Recycling	67
Composting	21
Planting trees	16
Buying environmentally friendly products	11
Litter control	11
Conserving water	8
Reducing water pollution	7
Reducing use of chemicals	5
Driving car less	5
Not buying aerosols with CFCs	5
Conserving energy	5

Source: ANOP 1993.

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Chapter 12 — Pressures from Economic Activity on the Environment

12.1 Generation of wastes

With the overview of the Australian economy established in Chapter 11, Chapter 12 looks at the impacts of Economic Processes on the stock of Natural Assets in the PEP model. The chapter focuses on the kinds of pressures exerted on the environment, rather than on the industry sectors exerting them. The pressures covered are:

- effluents emitted to water (Section 12.1.1);
- emissions to air (Section 12.1.2);
- solid waste management (Section 12.1.3); and
- disposal of special wastes (Section 12.1.4).

In addition to the pollutants which are generated through economic activity, Chapter 12 also examines the ways in which land (Section 12.2.1) and water systems (Section 12.2.2) have been restructured by economic activity.

12.1.1 Effluents to water

The MacMillan Dictionary of the Australian Environment defines effluents as any treated or untreated "waste products from an industrial process, or any other human activity, that are discharged into the environment". Effluents to water are either from diffuse (scattered broadly and not specific) or point source origins. Diffuse sources may be runoff from forestry, mining or agricultural activities, whereas point source effluents may originate from feedlots, piggeries, irrigation drains, poultry farms, sewage treatment plants, stormwater, industry, shipping and landfill areas.

The waters from these sources may contain high levels of nutrients (phosphorus and nitrogen), organochlorines (including pesticides and herbicides), hydrocarbons, heavy metals and dissolved salts. For more information on the effects and concentrations of these substances see Sections 1.1 and 1.4.2.

The dominance of the two major categories of effluents sources to water varies depending on whether conditions are wet or dry. During dry periods, point sources are the dominant effluents, but during wet periods the diffuse runoff from disturbed land becomes the primary source, as seen in Table 12.1.1.1.

As mentioned in Section 1.1, the Great Barrier Reef lagoon is thought to be becoming eutrophic (eutrophication is defined there as a condition where an enrichment in mineral and organic matter in a lake or body of water reduces its oxygen content and light absorption to a point where it cannot sustain animal life). The eutrophication is linked to sediment and nutrients discharged from the various catchment areas along the Queensland coast (Zann 1995, p. 56). The nutrients nitrogen (N) and phosphorus (P) give rise to algal blooms under the appropriate conditions. Figure 12.1.1.2 shows effluent loadings of phosphorus and nitrogen from point and diffuse sources to the Great Barrier Reef lagoon, starting in the north at north-east Cape York and moving down the coast by catchment. Of interest is the high nutrient load for north-east Cape York, which includes input from the Fly River outflow from New Guinea (Brodie 1995, p. 8).

Diffuse sources

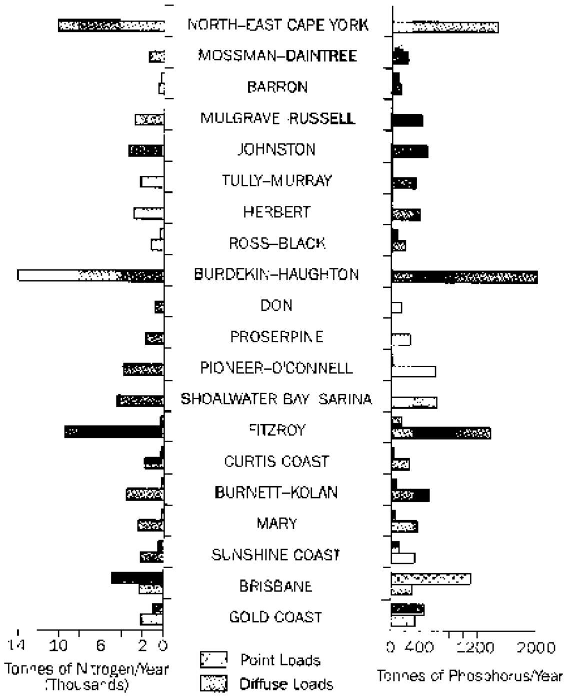
Nutrient loads from diffuse sources are estimated for the Murray-Darling Basin by land use category for dry, average and wet years in Table 12.1.1.3. Each land use exhibits different inputs of nutrients (e.g. fertilising affects the runoff from cropped areas) and differing tendencies (e.g. pasture compaction by hoofed animals results in increased runoff).

12.1.1.1 Total nutrient inputs from point and diffuse sources to streams in the Murray–Darling Basin

	Point sources		*Diffuse sources*		*Ratio Point/Diffuse*	
	TP	*TN*	*TP*	*TN*	*TP*	*TN*
Dry year	650	3 900	250	1 600	2.6	2.4
Average year	750	4 400	950	6 700	0.8	0.7
Wet year	900	5 300	4 300	28 000	0.2	0.2

Note: TP = Total Phosphorus TN = Total Nitrogen.
Source: MDBC 1992, p. S-8.

12.1.1.2 Comparison of magnitude of point and diffuse catchment sources of Nitrogen (N) and Phosphorus (P) along the east Queensland coast



Source: Moss et al. 1992, cited in Brodie 1995, pp. 6–7.

12.1.1.4 Export loads of diffuse effluents from tributaries to the Barwon-Darling River 1992–94

	Median dissolved solids exports (a)	*Median suspended solids exports (b)*
River	*tonnes/day*	*tonnes/day*
Namoi	166	19.0
Gwydir	129	4.0
Macintyre	76	40.0
Macquarie	68	21.0
Paroo	4	25.0
Culgoa	10	13.0
Castlereigh	11	0.1
Warrego	0	0.0
Moonie	0	0.0

(a) Nutrients, salts etc.
(b) Soils, clay and algae.
Source: Bek, Daly & Chivers 1994, p. 80.

The Barwon-Darling river system flows into the Murray. A study by the New South Wales Department of Water Resources on the water quality of the tributaries to the Barwon-Darling between 1992 and 1994 revealed high levels of suspended solid and dissolved exports derived from diffuse effluents to these rivers (see Table 12.1.1.4).

The conclusion is drawn that the Namoi, Gwydir and Macintyre Rivers (in that order) are the largest contributors to the Blue-green algae problem in the Darling (Bek, Daly & Chivers 1994).

As runoff travels over agricultural ground towards a stream it becomes a vehicle for pesticide and herbicide residues. In January 1995 the Central and North-West Regions Water Quality Program

12.1.1.3 Summary of diffuse source nutrient loads in the Murray-Darling Basin

	Dry Year		*Average Year*		*Wet Year*	
	Total Phosphorus	*Total Nitrogen*	*Total Phosphorus*	*Total Nitrogen*	*Total Phosphorus*	*Total Nitrogen*
Land use category	*tonnes/year*	*tonnes/year*	*tonnes/year*	*tonnes/year*	*tonnes/year*	*tonnes/year*
Murray-Murrumbidgee Basin						
Forest	35	700	180	3 600	550	11 000
Pasture	50	225	220	1 100	600	3 000
Crops	15	75	100	150	250	400
Total	100	1 000	500	4 850	1 400	14 400
Darling Basin						
Forest	10	200	40	800	300	6 000
Pasture	45	225	140	700	950	4 800
Crops	95	145	260	390	1 600	2 400
Total	150	570	440	1 890	2 850	13 200
Overall Total (a)	**250**	**1 570**	**940**	**6 740**	**4 250**	**27 600**

(a) Assuming that 'dry', 'average' and 'wet' conditions occur in the same year in both the Darling and Murray-Murrumbidgee Basins.
Source: Murray-Darling Basin Commission 1992, p. S-7.

12.1.1.5 Frequency of detection of diffuse effluent loadings of trace metals to river basins during 1993–94

	Cadmium	*Chromium*	*Mercury*	*Lead*	*Zinc*
Basin	*%*	*%*	*%*	*%*	*%*
Barwon	0	20	0	53	80
Gwydir	15	68	0	11	72
Namoi	22	43	2	2	43
Macquarie	37	48	5	30	68

Source: Department of Water Resources NSW 1995.

(New South Wales) reported on a storm event at Cox's Creek. The atrazine load was estimated at 29 kilograms per day while 480 grams per day of endosulfan were reported. During the same event 58 tonnes of phosphorus, 65 tonnes of nitrogen and 73,000 tonnes of suspended solids were exported through diffuse effluent into Cox's Creek and then on to the Namoi River over a period of 50 hours (Department of Land and Water Conservation 1995a, p. 5).

Sampling from the tributaries to the Darling River in 1993–94 indicated trace metals from both point and diffuse sources (Table 12.1.1.5).

This table includes only the metals where no EPA licensed discharges could account for a point source origin.

Cadmium, chromium, mercury and lead each exceeded the ANZECC recommended levels for the protection of aquatic ecosystems in at least one sample. Cadmium amounts are thought to be the result of its inclusion in phosphatic fertilisers.

Concentrations of metals may have been higher due to reduced river flow rates during the study period (Department of Water Resources NSW 1995).

In South Australia there is concern about the effect of diffuse runoff from the agricultural areas of the Mount Lofty Ranges on reservoirs supplying Adelaide's water supply. There was a perception that the water pumped from the River Murray (normally about 35% of Adelaide's water supply) was importing high levels of salts, nutrients and suspended sediments. Analysis of data since the 1970s has now attributed about half the salt loads to localised groundwater. Changes to agricultural practices and riparian management have been proposed (Williamson & van der Wel, 1991).

Point sources

The origins of point source effluent can be traced to specific points of entry into natural waterways as in sewage and stormwater outfalls, intensive animal industries and industrial discharges.

Waste water

A distinction can be drawn between waste water, that is sewage or industrial effluents which have a specific origin, and stormwater contributions to urban effluent, which may include runoff from landfills, roads, commercial/industrial sites, building sites and domestic residences.

Table 12.1.1.6 shows the contributions from nutrients and suspended solids to the central coastline of metropolitan Adelaide in South Australia from four major stormwater outfalls and the Glenelg Sewage Treatment Plant in 1981. While this is an old example it shows the significance of the contribution of stormwater effluent loads to urban effluent.

12.1.1.6 Estimated nutrient and suspended solid loadings from land-based discharges, Central Metropolitan Coast, Adelaide 1981

	Phosphorus		*Nitrogen*		*Suspended Solids*	
	tonnes/year	*% of total*	*tonnes/year*	*% of total*	*tonnes/year*	*% of total*
Phosphorus						
Edward Street Drain	0.13	<1	0.7	<1	100	<1
Young Street Drain	0.30	<1	10.0	1	550	3
Patawalonga Creek	6.30	4	104.0	9	8 360	50
Torrens River	12.50	8	257.0	23	7 640	46
Glenelg STW (a) effluent	140.00	88	740.0	67	130	1

(a) Sewage Treatment Works.
Source: Environmental Consulting Australia 1991, p. 28.

12.1.1.7 Audit of sources of pollutants, Port Jackson

	Urban stormwater	*Sewer overflows*	*Industrial discharges*	*Other*
Pollutant	%	%	%	%
Nitrogen	50	20	21	10
Phosphorus	61	32	2	5
Faecal bacteria	13	87	0	0
Suspended solids	94	4	0	1

Source: Langford & Dorrat 1995, unpub.

Stormwater

Table 12.1.1.7 reveals that urban stormwater is the major contributor to nutrient and sediment effluent loads in Sydney's Port Jackson. In the case of Port Phillip Bay, which receives Melbourne's effluent, sewage outfalls contribute 60% of the nutrient loadings to the bay. However, Melbourne stormwater accounts for more than 80% of effluent flow and contain most of the sediment, pathogens (disease causing agents), toxicants and litter (Langford & Dorrat 1995, p. 10).

The Murray-Darling Basin Commission also considered stormwater as a separate point source. However as Table 12.1.1.8 shows, municipal sewage treatment plants are the major contributor to nutrient loads in the Murray-Darling Basin, not urban stormwater.

The National Water Quality Management Strategy Draft Implementation Guidelines (1995) target urban runoff and stormwater as an item for possible regulatory control, and the CSIRO Division of Water Resources outlined the need for research into stormwater hydrology (CSIRO 1992).

12.1.1.9 Waste water treatment plants with average daily flow greater than twenty megalitres

Plant	*City*	*Average daily flow* *Ml/day*
Western	Melbourne	520.0
Malabar	Sydney	449.0
Eastern	Melbourne	395.0
North Head	Sydney	295.0
Luggage Point	Brisbane	183.0
Bolivar	Adelaide	133.0
Bondi	Sydney	130.0
Lower Molonglo	Canberra	91.0
Woodman Point	Perth	86.5
Beenyup	Perth	67.5
Glenelg	Adelaide	58.0
Cronulla	Sydney	53.5
Oxley	Brisbane	52.0
Subiaco	Perth	50.8
Burwood Beach	Newcastle	43.0
Dandenong	Melbourne	40.0
Gibson Island	Brisbane	37.0
Port Adelaide	Adelaide	35.0
St Marys	Sydney	34.0
Glenfield	Sydney	31.0
Christies Beach	Adelaide	24.0
Quakers Hill	Sydney	23.0
Bellambi	Sydney	21.0
Total		**2 852.3**

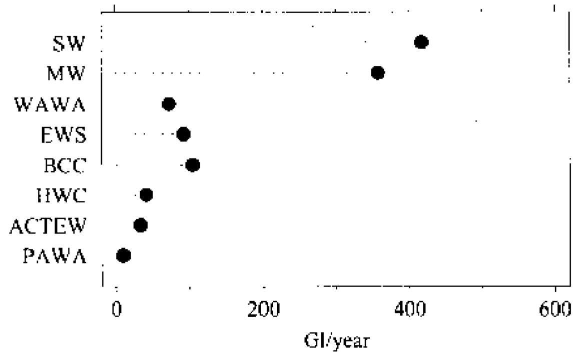
Source: Water Services Association of Australia 1995, p. 10, unpub.

12.1.1.8 Summary of point source nutrient loads in the Murray-Darling Basin

	Dry Year				*Average Year*				*Wet Year*			
	TP		*TN*		*TP*		*TN*		*TP*		*TN*	
Point source	*t/yr*	*%*	*t/yr*	*%*	*t/yr*	*%*	*t/yr*	*%*	*t/yr*	*%*	*t/yr*	*%*
Municipal sewage treatment plants	500	75	2 780	72	500	67	2 780	63	500	57	2 780	53
Irrigation drainage	110	16	630	16	170	23	980	22	260	30	1 480	28
Urban stormwater	60	9	450	12	80	10	660	15	120	13	1 000	19
Total	**670**	**100**	**3 860**	**100**	**750**	**100**	**4 420**	**100**	**880**	**100**	**5 260**	**100**

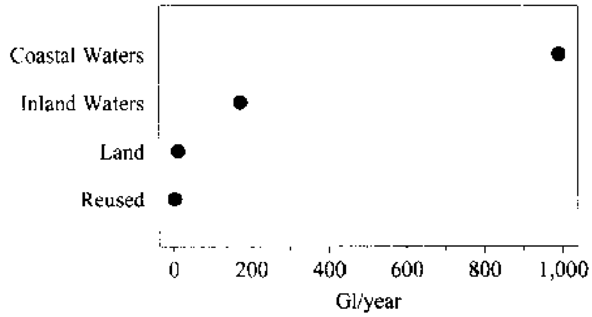
Notes: See notes for table 12.1.1.4.
Source: MDBC 1992, p. S-6.

12.1.1.10 Annual flow of effluents from major metropolitan waste water plants, 1992–93



Source: Water Services Association of Australia, p. 11, unpub.

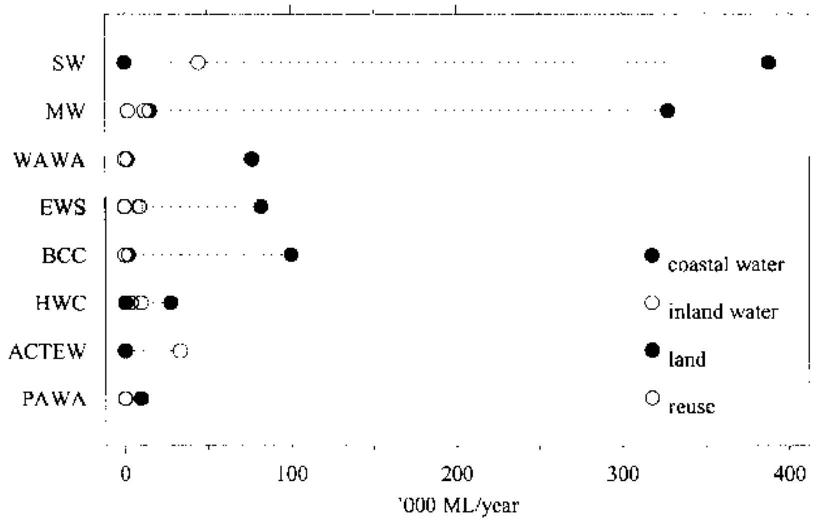
12.1.1.12 Major metropolitan effluent disposal — amounts to waters, land or reuse, 1992–93



Source: Water Services Association of Australia 1995. p.12, unpub.

Key to the waterboards in 12.1.1.10, 11, and 12:
SW — Sydney Water.
MW — Melbourne Water.
WAWA — Water Authority of Western Australia.
EWS — Engineering and Water Supply (South Australia).
BCC — Brisbane City Council.
HWC — Hunter Water Corporation.
ACTEW — ACT Electricity and Water.
PAWA — Power and Water Authority (Northern Territory).

12.1.1.11 Disposal of waste water to land, water or reused by authorities, 1992–93



Source: Water Services Association of Australia 1995, p. 12, unpub.

Sewage

Table 12.1.1.9 shows the daily flows of effluent from waste water treatment plants in Australia whose flows exceed 20 megalitres per day. The annual flow of effluent from major metropolitan wastewater plants is shown in Figure 12.1.1.10 and its disposal and reuse by authorities is shown in Figure 12.1.1.11.

As seen from Figure 12.1.1.12, about 88% of effluent from the major metropolitan waste water treatment plants is discharged to the coastal marine environment and 9% to inland waters. Only 1.5% is currently reused.

There are about 700 ocean sewage outfalls around Australia. Sydney Water has undertaken a program to clean up its 20,000 km stormwater system, in which $1.6 billion will be invested over the next 30 years (NSW Department of Land and Water Conservation 1995b, p. 3).

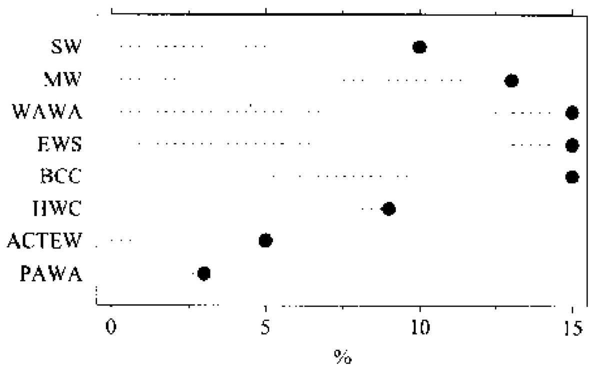
The major metropolitan waste water plants account for more than 80% of all sewage and urban effluent to water. The rural and smaller communities are not addressed here, though the nutrient loadings to the Murray-Darling Basin are provided in Table 12.1.1.8. Table 12.1.1.13 shows estimated annual phosphorus loadings for Western Australian waste water treatment plants.

12.1.1.13 Provisional estimates of the annual phosphorus discharges from waste water treatment plants, Western Australia

Region	Max population served or services (a)	Max or mean daily flow	Mean daily flow per service	Annual P load: high estimate	Annual P load: low estimate
	No.	m^3	m^3	tonnes	tonnes
North-west	11 904 (a)	31 062	2.61	170.00	91.00
Mid-west	23 611	5 694	0.24	311.80	166.30
Central Goldfields	14 500	3 494	0.24	19.13	10.20
Great Southern	36 404	8 650	0.24	47.36	25.26
South-west	28 094 (a)	24 753	0.88	136.00	72.00
Perth Metropolitan	1 189 164	286 143	0.24	1 566.63	835.54

(a) The south and north-west areas were provided as number of connections.
Source: Water Authority, Western Australia 1995, unpub.

12.1.14 Trade waste as a percentage of annual flow from major metropolitan waste water plants, 1992–93



Source: Water Services Association of Australia 1995, p. 13, unpub.

12.1.1.15 Industrial discharges to NSW coastal waters from major dischargers, 1989–90

Substance	tonnes
Cyanide	29
Arsenic	5
Lead	100
Cadmium	63
Copper	13
Chromium	4
Zinc	236
Selenium	99
Phenol	63
Fluorides	657
Manganese	11
Ammonia	3 577
Phosphorus	475
Suspended solids	21 161
Grease and oil	4 453

Source: ESD Working Groups 1991, p. 28.

Industrial or trade waste

While industrial or trade waste can be transported through the existing municipal systems, EPA licences for separate release are granted if guidelines and specified procedures are followed. The percentage of trade waste in the annual flows of major metropolitan wastewater plants is shown in Figure 12.1.14.

In 1989–90 the maximum permitted discharge of industrial wastewater to New South Wales coastal waters was 1.2 million megalitres, with toxic loads as shown in Table 12.1.1.15.

Groundwater is also at risk from industrial activity. In Western Australia, where groundwater is a significant urban water source (see Section 6.5), concerns about groundwater contamination are being addressed. The Kwinana Industrial Area outside Perth was chemically contaminating groundwater which, in turn, was moving towards Cockburn Sound. Table 12.1.1.16 summarises the problems occurring in 1988, and the remedial actions taken. As can be seen, leaking tailings ponds and open disused mine sites are potential sources of contamination from the mining sector.

Intensive animal industries

Intensive animal industries in agricultural areas such as the Murray-Darling Basin and the south-west area of Western Australia contribute nitrogen and phosphorus in effluent to waterways.

In the Murray-Darling Basin at the time of the 1992 study 'An Investigation of Nutrient Pollution in the Murray-Darling River System', it was noted that, while about two-thirds of the commercial feedlots surveyed had sedimentation ponds to remove manure from their waste streams, only 9% of the opportunity feedlots had

12.1.1.16 Sources of groundwater contamination in the Kwinana area

Company Responsible	Type of Contamination	Remedial Actions
Western Mining Corporation	Ammonium sulphate from leaking tailings dam.	Recovery of contaminants, new storage dam, monitoring.
Alcoa	Sodium hydroxide from leaking tailings dam.	Recovery of caustic contaminants, leak repair, monitoring.
Wesfarmers CSBP	Sulphate leaking from tailings pond and gypsum disposal area.	Gypsum stockpile covered, monitoring.
Cockburn Cement	Salt from sea-sand stockpile.	Recovery bore to capture salt from site, monitoring.
BP Refinery	Hydrocarbon in ground from leakages.	Monitoring, recovery, prevention.
CIK (property now owned by Nu-Farm)	Herbicides 2,4,5-T, 2,4-D, various chlorinated phenols.	Drilling program to find extent of plume. Exploring recovery methods. Wastes injected to deep wells.
SECWA — Perron Quarry (now disused)	Heavy metals.	Monitoring, recovery, circulation of groundwater.

Source: Government of Western Australia 1992, p. 148.

them. Of the 260 feedlots, almost 80% were in the Darling catchment area in northern NSW and Queensland.

Accurate estimates were not possible on the actual nutrient contributions. However, production estimates were derived using US research results that determined the per annum, per head feedlot wastes as 9kg phosphorus and 40kg nitrogen. Using pen capacity and average occupancy rates of feedlots in the basin, it was estimated that 1620 tonnes/year of total phosphorus and 7200 tonnes/year total nitrogen were yielded as feedlot waste. Measures of the amounts to reach the waterways were not available (MDBC 1992, p. 8–6).

There were about 1.1 million pigs producing about 2.3kg of phosphorus and 8.0 kg of nitrogen per head annually in the basin. If the guidelines for disposal of piggery wastes had been adhered to the above nutrients would not have resulted in loading to the effluent. Due to the absence of data, the Murray-Darling Basin Commission could only point to the potential nutrient pollution (MDBC 1992, pp. 8-8, 8-9).

Trout farms are considered a source of nutrients to waterways because of the high throughput of water. The only significant trout farms in the Murray-Darling Basin are in Victoria and New South Wales. It was estimated that trout farms in the two States contributed 17 tonnes of phosphorus and 120 tonnes of nitrogen annually to waterways (MDBC 1992, pp. 8-7, 8-8).

Shipping activities

The effluent from shipping activities in Australia's coastal waters comprises ballast water, anti-hull fouling chemicals, ocean litter and oil from accidental spills.

About 121 million tonnes of ballast water are imported (half from Japan) and discharged to Australian waters per year. Another 34 million tonnes move between Australian ports. Ballast waters can introduce non-native and environmentally harmful organisms (for a discussion of non-native species see Section 9.3) (SoE 1996, p. 8-16).

Anti-fouling hull paints are designed to leach into water, preventing organism growth on the hulls of commercial and recreational ships. The use of the most noticeably toxic of these (Tributyl tin) is now restricted in most States to ships over 25 metres in length. Others of these paints contain heavy metals such as lead and copper, organic substances and antibiotic compounds (SoE 1996, p. 8-17). The effects of Tributyl tin on biota are documented in Section 1.1.

Table 12.1.1.17 shows 1984–85 estimates of annual average volumes of oil spilled in Australian waters, and the dispersant required for clean-up activities. Australia has experienced three major oil spills this century. The *Oceanic Grandeur* spilled 1,067 tonnes into Torres Strait in 1970. The *Sanko Harvest* was shipwrecked off Esperance, WA, in 1991 and, while only 570 tonnes of oil were spilled, the cargo (30,000 tonnes of phosphate fertilisers) was lost to the sea. The largest spill occurred off Cervantes in

12.1.1.17 Annual average volume of oil spilled and dispersant required, 1984–85

State/Territory	Annual average total volume of oil spilled (litres)	Dispersant required (a) (drums)
New South Wales	22 300	37.2
Victoria	18 410	30.7
Queensland	8 510	14.2
South Australia	5 070	8.5
Western Australia	18 820	31.4
Tasmania	2 670	4.5
Northern Territory	610	1.0
Total	**76 390**	**127.3**

Note: reporting differences and methodologies between States and Territories vary (Nelson, P. 1996, pers. comm.).

(a) The dispersant refers to the number of drums required to neutralize these volumes of oil.

Source: ABS 1992 (4140.0), p. 196.

12.1.1.18 Quantified coastal vessel oil spill estimates, 1989–94

State/Territory	*tonnes*
New South Wales	16
Victoria	1 258
Queensland	130
South Australia	0
Western Australia	17 741
Tasmania	17
Northern Territory	10
Total	**19 172**

Source: Australian Maritime Safety Authority 1995, pers. comm.

Western Australia in 1991 when the *Kirki* lost 17,700 tonnes of oil. Most recently BHP's *Iron Baron* went aground off the Tasmanian coast in July 1995, spilling more than 300 tonnes of oil.

Table 12.1.1.18 sets out the quantified amounts of oil spilled from vessels in Australian waters between 1989 and 1994 (inclusive) in tonnes. While the Australian Maritime Safety Authority holds a database of all known spills, included here are only those spills the size of which was known, not those reported only in terms of estimated slick area. Tonnages could not be computed from area due to the different densities of various oil grades.

As mentioned in Section 1.1, the hydrocarbon content of urban and industrial runoffs is considered a greater risk to the marine environment than accidental oil spills, given the chronic nature of these runoffs. For example, over the period of 1989–90, as shown in Table 12.1.1.15, an estimated 4,453 tonnes of grease and oil were discharged to New South Wales coastal waters by industry alone.

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12.1.2 Emissions to air

The main causes of emissions of air pollutants include fuel combustion in power generation and transportation, industrial processes, solid and liquid waste taken to landfill, and waste incineration. The substances emitted by different sectors of the economy and their contribution to total emissions vary depending upon the type and volume of activity.

The combustion of fossil fuels has received a great deal of attention in recent years as emissions from human activity have been predicted to increase atmospheric concentrations of greenhouse gases, causing changes in climatic patterns (see Section 2.2).

Greenhouse gases

The Global Warming Potential (GWP) has been developed to provide an index for quantifying the relative contributions of different greenhouse gases to the enhanced greenhouse effect.

The GWP is the time-integrated 'radiative forcing' (an alteration in the balance between incoming and outgoing atmospheric radiation causing climatic temperature changes) from the instantaneous release of 1 kilogram of a trace gas expressed relative to that of 1 kilogram of a reference gas, carbon dioxide. The relative future global warming potential of a greenhouse gas is the product of the appropriate GWP and the amount of gas emitted, making it possible for emissions of different primary greenhouse gases to be expressed on a common scale (Lumb et al. 1995, p.3).

The lifetimes and Global Warming Potentials of significant greenhouse gases are shown in Table 12.1.2.1. These gases include:

- carbon dioxide, methane and nitrous oxide, emitted by natural processes and human activity; and
- chlorofluorocarbons (CFCs), which are mainly attributable to human activity.

As part of its obligations under the United Nations Framework Convention on Climate Change, Australia is required to compile an inventory of its greenhouse gas emissions and sinks. Greenhouse gas emissions are shown for 1994 in Table 12.1.2.2. Table 12.1.2.3 shows the proportion of emissions from each sector of activity for 1990 in CO_2 equivalent terms. The main anthropogenic sources of carbon dioxide are fossil fuel combustion and fugitive emissions from the energy sector, which include leaks and other losses and emissions from venting and flaring at drilling rigs and elsewhere. Slightly more than 30% of net carbon dioxide emissions are estimated to come from forestry and changes to land use, but major uncertainties are associated with this estimate. Methane sources are mainly agriculture, solid waste decomposition and fugitive emissions from the energy sector.

The State of Environment Report for Australia noted that Australia's gross greenhouse gas emissions contribute 1-2% of total global emissions. "Based on some criteria, Australia has very high emissions of greenhouse gases relative to other OECD countries. For example, over the period 1987–1992 our energy related CO_2 emissions per unit of GDP declined more slowly than the OECD average. These emissions have grown over the last 30 years principally because of population growth, industrialisation and continuing electrification. In contrast, in other OECD countries, where economic growth was also high, the effect on emissions was offset by large falls in fossil fuel consumption per unit of output. Australia has a higher proportion of energy intensive industry than most of those countries because of its strong natural resource base and competitive prices." (SoE 1996, p. 5–9).

12.1.2.1 Lifetimes and Global Warming Potentials of significant greenhouse gases

Gas	Chemical formula	Lifetime Years	Global Warming Potential (a) — Time Horizon 20 years	100 years	500 years
Carbon dioxide	CO_2	120	1	1	1
Methane (b)	CH_4	14.5 ± 2.5 (c)	62	24.5	7.5
Nitrous oxide	N_2O	120	290	320	180
CFCs					
CFC-11	$CFCl_3$	50 ± 5	5 000	4 000	1 400
CFC-12	CF_2Cl_2	102	7 900	8 500	4 200
CFC-13	$CClF_3$	640	8 100	11 700	13 600
CFC-113	$C_2F_3Cl_3$	85	5 000	5 000	2 300
CFC-114	$C_2F_4Cl_2$	300	6 900	9 300	8 300
CFC-115	C_2F_5Cl	1 700	6 200	9 300	13 000
HCFCs, etc					
HCFC-22	CF_2HCl	13.3	4 300	1 700	520
HCFC-123	$C_2F_3HCl_2$	1.4	300	93	29
HCFC-124	C_2F_4HCl	5.9	1 500	480	150
HCFC-141b	$C_2FH_3Cl_2$	9.4	1 800	630	200
HCFC-142b	$C_2F_2H_3Cl$	19.5	4 200	2 000	630
HCFC-225ca	$C_3F_5HCl_2$	2.5	550	170	52
HCFC-225cb	$C_3F_5HCl_2$	6.6	1 700	530	170
Carbon tetrachloride	CCl_4	42	2 000	1 400	500
Methyl chloroform	CH_3CCl_3	5.4 ± 0.6	360	110	35
Bromocarbons					
H-1301	CF_3Br	65	6 200	5 600	2 200
Other					
HFC-23	CHF_3	250	9 200	12 100	9 900
HFC-32	CH_2F_2	6	1 800	580	180
HFC-43-10mee	$C_4H_2F_{10}$	20.8	3 300	1 600	520
HFC-125	C_2HF_5	36	4 800	3 200	1 100
HFC-134	CHF_2CHF_2	11.9	3 100	1 200	370
HFC-134a	CH_2FCF_3	14	3 300	1 300	420
HFC-152a	$C_2H_4F_2$	1.5	460	140	44
HFC-143	CHF_2CH_2F	3.5	950	290	90
HFC-143a	CF_3CH_3	55	5 200	4 400	1 600
HFC-227ea	C_3HF_7	41	4 500	3 300	1 100
HFC-236fa	$C_3H_2F_6$	250	6 100	8 000	6 600
HFC-245ca	$C_3H_3F_5$	7	1 900	610	190
Chloroform	$CHCl_3$	0.55	15	5	1
Methylene chloride	CH_2Cl_2	0.41	28	9	3
Sulphur hexafluoride	SF_6	3 200	16 500	24 900	36 500
Perfluoromethane	CF_4	50 000	4 100	6 300	9 800
Perfluoroethane	C_2F_6	10 000	8 200	12 500	19 100
Perfluorocyclo-butane	$c\text{-}C_4F_8$	3 200	6 000	9 100	13 300
Perfluohexane	C_6F_{14}	3 200	4 500	6 800	9 900

(a) Referenced to the absolute Global Warming Potential of carbon dioxide. The typical uncertainty is ±35% relative to the carbon dioxide reference.

(b) The methane Global Warming Potential includes the direct effect and those indirect effects due to the production of tropospheric ozone and stratospheric water vapour. The indirect effect due to the production of carbon dioxide is not included.

(c) For methane the adjustment time is given, rather than the lifetime.

Source: IPCC 1994, p. 28.

12.1.2.2 Greenhouse gas emissions, 1994

Greenhouse gas source and sink categories	Carbon dioxide kilotonnes	Methane kilotonnes	Nitrous oxide kilotonnes	Oxides of nitrogen kilotonnes	Carbon monoxide kilotonnes	Non-methane volatile organic compounds kilotonnes
All Energy (fuel combustion plus fugitive)	278 208	1 330.8	11.7	1 329.4	4 461.5	977.1
Fuel combustion	273 934	112.8	11.6	1 328.1	4 453.8	744.4
Energy and transformation industries	150 851	2.1	1.5	489.1	43.9	6.9
Industry	45 342	1.3	0.3	325.0	104.0	10.3
Transport (mobile sources)	62 689	25.6	8.9	409.6	3 514.6	521.0
Small combustion	13 181	0.8	0.1	77.5	29.9	9.2
Other	1 872	0.2	0.0	11.1	3.5	1.1
Biomass burned for energy		82.9	0.8	15.8	753.9	195.9
Fugitive emissions from fuels	4 274	1 217.9	0.1	1.3	7.7	232.8
Solid fuels	na	758.6				
Oil & natural gas	4 274	459.4	0.1	1.3	7.7	232.8
Industrial processes	7 293	3.7	1.4	ne	ne	9.9
Solvent and other product use						166.4
Agriculture		3 140.8	67.4	799.8	10 583.4	620.0
Enteric fermentation		2 761.6				
Manure management		83.0	25.2			
Rice cultivation		25.0				
Agricultural soils			28.5			
Prescribed burning of savannas		265.7	13.6	788.8	10 375.1	607.8
Field burning of agricultural residues		5.4	0.1	11.0	208.3	12.2
Other						
Land use change and forestry (a)	−27 512	60.2	1.1	45.5	1 778.1	215.9
Changes in forest & other woody biomass	−19 519					
Forest & grassland conversion (a)	na	na	na	na	na	na
Abandonment of managed lands			0.0			
Other (b)	−7 993	60.2	1.1	45.5	1 778.1	215.9
Waste	na	766.9	ne	ne	ne	4.0
Solid waste disposal on land		710.0				4.0
Wastewater treatment		56.9				
Waste incineration	na	ne	ne	ne	ne	ne
Other waste		na	na	na	na	na
International bunkers (c)	7 240	0.8	0.2	91.4	10.4	4.3
Total national emissions and removals	**285 501**	**5 302.3**	**81.6**	**2 174.7**	**16 823.0**	**1 993.3**

(a) The inventory for the Forest & grassland conversion component of this sector is subject to large uncertainties. The methodology and data for Forest & grassland conversion are currently under review.
(b) CO_2 removal value is from pasture improvement; other emissions are from wildfire and prescribed burning.
(c) Not included in total national emissions and removals.
ne = not estimated.
Shading indicates not applicable.
Source: NGGI 1996.

12.1.2.3 Total emissions from each sector of activity, 1990

Sector	Emissions (a) kilotonnes	Proportion of total emissions %
All energy	305 222	53.4
Industrial processes	11 010	1.9
Agriculture	86 625	15.2
Land use change and forestry	139 651	24.4
Waste	29 215	5.1
Total	**571 724**	**100.0**

(a) carbon dioxide equivalent
Source: NGGI 1994, p. 5.

Sources of gas emissions

Energy

The energy sector is the single largest contributor to greenhouse gas emissions in Australia (NGGI 1994, p.6). A significant proportion of the emissions from this sector do not occur at the point of end use but, for example, at power stations where fuel is converted into electricity.

With carbon being the main constituent of fossil fuels, the principal gas emitted is carbon dioxide, coal having the highest carbon content. The vast reserves of coal in Australia and the dominance of this fuel for power generation contribute to Australia's high per capita emissions of energy-related carbon dioxide; 16.4 tonnes per person in 1990 (NGGI 1994, p.6). In 1994, around 55% of carbon dioxide emissions for fuel combustion for this sector came from energy conversion processes to transform one form of energy into another before use.

Industry

Gas emissions from industry are a by-product of the various production processes and operations. As for the energy sector, carbon dioxide is the main greenhouse gas emitted. Although emissions from the sector are small overall, they include some significant gases (although low in volume of output) such as perfluorocarbons generated during aluminium smelting, which are potent greenhouse gases and exist for long periods in the atmosphere.

Agriculture

Agriculture is the largest emitter of methane, which is produced from anaerobic (absence of oxygen) bacterial decomposition of organic matter. In this sector methane comes primarily from livestock where it is mainly produced as a by-product of the digestion of feed. In 1994 this accounted for 88% of total methane emissions from agriculture. Methane is also generated during rice cultivation when fields are flooded.

Other greenhouse gases are also emitted by controlled bushfires, including the practice of prescribed burning of grasslands, accounting for 98% of emissions of carbon monoxide from agriculture.

Changes in land use and forestry

The estimates of emissions from this sector of the Inventory are subject to large uncertainities, due to a lack of land clearing statistics and information on the carbon content of the vegetation cleared and the soils involved (NGGI 1994, p.8). For the 1994 National Greenhouse Gas Inventory it was reported that changes in forestry activities, principally from the growth or regrowth of managed forests and other biomass actions, such as pasture improvement, resulted in the removal of 27,512 kilotonnes of carbon dioxide from the atmosphere into carbon sinks.

Waste

The bulk of emissions from this sector consist of methane from the decomposition of organic matter from landfills, which in 1994 accounted for 93% of total methane gas emissions from this sector. Increasingly, landfill methane gas is recovered and used as fuel, thereby reducing emissions and acting as a substitute for fossil fuels. The first landfill gas-fuelled power station was commissioned in Victoria in May 1992, and that State now has three such power stations, with a capacity of 11.5 megawatts. Since 1994 similar power stations operate in New South Wales (4 megawatts) and South Australia (5 megawatts).

Projected energy sector greenhouse gas emissions

As a further part of Australia's commitment under the United Nations Framework Convention on Climate Change, a target consistent with the Convention is to stabilise greenhouse gas emissions at their 1990 level by the year 2000, a target that applies to the whole economy.

Australia's total greenhouse gas emissions are projected to be 366 million tonnes in 1999-2000 and 410 million tonnes in 2009-10 (see Table 12.1.2.4), an increase of 21% for 1999-2000 and 35% for 2009-10 when compared to energy sector emissions for 1989-90.

Black coal will continue to account for the bulk of emissions — 38% in both 1999-2000 and 2009-10. For the industry sectors within energy, electricity is expected to dominate emissions (45% in 1999-2000 and 46% in 2009-10), reflecting its heavy use of black coal.

Reducing greenhouse gas emissions

Given Australia's commitment to reducing greenhouse gas emissions, studies have shown that there is considerable scope for action on certain aspects, such as energy efficiency and conservation. A range of available options have been identified, which are summarised in Table 12.1.2.5.

Emissions to air in Australian cities

The principal contributor to emissions to air in city and urban areas is fossil fuel combustion, particularly by motor vehicles, which account for the bulk of carbon monoxide and oxides of nitrogen, as shown in Table 12.1.2.6. Stationary sources, such as industrial processes, domestic heating and electricity generation account for the rest.

12.1.2.4 Projected greenhouse gas emissions from the energy sector (a)

	1999–2000	*2004–05*	*2009–10*
	megatonnes	*megatonnes*	*megatonnes*
Fuel			
Black coal (b)	145	153	158
Brown coal	51	55	54
Petroleum products	106	110	113
Natural gas (c)	57	64	73
Wood and bagasse	19	19	20
Industry			
Combustion activities			
Agriculture	4	5	5
Mining and manufacturing (d)	70	72	74
Electricity generation	161	175	183
Other energy transformation (e)	31	33	34
Road transport	65	69	71
Other domestic transport	9	10	10
Commercial	4	4	5
Residential	7	8	9
Non-combustion activities (f)	7	7	7
Total domestic (g)	358	382	399
of which is CO_2	328	351	370
International transport (h)	8	10	12
Total energy (g)	**366**	**392**	**410**
of which is CO_2	**336**	**361**	**382**

(a) Includes CO_2, CH_4 and N_2O on a CO_2 equivalent basis. To convert to CO_2 equivalent, global warming potentials of 21 for CH_4 and 290 for N_2O were used.
(b) Includes coal seam gases.
(c) Includes vented and flared gases from oil and gas production.
(d) Includes construction.
(e) Petroleum refining, coke ovens, briquetting and gas industry own use and losses.
(f) Includes direct emissions from coal mining and petroleum production (venting, flaring and coal seam gases) and petrochemical feedstocks, lubricants, bitumen, solvents and waxes (excluding carbon sequestered in these products).
(g) Excludes emissions from wood and bagasse combustion.
(h) International aviation and marine bunker fuels loaded in Australia.
Source: Bush, Holmes & Ho Trieu 1995, p. 43.

12.1.2.5 Options for reduction of greenhouse gas emissions

Factors		*Options*
Residential	Lighting	Compact fluorescent lights to replace incandescents.
	Cooking	Microwave cooking, electric induction, improved gas.
	Water heating	Better tank insulation, low flow shower heads, pipe lagging, improved gas combustion, electronic ignition.
	Space heating	Building improvements including weatherisation and insulation, new solar efficient design, improved gas combustion efficiency, improved wood and electric heaters.
	Space cooling	Building improvements, technology improvements.
Commercial	Lighting	More efficient fluorescents, compact fluorescents, daylighting.
	Electric drive	High efficiency motors, ducting redesign.
	Space cooling	Building improvements, improved cooling technologies efficiency/operation.
	Space heating	Building improvements, better furnace efficiency/operation.
	Water heating	Tank insulation, pipe lagging, gas combustion, ignition.
Industrial	Smelting	Intelligent controllers, heat recovery, increased scrap usage.
	Metal processing	Heater design, combustion control, heat recovery.
	Furnaces	Combustion efficiency and control, heat recovery.
	Steam	Pipe insulation, optimised distribution.
	Fluid heating	Better heat exchangers, efficient use, combustion efficiency.
	Drying	Combustion efficiency, better heat transfer, intelligent controllers efficiency.
	Mechanical drives	Efficient motors, variable speed drives, optimal sizing, improved in-house wiring, optimisation of use.
	Aluminium	Electrode tuning, increased use of recycled material.
Transport	Cars	Improved fuel economy from downsizing, continuous gearing, electronic ignition, improved aerodynamics.
	Trucks	Better fuel ignition and gearing systems, fleet and dispatch control.
	Rail	Control systems, electric motor efficiencies.
Mining		Improved efficiency in gas preparation, chilling, liquefaction, vehicle efficiency.
Agriculture		More efficient farm vehicles, electric motors and processing equipment.

Source: Deni Greene Consulting Services 1991 in ABS 1992 (4140.0) p.137.

These emissions can impact on the quality of life of urban dwellers. In recent years air pollution, to which these emissions contribute, has been the main environmental concern of people in Australia, particularly metropolitan populations (see Section 2.3).

Other significant emissions

Ozone-depleting substances

Under an international agreement signed by more than 149 countries, called the Montreal Protocol on Substances that Deplete the Ozone Layer, Australia is obligated, under set targets, to phase out the production and consumption of substances implicated in the depletion of the stratospheric ozone layer. These substances,

12.1.2.6 Relative percentage contribution to atmospheric pollution in major Australian cities by source

	Carbon monoxide		*Hydrocarbons*		*Oxides of nitrogen*		*Sulphur dioxide*	
	Average	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*
Source	%	%	%	%	%	%	%	%
Motor vehicles	86	82–89	45	41–50	67	54–80	10	4–18
Other mobile	3	2–3	2	2–3	5	4–5	2	1–5
Waste combustion	1	1–2	1	1–2	<1	<1	<1	<1–1
Fuel combustion	7	4–12	10	6–16	21	9–34	32	14–76
Petroleum/solvent	<1	<1	35	30–38	4	2–5	37	12–64
Miscellaneous	2	<1–3	5	4–8	4	1–6	18	<1–68

Extrapolated from Air Emission Inventories (1985) for the Australian Capital Cities — Australian Environment Council Report No. 22. Percentages quoted are indicative only and are an arithmetic average of the values for Sydney, Melbourne, Brisbane, Perth and Adelaide. The range values shown are the lowest and highest percentage for each gas from the 5 cities.

Source: Federal Office of Road Safety 1993, p. 2.

12.1.2.8 Activity of Ozone Depleting Substances (ODS) licensees, by type of ODS, 1995

	Total import	*Manufacture*	*Export*	*Import used for feedstock*
ODS type	*ODP tonnes*	*ODP tonnes*	*ODP tonnes*	*ODP tonnes*
Methyl Chloroform	846.44	0	0	0
Carbon Tetrachloride	3 070.89	0	0	3 070.73
Methyl Bromide	664.37	0	0	168.11
CFCs	567.92	3 849.93	1 579.07	0

Note: ODP = Ozone Depleting Potential
Source: EPA 1996.

including halogenated compounds such as chlorofluorocarbons (CFCs), methyl chloroform, carbon tetrachloride and hydrochlorofluorocarbons (HCFCs) containing chlorine, and halons and methyl bromide containing bromine, were commonly used in the past as refrigerants, foam blowing agents, industrial cleaning solvents, fire retarding chemicals and pest fumigants (ANZECC 1994). Australia is currently ahead of schedule in its obligations.

In 1989 a Strategy for Ozone Protection was adopted (and revised in 1994) to provide a timetable for the phase-out operation. CFCs have been successfully phased out, except for essential uses, and other substances are subject to continuing Commonwealth Government controls which will further reduce, and in time eliminate, their import and manufacture. For example, HCFCs will be phased out through a scheme which sets a limit for Australia of 300 Ozone Depleting Potential tonnes in 1996, reducing to 3 ODP tonnes in 2015 and zero by 2030.

Alternative substances and technologies to ozone-depleting substances (ODSs) which are environmentally benign have been identified or are under development for many applications, as well as improvements to systems which still use ozone-depleting substances in order to prevent the leakage of these substances into the atmosphere. The Protocol allows for the very limited production of ozone-depleting substances for essential uses, such as medical aerosols, until alternatives have been developed and fully tested. Tables 12.1.2.7 and 12.1.2.8 show the past consumption and import of ozone-depleting substances.

12.1.2.7 Use of major ozone-depleting substances

	1986	*1989*	*1992*
Australian domestic consumption	*tonnes*	*tonnes*	*tonnes*
Total CFC	14 633	14 293	5 540
Car air-conditioning CFC	1 765		2 372
Halon-1211	690		15
Halon-1303	220		39
Methyl chloroform		8 537	4 680(a)
Carbon tetrachloride (b)		6	
HCFC 22		2 700	

(a) Estimated
(b) Excluding feedstock
Source: ANZECC 1994, pp. 13, 27, 47.

Lead

Engines used in transport are responsible for almost all of the lead in major urban areas, with motor vehicles contributing around 90% of airborne lead in these areas. A number of population centres in Australia are also potentially exposed to lead due to mining and smelting operations, with most of this lead entering the human body by being swallowed or inhaled in the form of fine particles, which may accumulate in household dust, soil and water.

There has been a gradual reduction in the lead content of leaded fuel in Australia since the mid 1970s, primarily due to government regulation and industry agreement (see Table 12.1.2.9). The introduction of unleaded petrol in 1986 (which is considered to have a nil or negligible lead content, although it is permitted to contain up to 13 milligrams of lead per litre due to contamination from pipelines and tankers) has further reduced lead emitted from motor vehicles (see Table 12.1.2.10). This trend will continue to become more significant as older, lead-fueled vehicles are gradually replaced with vehicles using unleaded fuels.

12.1.2.9 Maximum lead content in leaded fuel, States and Territories

Year	Sydney, Newcastle & Wollongong	Rest of NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT
	grams/litre	grams/litre	grams/litre	grams/litre	grams/litre	grams/litre	grams/litre	grams/litre	grams/litre
1980	0.40	0.84	0.45	na	0.84	na	0.45	na	0.84
1990	0.40	0.84	0.30	0.84	0.65	na	0.45	na	0.84
1995	0.20	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.20
1996	0.20	0.20	0.20	0.20	0.30	0.20	0.20	0.20	0.20

Source: AIP 1996.

It has been estimated that over the life of a car about 75% of the lead added to the fuel is emitted from the exhaust system of the vehicle as a diverse mixture of inorganic lead salts. In addition, about 2% of the lead in petrol may escape unchanged to the atmosphere due to evaporation from the fuel tank, carburettor or spillage during transport and refuelling, with the major portion of the remaining lead being retained in the vehicle's engine, exhaust system and sump oil (EPA Vic. 1991, p.34).

Another major source of lead exposure is lead based paint which, if in poor condition, may contaminate household dust and soil.

National Pollutant Inventory

In his 21 December 1992 Statement on the Environment, the Prime Minister announced that the Commonwealth government will establish a legislated National Pollutant Inventory (NPI), in cooperation with State and Territory governments.

The NPI proposed for Australia will be a system of information providing an annual report of major pollutants and wastes released into the environment, and is planned to provide easily accessible information to the community on a regular basis (EPA 1994). Pollutant inventories have been established in North America and Europe. Other countries with established or pending inventories include Norway, the Netherlands, the United Kingdom and Canada.

While the exact structure and organisation for gathering information for the NPI have yet to be determined, the Commonwealth Environment Protection Agency, in a discussion paper released

12.1.2.10 Leaded petrol sales and emissions from lead-fueled motor vehicles

	Sales of leaded petrol			Estimated lead emissions from vehicles (a)		
	1980	1990	1995	1980	1990	1995
	megalitres	megalitres	megalitres	tonnes	tonnes	tonnes
NSW (b)	4 988	3 668	2 220	ne	ne	ne
Vic.	4 131	3 328	1 989	1 431	769	306
Qld	2 382	2 212	1 498	ne	1 431	346
SA	1 320	1 071	652	854	536	151
WA	1 417	1 193	772	ne	ne	178
Tas.	425	357	256	147	124	59
NT	110	101	66	ne	ne	15
Australia	**14 772**	**11 930**	**7 452**	**na**	**na**	**na**

ne = not estimated

(a) Lead emissions have been estimated using AIP lead content in leaded fuel data (where available), DPIE data for leaded petrol sales, and EPA Victoria data that 75% of lead used in lead-fueled vehicles is emitted to the atmosphere via the exhaust system, and a further two per cent escaping into the atmosphere due to evaporation or spillage.

(b) Includes ACT.

Source: DPIE 1996 (pers. comm.); AIP 1996 (pers. comm.).

in May 1994, stated that the objectives of the inventory are:

- "to provide information to enhance and facilitate policy formulation and decision making for environmental planning and management;
- to satisfy community right to know needs, by providing publicly accessible and available information, on a geographic basis, about the pollutants and wastes that are being released into the environment, especially those of a toxic or hazardous nature;
- to promote and facilitate waste minimisation and cleaner production programs for industry and government;
- to assist Australia in meeting international obligations; and
- to assist in identifying priority contaminants entering the environment

Six information modules are proposed for the inventory. They are

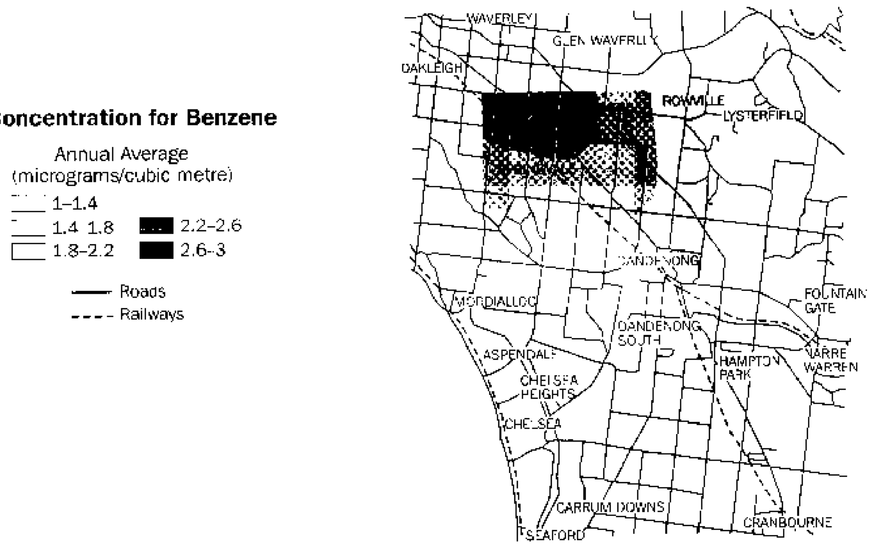
- 1 — annual reports of releases of specified hazardous and toxic materials from secondary industries, and government facilities;
- 2 — pollutant release information derived from existing licence arrangements;
- 3 — five yearly reports on urban transport and photochemical smog related emissions;
- 4 — solid (non-hazardous) wastes;
- 5 — scheduled ('intractable') wastes, and
- 6 — greenhouse gas emissions."

National Pollutant Inventory Case Study — Trial Air Emissions Study of the Dandenong Region (Victoria)

The National Pollutant Inventory has undertaken a major trial in the Dandenong region (see figure 12.1.2.11) on air emissions.

Information on emissions was gathered through voluntary reports by industry and a survey of households as well as estimation of vehicles and other small emissions sources. A database displayed the trial results in a local library to encourage community input.

12.1.2.11 National Pollutant Inventory air emission trial of the Dandenong Region, 1994



Source: EPA 1995, unpublished.

12.1.2.12 Emissions in tonnes, 1994

	Industry	*Motor Vehicles*	*Solid Fuel Burning*	*Lawnmowers*
Substance	*tonnes*	*tonnes*	*tonnes*	*tonnes*
Oxides of nitrogen	3 378.8	5 460.6	13.8	4.6
Carbon monoxide	599.7	56 582.6	878.6	749.1
Sulphur dioxide	407.4	1 012.3	2.0	0.4
Particulates	461.6	316.7	221.7	7.1
Polyaromatic hydrocarbons	0.0	11.3	1.2	0.0
Benzene	0.9	309.8	3.3	15.7
Toulene	52.7	534.8	1.2	28.0
Lead and compounds	0.2	41.4	0.0	0.0

Source: EPA 1995.

Table 12.1.2.12 shows the emissions of several substances by industry, motor vehicles, solid fuel burning and lawnmowers in the Dandenong region. Information is available on other substances and emission sources.

The first four substances in Table 12.1.2.12; oxides of nitrogen, carbon monoxide, sulphur dioxide and particulates are all urban air pollutants. They contribute to the smog we see and breathe in our cites. The other substances are hazardous or toxic substances commonly found in urban air. For instance, lead and benzene are often associated with combustion sources such as cars. The concentration of these chemicals varies markedly within an urban area (see Figure 12.1.2.11)

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12.1.3 Solid waste management

Introduction

Waste disposal has become a necessary function of modern society. Economic activity involves the production, consumption and ultimate disposal of materials consumed by individuals and organisations. There appears to be a trend in some OECD countries of increased waste production alongside increased consumption and GDP (OECD 1995, pp. 92–93).

The Senate Standing Committee on Environment Recreation and the Arts (Australia, Parliament 1992) defines waste in a number of ways, namely as a material:

- which has been discarded or remains after industrial, commercial, domestic or other activity;
- with no utility to society;
- which cannot be recovered or recycled; and
- for which a use has not yet been found or which current levels of technological innovation cannot yet transform.

Definitions of solid waste change over time from the perspectives of both groups and individuals, depending on the value of a given material. What is currently considered a waste may not be in the future.

Solid waste is generally taken to mean waste generated by the municipal (including households and council activities), industrial, commercial and building and demolition sectors in Australia (Australia, Parliament 1994 p. 2). The waste produced by these sectors comprises most of the waste that is disposed of centrally (e.g. to landfill or incineration). Municipal waste includes packaging materials, food wastes, old furniture and garden wastes from households and wastes generated by council activities such as maintenance of landscapes. Industrial and commercial wastes include materials such as offcuts from manufacturing and packaging materials. Building and demolition wastes include demolition rubble and building offcuts.

Solid wastes are also generated by other industry sectors, such as mining and agriculture. These are often managed on site, as opposed to being transported to a conventional, centralised disposal facility. Agriculture, in particular, reuses the waste crop residues that it produces.

It is estimated that 14 million tonnes of solid waste are generated in Australia every year in the urban environment (Bullock 1994, p. 3; Australia, Parliament 1994). This is equivalent to 0.8 tonnes per person per year (Bullock 1994, p. 3), which is about 1.7 times the average production of other OECD countries, but only 0.6 times per capita waste generation in the USA. However an estimate of 22 million tonnes was made for 1990–91, for solid waste generation for the same sectors (Connor, Evans & Hurse 1995). While it is difficult to estimate the exact amounts of solid waste generated per year (for reasons outlined below) the large amounts are of concern, because of the resources being consumed and the environmental pollution associated with disposal.

Problems with data on solid waste

Current data on solid waste have a number of problems, and need to be interpreted with caution. Recent reports on solid waste have been based on sample surveys, or on surveys with response rates that resulted in variable coverage, making comparison between States and different sized communities difficult. A survey conducted for the Environment Protection Agency (EPA) (1994), to monitor performance against waste minimisation and recycling targets, met with a response rate of about 57% and covered only 68.5% of the population (see Table 12.1.3.1).

12.1.3.1 EPA survey response rates, 1994

	Total LGAs	*Total responses*	*Response rate*	*Population covered by responses*	
State	*No.*	*No.*	*%*	*No.*	*%*
NSW	177	124	70.1	4 322 083	71.9
Vic.	211	104	49.3	3 248 181	72.8
Qld	134	73	54.5	1 569 122	50.4
SA	121	73	60.3	757 533	51.8
WA	139	95	68.3	1 400 495	83.5
Tas.	29	20	70.0	383 947	81.4
NT	65	13	20.0	126 686	75.3
ACT	1	1	100.0	298 730	100.0
Aust.	**877**	**503**	**57.4**	**12 106 777**	**68.5**

Source: EPA 1994.

12.1.3.2 Classifications used for solid waste data collection in Australian capital cities

City	*Classifications*
Sydney	municipal, commercial/ industrial, building/demolition.
Melbourne	municipal/other.
Brisbane	household, industrial refuse, collection vehicles, hardfill.
Adelaide	domestic, other domestic, council generated waste.
Perth	municipal, construction/demolition, organic, industrial commercial, unclassified.
Hobart	commercial/domestic, garden, solid fill, industrial, household, car hazardous.
Darwin	domestic, industrial, tyres, cardboard, landscape, car wrecks, transfer station, fill/ rubble, other.
Canberra (a)	commercial/household

(a) Includes Queanbeyan.

Source: ACT Department of Urban Services 1995 unpub.; Department of Commerce and Trade Western Australia 1990; Department of Environment and Natural Resources (SA) 1995; Puplick & Nicholls 1992; Darwin City Council 1996 unpub.

The EPA (1994) identified a number of more general problems related to data collection, including:

- private landfills not being required to keep records (many small government-operated ones do not keep records either);
- inconsistent methodologies for data collection from year to year and only partial data collection (e.g. data for self haul disposal are sometimes completely ignored);
- some sectors of the waste stream that are major producers of waste are completely ignored, such as the commercial/industrial and building and demolition sectors; and
- inconsistent terminology and classification for waste streams and their components.

Comparison of sectoral solid waste statistics between cities is difficult, not only because there is a lack of reliable data, but also due to the different classifications of waste groups used to record data from facility to facility. These are often based on the procedures used for collection and disposal rather than on the sectors generating the wastes. Table 12.1.3.2 shows categories used for classification of wastes in some of Australia's capital cities. The capital cities have different types and levels of economic activity, which influences the types and amounts of waste generated.

A considerable gap exists between attempts to collect data on a nationwide scale. The most recent study prior to the EPA study was based on data from 1989 (Industry Commission 1991). The EPA study was conducted in 1993. Given the community concern about environmental issues and the rapid adoption of new waste management practices, it is likely that older figures will not reflect current progress in waste management.

Data coverage is inconsistent across sectors. Comprehensive sample surveys have been performed to estimate the composition of the domestic waste stream for some of Australia's capital cities, but few comprehensive surveys exist for the commercial/industrial or building/demolition sectors.

Such studies commonly characterise a waste collection and disposal activity for either an individual industry or local government. Collection and disposal of wastes, particularly for the commercial/industrial and building/demolition sectors (the most poorly characterised sectors), is often managed by private contractors, making the task of compiling a complete picture of the entire waste stream complex and expensive.

These problems make it difficult to accurately characterise the composition of wastes, the rates of waste generation and the practices of waste management services and bodies. The EPA and the Co-operative Research Centre for Waste Management and Pollution Control are addressing the problems of classification and co-ordination of data in the development of a National Solid Waste Classification System and the Australian Waste Database. The success of the database will still depend on reliable data collection at a local level by State EPAs through licences and levies.

Composition of the waste stream

Data relating to solid waste disposal provide an indicator of the rate of the transformation of primary natural resources for human activities, through the amount and type of refuse being discarded.

Table 12.1.3.3 shows the total amounts of solid waste disposed to landfill for the years 1990 to 1994 in the Sydney metropolitan area. These figures represent the municipal, commercial/industrial and building/demolition sectors. As indicated earlier, characterising the contribution of different sectors to the waste stream is difficult, given the lack of records kept about disposal of wastes across sectors.

12.1.3.3 Contribution by major sectors to Sydney metropolitan landfill

	Municipal		Commercial/industrial		Building/demolition		Total per capita
	Total	Per capita	Total	Per capita	Total	Per capita	
Year	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
1990	1 538 581	0.46	1 462 689	0.44	404 825	0.12	1.02
1991	1 400 420	0.42	1 245 365	0.37	296 524	0.09	0.88
1992	1 442 380	0.43	959 479	0.28	428 059	0.13	0.84
1993	1 380 865	0.41	868 677	0.26	384 879	0.11	0.78
1994	1 366 973	0.40	906 225	0.26	473 536	0.14	0.80

Source: NSW EPA 1995, unpub.

Municipal waste declined by about 13% from 1990. It accounts for slightly less than 50% of total waste disposed of to landfill. Building and demolition waste fluctuates, with a slow increase from nearly 12% of the total waste stream in 1990 to about 17% of the total waste stream in 1994. Commercial/ industrial waste has shown a total declined from 43% of the total waste stream in 1990 to 33% in 1994 (NSW EPA 1995).

The Brisbane City Council conducted a survey, based on a sample of 123 enterprises, to characterise waste composition for the commercial/industrial sector of that city. Table 12.1.3.4 shows the results for various commercial and industrial activities. There were marked differences in proportions of waste for the various categories of materials for the different activities. Nearly 4% of solid waste generated by the wood manufacturing sector was composed of plastics, over four times that percentage was generated by light manufacturing industry. Organic materials and paper both contributed a large proportion to all of the commercial and industrial activities surveyed. These proportions are not dissimilar to those shown in Table 9.2.4 for the composition of the household solid waste stream for various Australian capital cities.

Recycling estimates provide a further indication of the amounts of particular materials in the waste stream. They refer to those materials currently targeted for recycling, for which better estimates exist for the municipal sector than for either the commercial/industrial or the building/demolition sectors.

Management options

The National Waste Minimisation and Recycling Strategy

In 1991 the Commonwealth government, in consultation with ANZECC, developed the National Waste Minimisation and Recycling Strategy (NWMRS) (EPA, 1994). The strategy outlines the current waste management situation including problems, barriers and solution to reducing waste. It highlights the opportunities that a national, co-ordinated approach to waste management will bring. The Commonwealth Environmental Protection Agency (CEPA, now

12.1.3.4 Composition of solid wastes generated by the commercial/industrial sector, Brisbane 1995

	Shopping centres	Wood manufacturing	Utility	Commercial Business District	Light manufacturing	Total
Material	%	%	%	%	%	%
Paper	38.0	6.4	43.4	40.3	35.8	32.7
Plastics	10.8	3.6	11.2	5.7	14.7	8.5
Textiles	1.6	2.3	0.5	0.9	4.7	1.9
Metal	1.2	4.4	6.0	6.4	5.7	4.9
Glass	1.1	0.1	2.1	3.7	1.8	2.0
Other Inorganic (a)	1.1	4.4	6.8	2.9	9.0	4.5
Organic	46.3	78.9	25.2	39.8	27.3	44.4
Household (b)	0.0	0.0	4.9	0.3	1.0	0.9
Totals	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

(a) Includes construction/demolition materials, concrete, dust/dirt, ceramics, other.
(b) Includes electrical equipment, furniture, household hazardous, whitegoods, tyres/ rubber, medical waste.
Source: Brisbane City Council 1996, unpub.

12.1.3.5 National Waste Minimisation and Recycling Strategy Targets and achievements, 1994

Material	*Target*	*Progress by 1994*	*Comment*
Rigid and semi-rigid plastic containers	25% by 1995	–	Difficult to predict but some areas doing well.
HDPE (milk bottles etc)	50% by 1995	20%	Limited markets, and collection programmes. May not be reached.
PET (plastic soft drink bottles etc)	30% by 1995	22%	Target is likely to be achieved.
Vinyl	15% by 1995	6%	Not likely to be achieved but 10% is expected by 1995.
Polystyrene and	10% by 1995	na	Data not available.
polypropylene	15% by 1995	na	Data not available.
Glass containers	45% by 1995	42%	Target is likely to be achieved.
Aluminium cans	65% by 1995	64%	Target is likely to be achieved.
Steel cans	25% by end of 1996	18%	Target may be achieved.
Liquid paperboard (milk and juice cartons)	20% by 1995	11%	Target is unlikely to be achieved.
Newsprint	40% by 1995	43%	Target has been exceeded.
Paper packaging industry	71% recycled content by 1995	79%	Target has been exceeded.
Oil	70% collected by industry by 1995	45%	Target unlikely to ne achieved.
Local government target	100% of councils to have waste management plans by mid 1993	24%	Target was not met.
	90% of major urban areas to have a kerbside collection system by June 1994.	81%	Target may be achieved.
	60% of households with kerbside collection to use it at least once a month by June 1993.	na	60% of councils surveyed with kerbside collection had achieved this target.
National target	50% reduction in waste going to landfill by the year 2000.	na	There are difficulties in obtaining data for the base year as records are not consistent. Indications that progress has been insufficient.

Source: EPA 1996 unpub.

EPA) suggested in 1991 that solid waste management consists of four major concerns:

- Reduction of wastes, through avoidance or source reduction and minimisation by production techniques such as lightweighting and appropriate design;
- Recycling or reclamation, through re-use or reclamation including composting and energy recovery;
- Treatment of any harmful or potentially harmful wastes; and
- Disposal of materials that cannot be treated any other way.

Targets were established as the focus for NWMRS activity. In 1991 ANZECC endorsed the National Kerbside Recycling Strategy. This strategy was established to assist in reaching the waste recycling targets and achieving the 50% diversion of domestic waste from landfill through municipal collections on a per capita basis.

A national taskforce was established to report on the development and implementation of the strategy. Targets and achievements as at 1994 are outlined in Table 12.1.3.5. Not all of the targets initially set were expected to have been met by 1995. Some reduction targets are difficult to gauge as data can be unreliable or unobtainable. The 50% reduction of total waste to landfill is one such example. Table 12.1.3.6 shows that there was no data for Tasmania for the year 1990 on which to base a meaningful reduction target.

Many LGAs have not recorded amounts of waste going to landfill (EPA 1994). Table 12.1.3.6 indicates that from 1990 to 1993 an increase in total solid waste going to landfill was reported. However, this is more likely to be a reflection of improved data collection rather than an actual increase.

New strategies to achieve the 50% reduction in waste going to landfill by the year 2000 are now being set. In addition to reductions gained by existing local government kerbside recycling schemes, new targets will be negotiated between

12.1.3.6 Annual waste to landfill including changes from 1990 to 1993

	Total waste to landfill		*Population*		*Waste per person*		*Change*
	1990	*1993*	*1990*	*1993*	*1990*	*1993*	*1990–93*
	tonnes	*tonnes*	*persons*	*persons*	*t/person*	*t/person*	*%*
New South Wales							
Sydney	3 406 095	2 757 115	3 351 050	3 415 913	1.02	0.81	– 20.6
Wollongong	172 000	na	172 030	172 800	1.00	na	na
Newcastle	152 600	162 330	133 500	137 154	1.14	1.18	3.5
Victoria							
Melbourne E	519 808	713 000	678 700	689 000	0.77	1.04	35.1
Melbourne N	780 000	854 000	793 405	825 000	0.98	1.04	5.3
Melbourne SE	695 920	1 074 035	1 036 000	1 072 000	0.67	1.00	49.2
Melbourne W	450 145	797 000	569 300	591 400	0.79	1.35	70.4
Ballarat region	90 000	126 000	88 600	89 800	1.02	1.40	38.1
Bendigo	109 350	95 420	77 620	78 252	1.41	1.22	– 13.4
Shepparton	56 900	na	51 957	53 000	1.10	na	na
Mildura	137 600	na	41 480	43 400	3.32	na	na
Geelong	239 420	218 000	197 000	197 000	1.22	1.11	– 8.9
Central Gippsland	50 000	na	83 000	82 364	0.60	na	na
Flinders	43 200	51 400	39 250	46 750	1.10	1.10	– 0.1
Queensland							
Brisbane	915 491	685 368	747 177	755 000	1.23	0.91	– 25.9
South Australia							
Adelaide	1 296 337	1 118 010	1 049 900	1 067 322	1.24	1.05	– 17.9
Western Australia							
Perth Mindarie	436 740	na	na	na	na	na	na
Perth E	398 000	na	na	na	na	na	na
Perth SE	277 004	na	1 173 940	na	1.37	na	na
Perth W	55 893	na	na	na	na	na	na
Perth SW	442 745	na	na	na	na	na	na
Albany	14 816	na	24 600	na	0.60	na	na
Bunbury	28 877	na	37 000	na	0.78	na	na
Carnarvon	10 400	na	8 500	na	1.22	na	na
Other rural	369 055	na	398 820	na	0.93	na	na
Tasmania							
Hobart	na	85 000	na	47 436	na	1.79	na
Glenorchy	na	50 000	na	42 172	na	1.19	na
Clarence City	na	24 000	na	47 706	na	0.50	na
Launceston	na	66 200	na	64 360	na	1.03	na
Other rural	na	227 637	na	219 701	na	1.04	na
Northern Territory							
Darwin	61 710	56 630	77 400	78 500	0.80	0.72	9.5
Australian Capital Territory							
Canberra (a)	314 000	684 100	311 200	340 500	1.01	2.01	99.1

(a) Includes Queanbeyan. Data for 1990 based on estimates of a waste management study. 1993 data estimated from weigh bridge records and believed to be well in excess of actual amounts, given the introduction of disposal fees that year.
Source: EPA 1994.

industry groups and ANZECC to assist in achieving the overall landfill reduction target. ANZECC resolved to establish a new Task Force to develop Industry Waste Reduction Agreements. These agreements will be developed, based on voluntary action by industry sectors; both on recycling targets and source reduction objectives to achieve the targets. Sectors to be treated as priorities now include construction and demolition, commerce and industry, and public institutions. The waste streams now being targeted include organic wastes, construction and demolition wastes, and packaging and office wastes (ANZECC 1995, resolution no. 191).

12.1.3.7 Achievements in packaging lightweighting

Packaging product	*Weight reduction* %	*Period*
Aluminium can	32	1970–90
	19	1980–90
Glass bottle (average)	50	1980–92
Milk bottle	28	1960–90
Steel can	18	1970–90
Corrugated cardboard	24	1970–90
PET plastic bottle	36	1983–90
	20(a)	1989

(a) Base cup removal.
Source: Puplick & Nicholls 1992.

Waste Minimisation

Waste minimisation encourages consideration of resources used to prevent the generation of waste products. It includes techniques such as the life cycle approach to product design, ensuring minimum resource use or maximum recyclability. These considerations can result in other environmental and economic gains, such as lower energy use. Lightweighting is an example of a waste minimisation strategy, where products are redesigned to use less materials without reducing the utility of the product. Table 12.1.3.7 shows some examples of achievements in lightweighting of packaging materials over time. Data on waste minimisation achievements for other manufactured goods or manufacturing processes (which make up a significant part of the waste stream) are often limited to individual companies, rather than covering whole industry sectors.

Participation in recycling schemes

Table 12.1.3.8 shows the availability of kerbside recycling schemes in a sample of Australian Local Government Areas. Of the councils that responded to the survey, 72% provided a regular kerbside service. The number of large councils providing kerbside recycling services was over four times the number that did not. This may seem to be due to the economies of scale provided by large communities except that, of the medium sized communities covered by council responses, only one third had access to these services, while two thirds of small communities did (EPA 1994). The respondent councils that did provide kerbside recycling schemes were more likely to have shown a reduction in waste generated needing disposal (mostly to landfill) relative to those that did not provide these schemes. However both categories were equally likely to have experienced an absolute increase in waste generated (based on the few respondent councils that have kept records of waste generation over time) (EPA 1994).

An ABS survey of households conducted in 1992 shows that many participate in other methods of recycling instead of or in addition to using kerbside services. The survey showed that 45% of households composted or mulched household and garden wastes and nearly 43% reused wastes within the home. Only 46% of households surveyed had access to kerbside recycling services in 1992. The absence of kerbside recycling services was one of the major reasons given why households did not recycle (ABS 1993, 4602.0). Section 10.1 discusses in greater detail the participation by individuals in recycling.

12.1.3.8 Availability of kerbside recycling schemes, 1993

	LGAs with kerbside collection schemes (a)			*Major areas (pop.> 100 000)*		*Small communities (pop.<10 000)*		*Other areas*	
	LGAs	*Population covered (b)*	*Proportion of population*	*With*	*Without*	*With*	*Without*	*With*	*Without*
	No.	'000	%	No.	No.	No.	No.	No.	No.
NSW	63	3 581 136	59.6	31	3	15	39	17	18
Vic.	83	2 376 898	53.3	29	0	34	19	20	0
Qld	26	967 527	31.1	11	6	12	34	3	6
SA	26	487 137	33.3	9	3	15	39	2	5
WA	39	1 120 643	66.8	15	3	16	51	8	2
Tas.	11	129 752	27.5	0	4	5	3	6	2
NT	1	650	3.9	0	2	1	10	0	0
ACT	0	0	0.0	0	1	0	0	0	0
Australia	**248**	**8 663 743**	**49.1**	**95**	**22**	**98**	**195**	**56**	**33**

(a) Does not include paper chases and bottle drives, which can be additional to the above figures.
(b) Population as innumerated by survey, not adjusted for non-response.
Source: EPA 1994.

12.1.3.9 Waste management planning

	Total LGAs	*LGAs with plans*	*Population covered by plans*	*Plans with a 50% reduction target*	
State	*number*	*number*	*number*	*number*	*%*
New South Wales	177	35	1 786 706	19	54
Victoria	211	28	850 999	19	68
Queensland	134	7	438 417	4	57
South Australia	121	18	212 686	6	33
Western Australia	139	21	729 581	10	48
Tasmania	29	11	263 362	9	82
Northern Territory	65	1	3 503	0	0
Australian Capital Territory	1	1	298 730	1	100
Australia	**877**	**122**	**4 583 984**	**68**	**56**

Note: figures are as innumerated by survey, not adjusted for non-response.
Source: EPA 1994.

Waste management planning

Waste management planning was one of the NWMRS targets (see Table 12.1.3.5). Such planning is essential for the development of appropriate policies to accommodate waste generation in a given area, particularly if the NWMRS targets are to be met. Waste management plans cover issues from collection to recycling to disposal, for both present and future needs. Table 12.1.3.9 shows the number of councils responding to an EPA survey which indicated that they have waste management plans. Of the 503 responding councils, 24% had a current waste management plan at the beginning of 1994. Of those with plans, 56% incorporated the 50% reduction target.

Disposal

In Australia landfill is the main method of solid waste disposal. Incineration accounts for less than 1% of waste disposed. Table 12.1.3.10 shows a comparison with other selected countries of the proportions of solid waste disposed by incineration.

12.1.3.10 Proportion of municipal solid waste disposed of by incineration, various countries

	Municipal solid waste incinerated
Country	*%*
Singapore	85
Denmark	65
Sweden	55
France	42
Netherlands	40
Germany	30
Australia	**<1**

Source: Australia. Parliament 1994.

Landfill has remained the dominant method of disposal in Australia as landfill costs are currently relatively cheap and a critical shortage of space has not yet been reached, unlike the case in many European countries. Landfill in some cities is facing the future problem of diminishing space close to the regions generating the waste. Cities face different problems in establishing new landfill sites, including available space, inappropriate geology and community opposition. Table 12.1.3.11 shows the estimated life expectancy of current landfill sites for the major capital cities.

12.1.3.11 Life expectancy of current landfill sites in Australian capital cities

City	*Year expected to reach capacity (a)*
Sydney	na
Melbourne	2000+(b)
Brisbane	2016
Adelaide	
North and central regions	2003 (2009)(c)
South regions	2016 (2020)(c)
Perth	2007
Tasmania	na
Darwin	2026
ACT and Queanbeyan	2005–07

(a) Estimates taken at different times, on basis of existing landfill sites.
(b) Usually only licensed for 5 to 7 years at a time.
(c) Best case scenario based on 8% reduction for 5 years and 0% reduction thereafter.
Source: Department of Commerce and Trade Western Australia 1990; Waste Recycling and Processing Service 1994; ACT Department of Urban Services 1995, unpub.; Department of Environment and Natural Resources SA 1995; Darwin City Council 1996, unpub.; Brisbane City Council 1996, unpub.; Wallwork and Joy 1993.

12.1.3.12 Estimates(a) of methane produced by landfill sites 1989–1990

State	Municipal solid waste to landfill '000 tonnes	Net methane emissions '000 tonnes
NSW	5 462	517.3
Vic.	3 508	284.1
Qld	1 909	211.9
SA	1 478	139.2
WA	1 605	125.2
Tas.	285	27.0
NT	102	9.7
ACT	314	29.8
Australia	**14 663**	**1 344.3**

(a) These are estimates and may not reflect actual totals.
Source: DEST 1994.

Landfill can create problems of pollution to air, water and soil. Social amenity can be reduced through increased traffic, odour, vermin and litter. In 1993 the Victorian EPA received 580 complaints about landfill sites, mostly regarding odour (Newton 1994, p. 244).

Landfill sites are generally located on cheap, socially undesirable land (Australia, Parliament 1994) at the edge of the cities they serve. Waste is dumped in large excavated pits and covered with successive layers of earth and waste. Depending on the level of management (often determined by the scale of the operation) the pit may be lined with impermeable materials such as clays or HDPE to prevent or direct the escape of leachates from the pit. The waste decomposes anaerobically by a chain of reactions, initially producing a high strength acidic leachate followed by gas production composed of 40 to 70% methane (Moore S., pers. comm.). Provision must be made for the collection and appropriate disposal of waters that enter the landfill as these can pollute surface and ground waters.

The gas produced by landfill sites is estimated to be the second largest contributor of methane to the atmosphere, about 21.6%, after agriculture at 54.5% (DEST 1994, p. 11). In 1989–90 an estimated 1.3 million tonnes of methane was produced by landfill sites across Australia (Table 12.1.3.12).

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12.1.4 Generation and disposal of special wastes

Introduction

The generation and disposal of special wastes are considered here from the perspective of the pressures from such wastes on the environment. Wastes are a result of economic processes. How they are handled is of particular consideration in assessing the effectiveness of industry's actions to alleviate their pressure on the environment. Those wastes deemed hazardous are the primary concern of this section. The information presented here draws on data provided by the Australian Waste Database, also referred to as the National Waste Database Project.

Defining and classifying hazardous wastes for management and disposal within Australia

Hazardous wastes are defined in many different ways, for example:

"a substance or mixture of substances which has no further economic use and which if disposed of untreated to land, water or air will be potentially harmful to man (sic) or his environment by reason of its chemical, biological or physical properties" (AEC quoted in EDO 1992).

In Australia, hazardous wastes are often defined under two criteria, generic and constituent:

- Generic definitions describe the process from which the waste arises (see Table 12.1.4.1); and
- Constituent defines designated wastes according to the measurable concentrations of hazardous compounds present in the substance.

At present, however, with management and disposal of hazardous wastes within Australia falling under the jurisdictions of the varying State and Territory governments, there is no uniform legislation for such management and disposal. It follows that there is also no uniformly accepted definition across those jurisdictions of what actually constitutes a "hazardous" waste (EPA 1996, pers comm.).

12.1.4.1 Australian Environment Council hazardous waste classification, 1986

Type of waste	*Waste sub-types*
Plating and heat treatment	Discarded plating solutions and heat treatment solutions. Complex cyanides and other cyanide solutions.
Acids	Sulphuric, hydrochloric, nitric, phosphoric, chromic, hydrofluoric. Sulphuric/hydrochloric mixtures. Other mixed acids. Organic acids.
Alkalis	Caustic soda, potash, alkaline cleaners, ammonium hydroxide. Slurries of lime or cement not containing metal sludges. Lime neutralised metal sludges. Other sludges.
Inorganic chemicals	Non-toxic salts. Arsenic, cadmium, chromium, mercury. Compounds of arsenic, boron, cadmium, chromium, lead, mercury. Equipment containing mercury. Other inorganic salts and complexes.
Reactive Chemicals	Oxidising agents, reducing agents. Explosive and unstable chemicals. Highly reactive chemicals.
Paints, resin, inks, dyes, adhesives, organic sludges	Aqueous based non combustible or flammable. Solvent based combustible or flammable. Flammable aqueous based. Paint residues. Cured adhesives or resins.
Organic solvents	Non-halogenated flammable or combustible. Halogenated combustible or flammable and halogenated non-combustible or non-flammable vapours.
Pesticides	Inorganic, organo-metallic. Organo phosphorous. Pesticides containing nitrogen, halogen, sulphur. Biological pesticides.
Waste oil	Contaminated oils. Oil/water mixtures. Water/oil sludge.
Textile	Tannery wastes. Wool scouring. Textile washwaters.
Putrescible/ Organic wastes	Animal effluent, residues and oils. Grease trap waste- industrial and domestic. Bacterial sludge. Vegetable oils and sludges. Tallow derivatives.
Washwaters	Truck machinery washwaters. Other industrial washwaters.
Inert wastes	Inert sludges and slurries.
Organic chemicals	Insoluble non-halogenated aliphatics, aromatics and phenolics highly odorous. Pharmaceuticals and residues. Surfactants and detergents. Insoluble polychlorinated, halogenated organics. Other.
Bags, containers	Containers and bags that have contained hazardous wastes.
Immobilised wastes, inert wastes	Encapsulated, chemically fixed, solidified, polymerised or inert.
Miscellaneous	Contaminated soils — with specified contaminant. Pathogenic. Other.

Source: AEC 1986 cited in National Waste Database Project 1993.

Hazardous wastes — international

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention), to which Australia is a signatory, was developed under the auspices of the United Nations Environment Program (UNEP). The Convention aims to reduce the amount of waste being transported across national boundaries with a view to reducing the amount of such wastes generated by countries, as well as encouraging local disposal, and ensuring disposal by safe means in the country of destination when exported. Australia ratified the Convention in 1992, following the implementation of the *Hazardous Waste (Regulation of Exports and Imports) Act 1989* (EPA 1996, pers comm.).

In March 1994 the Conference of parties to the Basel Convention decided to prohibit all transboundary movements from OECD to non-OECD countries of hazardous wastes which are destined for final disposal. It was also proposed to phase out the trade in hazardous wastes, destined for recycling or recovery operations, by 31 December 1997 (DFAT, EPA & DPIE 1995). This decision and proposal, if adopted by Australia's trading partners, are likely to have an effect on Australia's trade in hazardous wastes.

The Basel Convention defines hazardous wastes by a specific list of hazardous characteristics — Annex III (see Table 12.1.4.2) as well as extending to wastes covered by a country's own definition. Annex III is currently being subjected to extensive clarification work by the Convention's Technical Working Group (EPA 1996, pers comm.).

Another system of identification and classification of hazardous wastes, developed by the Organisation for Economic Co-operation and Development (OECD), categorises them into three tiers. These are listed in order from least hazardous to most hazardous: Green (Table 12.1.4.3) Amber (Table 12.1.4.4 and Red (Table 12.1.4.5).

The OECD's system is not used by Australia in defining wastes for the purposes of import or export under the Basel Convention; rather, they are assessed against the Basel Convention's own classification system, subject to its ongoing clarification. The following figures on OECD-listed substances would not necessarily translate to give even an approximate indication of wastes that would be subject to the Convention (EPA 1996, pers comm.).

A survey of 80 companies in Australia most likely to trade in hazardous waste destined for recovery operations found that 31 traded in the OECD amber listed substances during 1994–95 (DEFAT, EPA & DPIE 1995). Of these, 22 were exporters only and 9 both exported and imported amber listed substances. Twenty one companies also exported other substances (that have not yet been classified as hazardous waste under the Basel Convention) presently on the OECD green list. The survey ascertained that both exports and imports of hazardous wastes were not destined simply for final disposal. No trade in red listed substances was identified (DFAT, EPA & DPIE 1995).

12.1.4.2 Basel Convention — List of Hazardous Characteristics, Annex III

UN Class (a) Code	*Characteristics*
1 H1	Explosive — substance capable by chemical reaction of producing gas at such a temperature, pressure and speed as to cause damage to the surroundings.
3 H3	Flammable liquids — (also meaning inflammable) which give off a flammable vapour at temperatures of not more than 60.5°C, closed-cup test or not more than 65.5°C open-cup test.
4.1 H4.1	Flammable solids — other than those classed as explosives, which under conditions encountered in transport are readily combustible or may cause/contribute to fire through friction.
4.2 H4.2	Substances or wastes liable to spontaneous combustion — under normal conditions encountered in transport, or to heating up on contact with air and then liable to catch fire.
4.3 H4.3	Substances or wastes which in contact with water emit flammable gases.
5.1 H5.1	Oxidising — not necessarily combustible but may cause or contribute to the combustion of other materials.
5.2 H5.2	Organic Peroxides — materials which contain the bivalent-0-0 structure which are thermally unstable substances.
6.1 H6.1	Poisonous (Acute) — cause death or serious injury or harm to human health if swallowed, inhaled or by skin contact.
6.2 H6.2	Infectious substances — containing viable micro-organisms or their toxins.
8 H8	Corrosives — by chemical action will cause severe damage.
9 H10	Liberation of toxic gases in contact with air or water — give off toxic gases.
9 H11	Toxic (delayed or chronic) — inhaled, ingested or penetrate skin may involve delayed or chronic effects (including carcinogenecity).
9 H12	Ecotoxic (1) — if released may cause impacts to environment by means of bioaccumulation and/or toxic effects upon biotic systems.
9 H13	Ecotoxic (2) — may yield another material, e.g. leachate which possesses characteristics of Ecotoxic (1) above.

(a) Corresponds to the hazard classification system included in the United Nations Recommendations on the Transport of Dangerous Goods (ST/SG/AC.10/1/Rev.5, United Nations, New York, 1988).

Source: EPA 1996, pers comm.

12.1.4.3 Green tier wastes

Category	Waste Type
Metal and metal-alloy wastes in metallic, non-dispersible form	Waste and scrap of: precious metals and their alloys, iron and steel, non-ferrous metals and their alloys, hafnium, indium, niobium, rhenium, gallium, thallium, thorium, selenium, tellurium, rare earths.
Metal bearing wastes arising from melting, smelting and refining of metals	Hard zinc spelter and zinc drosses, aluminium skimmings, slags from precious metals and copper processing, tin slags < 0.5% tin.
Other wastes containing metals	Electrical assemblies wholly of metals or alloys and electrical scrap, vessels, structures, and vehicles cleaned of other materials. Spent catalysts, slags from manufacture of steels, mill scale.
Wastes from mining operations in non-dispersible form	Natural graphite, slate, mica, leucite, nepheline, nepheline syenite, felspar, fluospar, silica in solid form excluding that used in foundries.
Glass waste in non-dispersible form	Cullet, scrap, fibre, excluding glass from cathode-ray tubes or other activated glasses.
Ceramic wastes in non-dispersible form	Cermet wastes and scrap including metal ceramic composites, fired ceramics including used vessels, fibres not listed elsewhere.
Other wastes containing principally inorganic constituents, which may contain metals and organic materials	Partially refined calcium sulphate from flue gas desulphurisation, gypsum wallboard or plasterboard from demolition sites, bottom or fly ash and slag tap from coal fired plants, anode butts of petroleum coke and bitumen, spent activated carbon, chemically stabilised slag from copper production with a >20% iron content, sulphur in solid form, limestone from calcium cyanamide production with ph <9, neutralised red mud from alumina production, chlorides of sodium, potassium and calcium, silicon carbide, broken concrete, lithium-tantalum and lithium niobium containing glass scraps.
Solid plastic wastes	Waste, parings and scrap of polymers: ethylene, styrene, vinyl chloride, polypropylene, polyethylene terephthalate, acrlonitrile copolymer, butadiene copolymer, styrene copolymer, polyamides, polybutylene terephthalate, polycarbonates, polyphenylene sulphides, acrylic polymers, paraffins (C10-13), polyurethane (not containing chlorofluorocarbons), polysiloxalanes, polymethyl methacrylate, polyvinyl alcohol, polyvinyl butyral, polyvinyl acetate, polymers of fluorinated ethylene (Teflon, PTFE).
	Resins or condensation products such as: formaldehyde resins, epoxy resins, alkaloid resins, polyamides.
Paper, paperboard, and paper product wastes	Waste and scrap of paper or paperboard including laminated paper products.
Textile wastes	Wastes of: silk, wool excluding garneted stock, cotton, flax, true hemp, jute, sisal, coconut, abaca, ramie and other vegetable fibres not specified, man-made fibres, worn clothing, rags.
Rubber wastes	Waste, scrap and parings of rubber and hard rubber, used pneumatic tyres.
Untreated cork and wood wastes	Wood: logs, briquettes, pellets, or similar forms.
	Cork: crushed, granulated or ground.
Wastes arising from agro-food industries	Wine lees, dries and sterilised vegetable waste, residues or by products, degras, bones, horns, fish wastes, cocoa wastes, wastes excluding by-products which meet national and international requirements for human and animal consumption.
Wastes arising from tanning and fellmongery operations and leather use	Skins, hair, bristles of: horses, pigs, boars, hogs.
	Skins and feathers of birds.
	Parings and other wastes of leather not suitable for manufacture, excluding leather sludge.
Other wastes containing principally organic constituents, which may contain metals and inorganic materials	Human hair, straw, photographic film base and film not containing silver, single use cameras without batteries, deactivated fungus mycelium from penicillin production to be used as animal feed.

Source: OECD 1995a.

12.1.4.4 Amber tier wastes

Category	*Waste type*
Metal bearing wastes	Ashes and residues of: lead, copper, aluminium, vanadium, other metals or metal compounds not specified elsewhere. Dross, scalings and other wastes from the manufacture of iron and steel. Waste and residue of thallium, arsenic and mercury. Residue from alumina production not specified elsewhere. Galvanic sludges. Liquors from pickling metals, Leaching residues from zinc processing; dust and sludges such as jarosite, hematite, goethite, and other substances. Ash, sludge, dust and other residues, which may contain inorganic cyanides, from precious metals. Lead-acid batteries, batteries or accumulators and scrap arising form the production of batteries and accumulators not specified elsewhere.
Wastes containing principally inorganic constituents which may contain metals and organic materials	Slag, ash and residues not listed elsewhere, residues arising from the combustion of municipal wastes, non-cyanide based systems wastes, glass from cathode-ray tubes and other activated glasses, calcium fluoride sludge, other inorganic fluorine compounds in the form of liquids or sludges, sands used in foundry operations, waste catalysts not on the green list, hydrates of aluminium and alumina, basic solutions, inorganic halide compounds not elsewhere specified, blasting grit, gypsum arising from chemical industry processes, unrefined calcium sulphite and calcium sulphate from flue gas desulphurisation.
Wastes containing principally organic constituents which may contain metals and inorganic materials	petroleum, coke and bitumen processing and production wastes, excluding anode butts; asphalt cements wastes, waste oils, leaded petrol sludges, thermal fluids, hydraulic fluids, brake fluids, antifreeze, wastes from the production, formulation and use of resins, latex, plasticisers, glues and adhesives; nitrocellulose; phenols, phenol compounds including chlorophenol in liquid or sludge form; polychorlinated naphthalenes; ethers; triethylamine catalysts for setting foundry sands; chlorofluorocarbons; halons; treated wood and cork wastes; leather dust, ash, sludges and flours; fluff from automobile shredding; organic phosphorous compounds; non-halogenated and halogenated solvents and non-aqueous distillation residues arising from organic solvent recovery operations; wastes arising from the production of aliphatic halogenated hydrocarbons; surfactants; liquid pig manure; faeces; sewage sludge.
Wastes which may contain either inorganic or organic constituents	Wastes from the production, preparation, formulation and use of: pharmaceuticals, phytopharmaceuticals, and biocides; wastes from manufacturing, formulation and use of wood preserving chemicals; wastes containing or consisting of inorganic cyanides — excepting precious metal-bearing residues in solid form containing traces of inorganic cyanides, organic cyanides; wastes oils/water, hydrocarbons/water mixtures, emulsions; wastes from production and use of inks, dyes, pigments, paints, lacquers, varnish; wastes of an explosive nature not subject to specific other legislation; wastes from production, formulation and use of reprographic and photographic chemicals and materials not elsewhere specified or included; non-cyanide based systems arising from surface treatment of plastics; acidic solutions; ion exchange resins; single use cameras with batteries; industrial pollution control devices for cleaning of industrial off-gases not elsewhere specified or included; naturally occurring organic material used as a filter medium; municipal/ hazardous wastes.

Source: OECD 1994.

12.1.4.5 Red tier wastes

Category	Waste Type
Wastes containing principally organic constituents which may contain metals and inorganic materials	Wastes, substances and articles containing of or contaminated with polychlorinated biphenyl and/or polychlorinated terphenyl and/or polybrominated biphenyl, including any other polybrominated analogues of these compounds at a concentration level of 50mg/kg or more; waste tarry residues— excluding asphalt cements, arising from refining, distillation and any pyrolitic treatment of organic materials.
Wastes containing principally inorganic constituents which may contain metals and organic materials	Asbestos dusts and fibres; ceramic based fibres of physio-chemical characteristics similar to those of asbestos.
Wastes which may contain either inorganic or organic constituents	Wastes that contain, consist of or are contaminated with: any congener of polychlorinated dibenzo-furan or polychlorinated dibenzo-dioxin; leaded anti-knock compound sludges; peroxides other than hydrogen peroxide.

Source: OECD, 1994.

12.1.4.6 Trade in amber listed substances, 1994–95 (a) (b)

	Export		Import	
Industry sector	*$ 000*	*Tonnes*	*$ 000*	*Tonnes*
Metals	44 640	38 747	5 920	7 220
Chemical	0	0	0	0
Oil/petrochemical	0	0	0	0
Mineral	0	0	0	0
Agricultural	0	0	0	0
Pharmaceutical	0	0	0	0
Lead acid batteries	3 660	19 976	0	0
Batteries other	3	150	0	0
Total Trade	**48 303**	**58 873**	**5 920**	**7 220**

(a) The metals industry sector accounts for the most trade in OECD amber listed substances. The largest trade was in lead ash and residues worth $17.58 million, second largest was copper ash and residues worth $12.15 million.
(b) Value of trade is expressed in current values.
Source: DFAT, EPA & DPIE 1995.

During 1994–95, exports valued at $48.3 million and imports valued at $5.9 million were recorded in amber listed substances (see Table 12.1.4.6. Other substances traded (by waste stream) were worth $184.77 million (see Table 12.1.4.7).

As there is no uniform legislation for the disposal of hazardous wastes in Australia, concern has been raised that wastes are being transported to jurisdictions with lower waste disposal standards. A national system that tracks the movement of wastes interstate is being developed by ANZECC (Parliament of Australia 1994, p. 103). The National Pollutant Inventory is intended to be a mandatory system whereby data are collected, the aim of which is to help industry better manage its outflows. Collection is to be underpinned by Commonwealth and State legislation and is designed to heighten public and industry awareness of the volumes of waste and pollution generated.

At present, however, each State is responsible for designating wastes as hazardous in its Regulations under Acts governing the management of hazardous wastes. A number of Acts relating to pollution control exist (refer to Section 13.1 Environmental legislation).

Data available on hazardous wastes relate to monitored wastes. Wastes monitored are those transported from the generator to a central treatment site (these are also referred to as manifested hazardous wastes). The National Waste Database lists the volume of manifested hazardous wastes generated. Data for Sydney (Table 12.1.4.8) and Adelaide (Table 12.1.4.9) present the most reliable and accurate picture of the manifested waste flows. The National Waste Database does not include wastes disposed of on site, nor radio-active wastes.

Methods of treatment and disposal

There are a number of methods available in Australia for the treatment and disposal of wastes. At present hazardous wastes can be:

- dealt with at the place of their generation, on site;
- transported to a central waste treatment plant and/or disposal site.

Generally only large companies can sustain the disposal of wastes on site. Smaller companies must use central treatment stations.

12.1.4.7 Trade in selected substances by waste stream (a), 1994–95

	Export	
Waste Stream	*$m*	*tonnes*
Copper waste and scrap	26.07	15 443
Zinc skimming	0.19	446
Granulated slag arising	0.34	31 900
Electronic scrap	1.17	2 703
Cobalt waste and scrap	119.90	6 236
Polymers and co-polymers	2.15	5 673
Polymers of ethylene	0.84	1 859
Paper and paperboard (made mainly of bleached chemical pulp)	1.91	12 412
Paper and paperboard made mainly of mechanical pulp	9.73	113 493
Paper and paperboard unsorted waste and scrap	7.81	45 393
Slags from precious metal	0.65	13
Metals other	14.00	14 000
Total	184.76	249 571

(a) Most of the values and quantities obtained of trade in the above substances viz. copper, plastics and paper covering the full financial year were obtained by extrapolating STARS data base figures covering an 11 month period July 94 to May 95.
Source: DFAT, EPA & DPIE 1995.

12.1.4.8 Manifested hazardous wastes generated annually by industry, Sydney 1990–94 (a)

Waste	*Agriculture (b)*	*Mining*	*Manufacturing*	*Electricity, Gas & Water*	*Construction*	*Wholesale, Retail Trade*	*Accommodation & Hospitality*
	kl	*kl*	*kl*	*kl*	*kl*	*kl*	*kl*
Plating and Heat	0	0	742	0	0	54	3
Acids	0	56	5 744	97	0	90	0
Alkalis	0	9	6 457	66	6	416	0
Inorganic Chemicals	67	166	2 921	57	14	616	0
Reactive Chemicals	0	0	180	8	0	3	0
Paint— Organic Sludges	0	0	8 052	1	21	499	0
Organic Solvents	0	0	3 077	6	2	319	0
Pesticides	0	0	106	0	0	1	0
Waste Oil	11	21	7 298	228	282	2 077	4
Textiles	0	0	441	0	0	0	0
Putrescible	0	0	7 945	181	1	769	0
Wash-waters	0	55	5 904	276	45	2 290	56
Inert	0	0	395	7	0	46	0
Organic Chemicals	0	1	1 949	9	2	41	0
Bags etc	0	0	13	0	0	2	0
Immobilised	0	0	4 560	0	2	3	0
Miscellaneous	0	84	1 675	1 424	955	1 155	0
Total (c)	**78**	**393**	**57 460**	**2 362**	**1 330**	**8 381**	**63**

Waste	*Transport & Storage*	*Communication Services*	*Finance, Insurance, Property, Business Services*	*Health & Community Services*	*Total*
	kl	*kl*	*kl*	*kl*	*kl*
Plating and Heat	1	12	17	0	830
Acids	4	28	194	0	6 212
Alkalis	67	9	2 345	0	9 375
Inorganic Chemicals	12	53	103	22	4 032
Reactive Chemicals	3	0	25	0	220
Paint— Organic Sludges	3	7	175	0	8 759
Organic Solvents	23	223	452	0	4 102
Pesticides	0	0	10	0	118
Waste Oil	124	3 661	2 922	0	16 628
Textiles	20	0	38	0	500
Putrescible	1	109	3 659	0	12 665
Wash-waters	118	126	1 418	1	10 290
Inert	2	1	57	0	507
Organic Chemicals	21	15	7 085	0	9 122
Bags etc	0	0	25	0	40
Immobilised	0	2	206	0	4 773
Miscellaneous	2 797	223	277	722	9 312
Total (c)	**3 195**	**4 466**	**19 011**	**745**	**97 485**

(a) Average over 5 years.
(b) Includes forestry and fishing.
(c) Excludes oily wastes and greasy wastes which are hazardous, but which are controlled by a separate manifest system.
Source: Australian Waste Database Project 1994.

12.1.4.9 Manifested hazardous wastes generated annually by industry, Adelaide 1990–92 (a)

Waste	Agriculture (b)	Mining	Manufacturing	Electricity, Gas & Water Supply	Construction	Wholesale, Retail Trade	Public Admin. & Defence
	kl	kl	kl	kl	kl	kl	kl
Plating and Heat	0	0	2 471	0	0	0	5
Acids	0	6	1 796	9	9	1	7
Alkalis	0	0	5 706	83	0	2	4
Inorganic Chemicals	0	2	953	0	0	0	34
Reactive Chemicals	0	0	7	0	0	0	1
Paint— Organic Sludges	2	0	785	1	1	5	14
Organic Solvents	1	1	384	2	7	0	5
Pesticides	0	0	158	0	0	2	4
Waste Oil	0	0	805	0	0	0	7
Textiles	0	0	1 687	0	3	0	0
Putrescible	0	0	0	0	0	0	0
Wash-waters	0	0	1	0	0	0	0
Inert	0	0	0	0	0	0	0
Organic Chemicals	8	1	549	10	3	0	0
Bags etc	0	0	0	0	0	0	0
Immobilised	0	0	2 188	4	8	1	10
Miscellaneous	0	41	1 709	2	3 041	0	1 210
Total (c)	**2**	**51**	**19 199**	**111**	**3 072**	**11**	**1 300**

Waste	Transport & Storage	Communication Services	Finance, Property, Business Services	Community Services	Rec, Personal & Other services	Total
	kl	kl	kl	kl	kl	kl
Plating and Heat	0	0	0	1	0	2 478
Acids	10	1	0	0	0	1 840
Alkalis	239	0	0	0	0	6 033
Inorganic Chemicals	0	0	0	3	0	993
Reactive Chemicals	0	0	0	0	0	9
Paint— Organic Sludges	36	0	0	2	0	845
Organic Solvents	16	0	0	7	0	422
Pesticides	0	0	0	2	0	165
Waste Oil	204	0	0	0	0	1 017
Textiles	0	0	0	0	0	1 690
Putrescible	0	0	0	12	0	12
Wash-waters	0	0	0	0	0	1
Inert	0	0	0	0	0	0
Organic Chemicals	3	1	0	29	0	595
Bags etc	0	0	0	0	0	0
Immobilised	0	0	0	0	1	2 212
Miscellaneous	228	1	13	13 350	0	19 595
Total (c)	**737**	**4**	**13**	**13 407**	**2**	**37 909**

(a) Average over 3 years.
(b) Includes forestry and fishing.
(c) Excludes oily wastes and greasy wastes which are hazardous, but which are controlled by a separate manifest system.
Source: Australian Waste Database Project 1994.

On site

If waste is treated on site, a number of methods are open to the generator. Information on companies' waste generation and disposal on site is checked by local Environment Protection Authorities. The National Pollutant Inventory, when established, will attempt to collate data on wastes emitted to the environment.

Much of the waste produced through industry is classified as hazardous or scheduled (scheduled wastes are described later in this section). Large industries often incinerate wastes or dispose of them to landfills on site.

Many companies clean up their own hazardous and scheduled wastes. Others clean them to the point where they can be discharged into the regular waste stream. Residues which cannot be dealt with by the regular waste stream are then stored or sent for processing off site.

Incinerators are used by hospitals and medical facilities to dispose of wastes not permitted to go to landfill.

"High temperature incinerators (HTI), meanwhile, are designed to combust materials which are extremely chemically stable and do not combust readily, such as PCBs" (Hyman cited in Parliament of Australia 1994, pp. 125). The Senate Standing Committee on Environment, Recreation and the Arts did not support the construction of a high temperature incinerator as there was a lack of community support, and it considered that there were alternative technologies available (Parliament of Australia 1994, p. 127).

Off site

Reliable data on the volumes of hazardous wastes generated in Australia are only available for wastes which are disposed of off site (see Tables 12.1.4.8 and 12.1.4.9).

Recycling and storage

Some wastes generated by industry are recycled within the industrial process. This is usually as fuel. Other processes include:

- steelworks dust and sewage sludges to produce cast iron and zinc oxide. The heavy metals in the waste remain in the cast iron at the end of the process; and
- electroflotation can be used to treat metal and oil contaminations in industrial waste water. Metal salts, such as aluminium sulphate or iron chloride, can be recovered and reused for flocculation (Parliament of Australia 1994).

Storage is acknowledged not to be a bona fide method of disposal as it is expensive and still potentially hazardous. It is still used by many companies without the infrastructure to develop methods of safe disposal (Independent Panel on Intractable Wastes cited in Parliament of Australia 1994, p. 252).

Scheduled wastes

Scheduled wastes (previously referred to as intractable wastes) are especially classified as they are considered to be difficult to dispose of without special technologies or equipment (Scheduled Wastes Management, 1994a). They are stored until a suitable and economically viable method of disposal is developed.

The Commonwealth and State/Territory governments have agreed to the implementation of a national approach for the management of scheduled wastes. The first groupings of scheduled wastes, referred to as schedule X wastes, include:

- Polychlorinated biphenyls (PCBs);
- Hexachlorobenzene waste;
- Organochlorine pesticides (e.g. DDT and DDD); and
- Other chlorinated hydrocarbons (e.g. pentachloro-) (Scheduled Wastes Management 1994a).

The actual volume of these scheduled wastes stored in Australia is unknown. However it is estimated that there are:

- between 3,000 and 100,000 tonnes of PCB contaminated wastes ; and
- several thousand tonnes of organochlorine pesticides in storage (Ebell et al., cited in Parliament of Australia 1994, pp. 118).

PCBs have never been manufactured in Australia, and since 1975 their importation has been banned. It is believed, however, that 10–20 thousand tonnes have been imported into Australia since the 1930s, with between 3 and 7 thousand tonnes being released into the environment. About 200 tonnes of the remaining PCBs are to be found in equipment of the electrical supply industry (because of their non-flammable, stable and electrically insulating qualities). The whereabouts of the rest are unknown (Scheduled Wastes Management 1994b).

Health and environmental concerns about PCBs date back to the 1970s, and include environmental persistence, possible carcinogenic properties and mutations in plants and animals. New technologies are now treating PCB waste in Australia (Scheduled Waste Management 1994b ; Bainton, P. 1996, pers comm.).

Radioactive wastes

The Commonwealth, State and Territory governments are responsible for the management of radioactive wastes produced within their jurisdictions.

State and Commonwealth regulations require that there be no release of any uranium ore mining or milling waste, or any adverse environmental impacts outside the mine sites. Wastes from mining and milling take two forms:

- waste rock and overburden; and
- tailings from the processing.

Waste rock/overburden are stored in waste rock dumps. Tailings are disposed of in specially constructed dams.

The Commonwealth/State Consultative Committee (C/SCC) was established in 1980 to co-ordinate policies for managing Australia's radioactive waste, specifically with regard to medical, industrial and research use of radionuclides (DPIE 1995).

Recycling of radioactive wastes, for example, radioactive sources in gauges is encouraged by State and Commonwealth governments, but this is not always possible. Materials which have been contaminated by radioactive residues cannot be recycled. These include contaminated soils, plastics, paper, clothing and laboratory equipment (DPIE 1995).

Much of the waste currently in storage is low level and short-lived intermediate level radioactive waste from past medical, research and industrial use of radionuclides. Certain types of waste are no longer generated or have been reduced in quantities because of technological advances (DPIE 1995; Jabs, S.,1996 pers comm.).

However, waste will continue to be produced in Australia through the use of radionuclides. For

12.1.4.10 Commonwealth/State radioactive waste holdings, 1994

Organisation	*Description of Waste*	*Volume*	*Annual Arisings*
		m^3	*m^3*
Australian Nuclear Science and Technology Organisation	Compacted wastes (paper, plastics, protective clothing, laboratory glassware, dried sludge))	795	40–45
	Uncompacted waste (laboratory equipment, filters and components from the HIFAR reactor)	360	0
Defence	Electron tubes, radium painted watches, compasses, sealed sources	60	<5
State waste	Industrial gauges, exit signs, smoke detectors, medical sources	100	5–10
CSIRO, Victoria	Contaminated soil	1950	0
Total		**3265**	**50–60**

Source: NRIC 1994.

example radioactive material is used in medicine for therapy as well as diagnosis, and is used to treat certain cancers and tumours. Radiation is also used by a range of industries from civil engineering and mineral analysis to agricultural and environmental research (DPIE 1995).

A small research reactor, operated by the Australian Nuclear Science and Technology Organisation at Lucas Heights is Australia's only nuclear reactor. Spent fuel generated by the reactor is stored at Lucas Heights in monitored retrievable facilities in accordance with international standards and guidelines. In April 1996, a quantity of spent fuel was shipped to the UK for reprocessing. The spent fuel elements stored at Lucas Heights contain a total of 0.23 tonnes of uranium and other heavy metals.

The C/SCC found that the majority of radioactive wastes generated in Australia are suitable for near-surface disposal at specially selected sites. However long-lived intermediate level wastes unsuitable for near-surface disposal are in existence, though in very small quantities. These wastes will be kept in storage until a deep disposal facility is established (DPIE 1995).

Details for 1994 of the quantity of State and Commonwealth radioactive wastes in storage pending disposal are shown in Table 12.1.4.10. This shows that, following more than 40 years of medical research and industrial use of radionuclides, there are 3,265 cubic metres of low level and short-lived intermediate level radioactive wastes with an annual arising of less than 60 cubic metres (DPIE 1995; Jabs, S., pers comm.).

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Organisation for Economic Co-operation and Development (OECD) 1995b, *155 Other scheduled wastes include glass tubing and plastic packaging from bio-medical processes (though blood and radio-active medical wastes are considered hazardous waste).*

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Scheduled Wastes Management 1994b, Fact Sheet 2, *A management plan for PCB wastes.*

12.2.1 Land restructuring activities

Introduction

Until recently Australians have thought more about adapting the environment to their activities than their activities to the environment (Flannery 1994, p. 355). Urbanisation, the development of transport infrastructure and the expansion of agriculture and mining have contributed substantially to the Australian economy and led to considerable landscape restructuring. On a continental scale, areas of high wilderness quality are now fragmented and largely restricted to arid lands and the 'wet-dry' tropics (Australian Heritage Commission 1995 — see Figure 12.2.1.1).

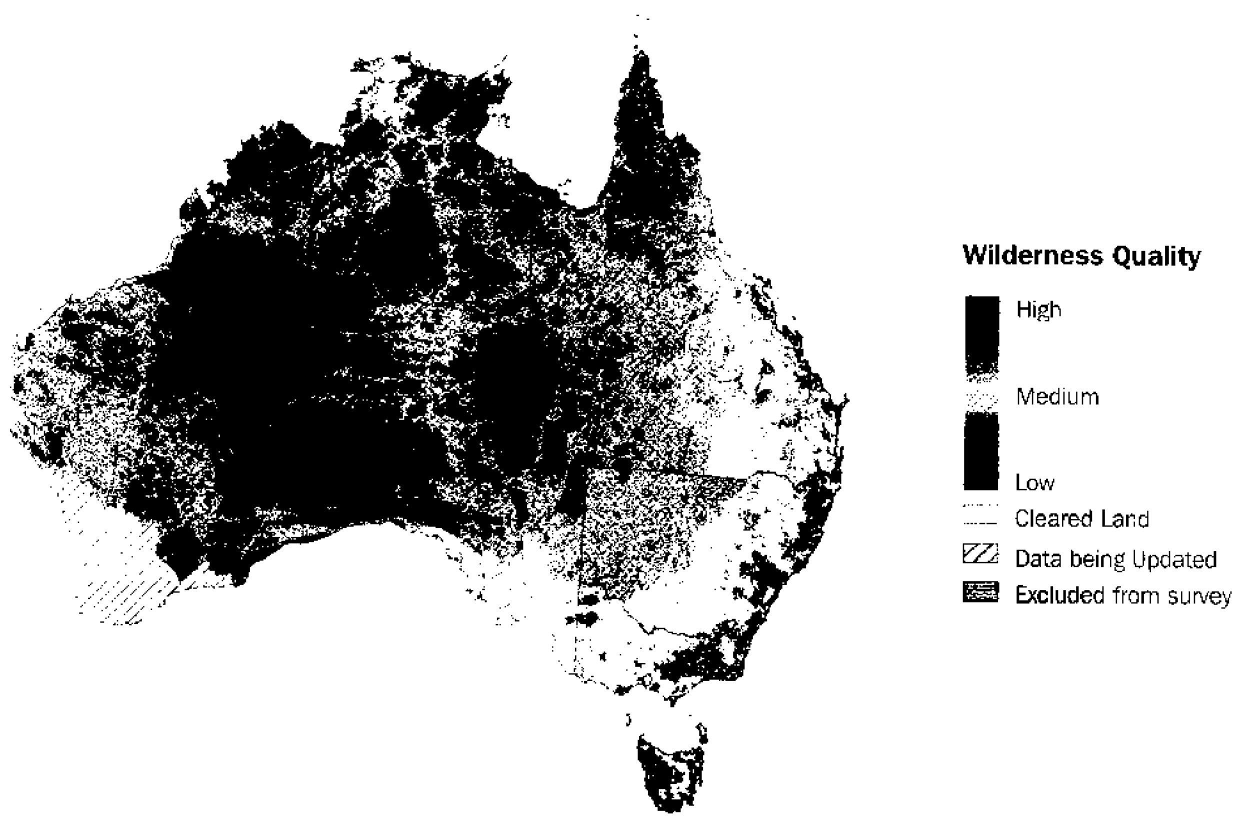
Sections which relate to the present discussion include: 1.3 (Soils and landscapes); 1.4 (State of flora and fauna); 6.1 (Forests); 6.4 (Agricultural plants and animals); 6.6 (Minerals); 6.7 (Soils and soil nutrients) and 8.1 (Population conditions, change, distribution and density).

Urbanisation

As Section 8.1 described, Australia's population has grown rapidly since 1788, and become increasingly urbanised (in 1991, 86% of the resident population lived in urban areas). Population density is concentrated on coastal areas and is higher in the eastern States (see Figure 8.1.7). At the same time the area of land given over to urban development has increased. The combined total area of the capital cities increased dramatically in the period from 1976 to 1981, and has continued to grow, though more slowly (see Figure 12.2.1.2).

Australia's population growth areas tend to be distributed in high biodiversity regions of the continent (Crome, Foran & Moore, unpub. p. 4). They are also in areas of relatively stable rainfall and were historically sited on fertile soils. Many species that have been listed nationally as being of conservation concern are found in these

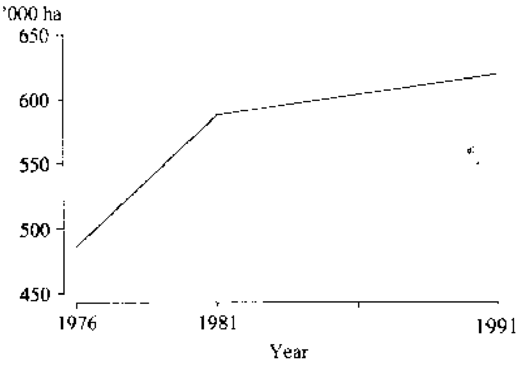
12.2.1.1 Wilderness quality (a) across Australia



(a) This estimate of wilderness quality by the National Wilderness Inventory incorporate four types of wilderness 'indicators': remoteness from settlement (how remote a site is from permanent human occupation), remoteness from access (how remote a site is from established access routes), apparent naturalness (the degree to which a site is free from permanent structures associated with modern technological society), and biophysical naturalness (the degree to which a site is free from biophysical disturbances caused by the influence of modern technological society).

Source: Australian Heritage Commission 1995.

12.2.1.2 Growth of capital cities, 1976–91



Sources: Division of National Mapping 1979; ABS 1991 (2882.0); ABS GDB 1991, unpub.

population growth areas (see Tables 12.2.1.3 and 12.2.1.4 and Sections 7.1 and 7.2). More than 50% of the threatened or rare mammals, birds, plants, reptiles and freshwater fish have important habitats in the population growth areas and/or the extended boundaries of the major cities in most mainland States (Crome, Foran & Moore, unpub. p. 1).

12.2.1.4 Proportion of species of conservation concern occurring in population growth areas (a)

	Plants	*Mammals*	*Birds*	*Reptiles*	*Fish*
	%	%	%	%	%
NSW	21.8	25.0	69.0	89.2	63.9
Vic.	11.5	16.7	53.3	66.7	30.0
Qld	62.1	27.8	52.9	77.3	80.0
SA	51.4	0.0	33.3	52.9	0.0
WA	42.4	25.0	51.5	21.2	13.0

(a) See footnotes to table 12.2.1.3.

Source: Crome, Foran & Moore, unpub., p. 6; Foran, B. 1996, pers. comm.

Transport

Australia has extensive rail and road networks. They reflect both the pattern of settlement and the distribution of natural resources, particularly arable land and mineral deposits (see Figures 12.2.1.5 and 12.2.1.6).

Government railways developed rapidly over a sixty year period, from 1,658 route-kilometres open in 1871 to 42,866 route-kilometres open in 1931 (Figure 12.2.1.7). This expansion then slowed in 1941, and the rail network has declined steadily as the competition from road transport has increased and the branch lines have become less economic (eds Camm & McQuilton 1987, p. 129). With large-scale changes to agricultural landscapes, railway sidings are known to be important reservoirs of native grasses.

12.2.1.3 Species of conservation concern (a) occurring in population growth areas (b) (preliminary)

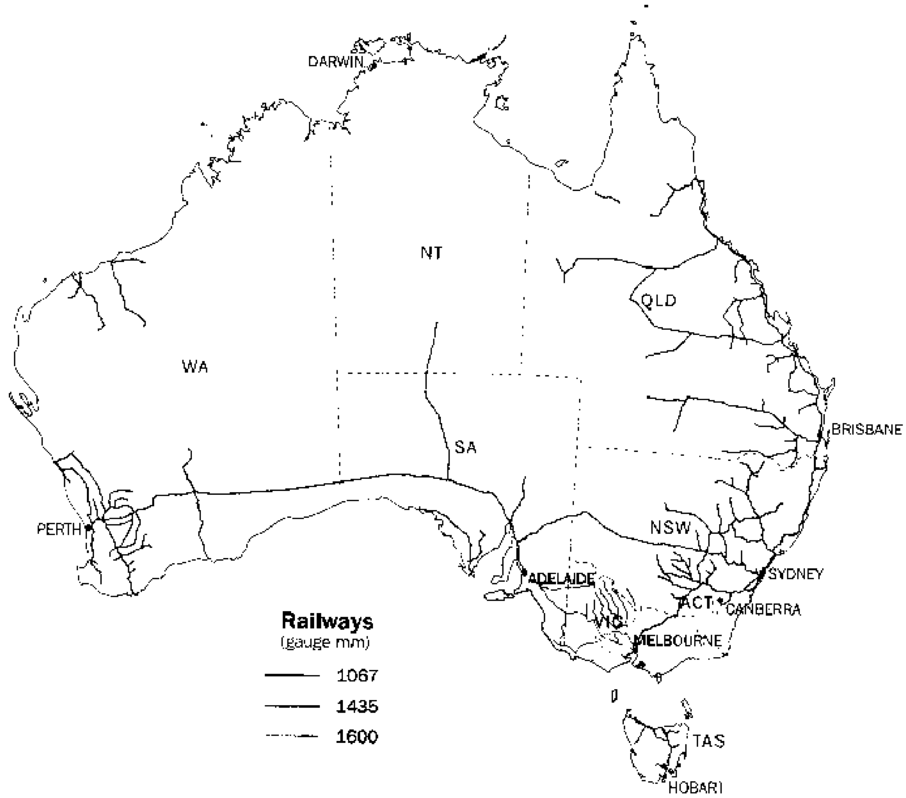
State/Growth area	*Plants* No.	*Mammals* No.	*Birds* No.	*Reptiles* No.	*Fish* No.
New South Wales	518	4	29	28	12
Greater Sydney	113	0	12	10	4
South-east	na	na	na	na	na
North coast	na	1	18	15	3
Victoria	815	6	30	12	10
Greater Melbourne	92	1	16	8	3
Queensland	1197	18	34	75	20
South-east	186	2	17	21	6
Cairns/Townsville	528	2	12	21	5
Rockhampton	29	1	7	16	5
South Australia	185	8	33	17	5
Greater Adelaide	95	0	11	9	0
Western Australia	1372	20	33	33	23
Perth and the South-west	582	5	17	7	3

(a) Species of conservation concern are those that have been listed nationally as being endangered, vulnerable, rare or poorly known and may occur in more than one growth area.

(b) The geographical extent of growth areas was based on boundaries used to agglomerate information on biodiversity distribution at the State and national levels. Agglomerations of biodiversity regions were selected that included the city itself, satellite towns and the hinterland and adjacent agricultural regions over which the population disperses, travels, builds roads, dams and holiday homes.

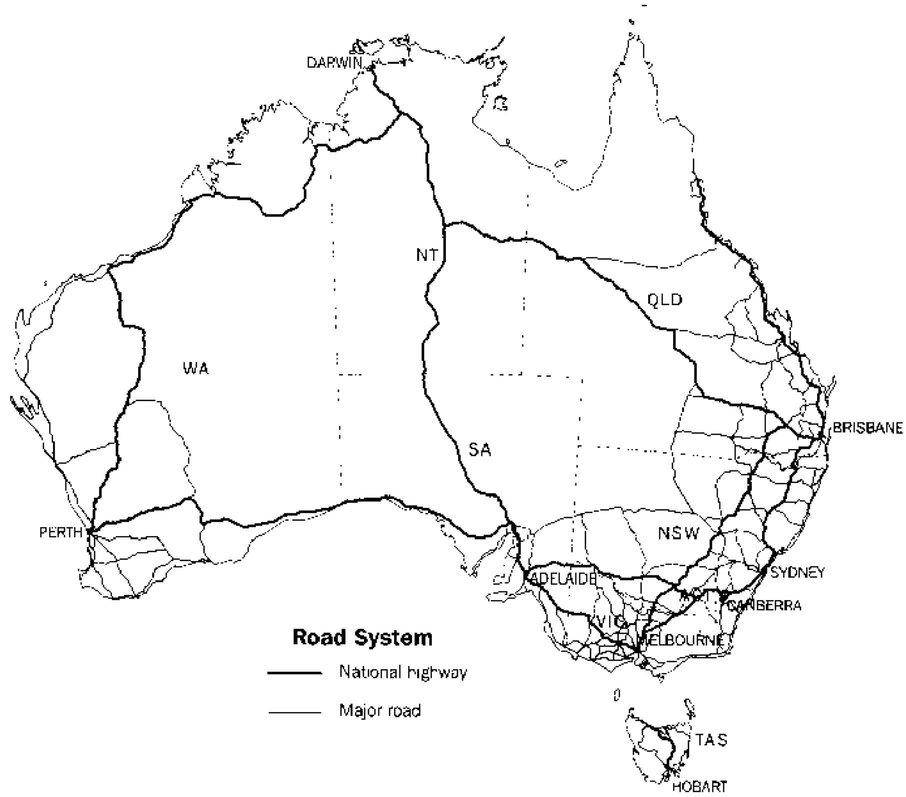
Source: Crome, Foran & Moore, unpub., p. 6; Foran, B. 1996, pers. comm.

12.2.1.5 Australia's rail network



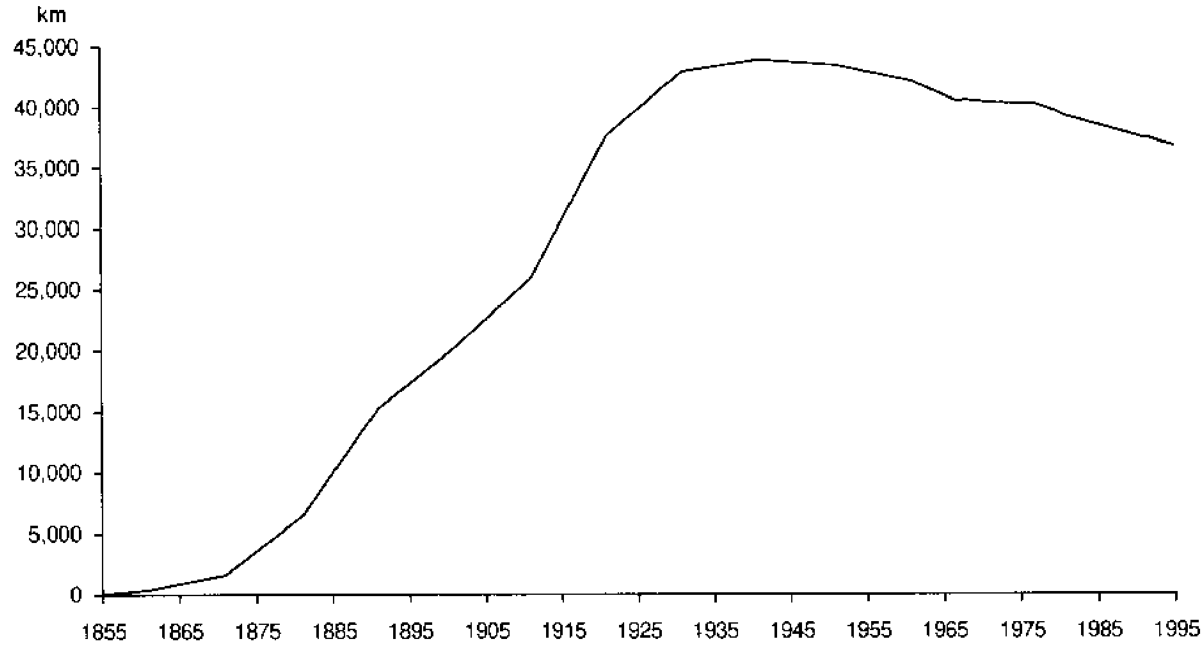
Source: AUSLIG 1992, p. 44.

12.2.1.6 Australia's road network



Source: AUSLIG 1992, p. 44.

12.2.1.7 Government railways: route-kilometres open, 1855–1993



Sources: ABS (1301.0), various years; ABS, unpub.

In the 1920s railways began to lose their position as the pre-eminent transport system, with the growth in motor vehicles and the development of road infrastructure. Following the Second World War government funding for road improvement and development schemes was increased (ABS 1992, 4140.0, pp. 277–278). As roads improved and motor vehicles became more readily available their use increased from a total of 2,182,193 registered motor vehicles in 1955 to 10,935,400 in 1995 (see Figure 12.2.1.8).

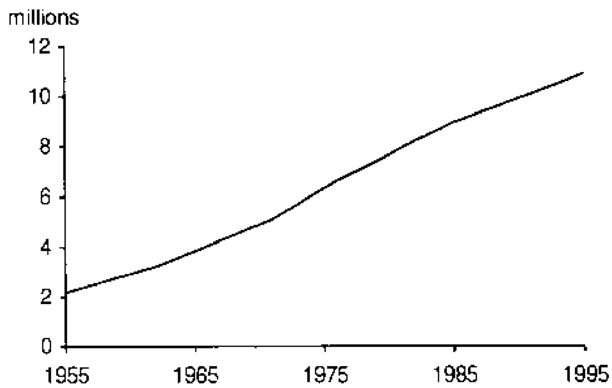
At first glance the available statistics appear to show that the total length of roads open for general traffic grew in the period 1960 to 1970, dropped in the following decade and has since stabilised (Table 12.2.1.9). However, from 1970 several types of road, including roads dedicated but not trafficable, have been excluded from these totals. Data collection by the States on the length of roads has been revised over the years. Since 1970, New South Wales, for example, has not included roads dedicated but not trafficable.

As road improvements are made (additional lanes, straighter and better surfaces etc) some of the other poorer quality roads and tracks fall into disuse. Other roads have deteriorated to such an extent that they are little used or only capable of being used by four wheel drive vehicles. Such roads are not always considered in statistical collections made by local, State and federal agencies. Better statistical methods have also found some over-estimation of road lengths.

Despite this problem, it can be shown that the proportion of higher grade roads (bitumen or concrete), has increased from about 12% of total road length in 1960 to about 36% in 1990. Over the same period the proportion of lower grade roads (formed or cleared only) has declined from about 62% in 1960 to about 38% in 1990. The proportion of gravel roads has remained fairly constant over this period (see Figure 12.2.1.10).

As roads have improved and the traffic increased, the disturbance factor to local environments has grown. Roads fragment habitats, and increased traffic increases road kills of native wildlife. Roads also promote the introduction of weeds and feral animals to a landscape (Mackey, B. 1996, pers. comm.). For further information on introduced fauna and flora see Section 9.3. The current status of roads open to general traffic by State and Territory is shown in Table 12.2.1.11.

12.2.1.8 Growth in the total number of motor vehicles, 1955–95



Sources: ABS (9309.0), various years; ABS 1996 (9303.0).

12.2.1.9 Length of roads in Australia, 1960–93

	1960	1970(a)	1980(b)	1990(c)	1993(d)
Surface of roads	*km*	*km*	*km*	*km*	*km*
Bitumen or concrete	103 302 (e)	188 780	243 750	288 702	300 459
Gravel, crushed stone or other improved surface	224 323	213 809	228 396	217 932	262 353
Formed or cleared only (f)	523 089	481 701	339 733	305 630	238 590
Total	**850 714**	**884 294**	**810 918**	**810 264**	801 402

(a) Figures for Western Australia at 30 June 1969.

(b) Figures for New South Wales at 30 June 1978 and excludes 15,397 km of road dedicated but not trafficable. Figures for Victoria, Western Australia, Tasmania and the Northern Territory at 30 June 1979.

(c) Excludes roads designated but not trafficable in New South Wales. Excludes Lord Howe Island and the unincorporated area of the Western Division. Excludes roads coming under the responsibility of the State Electricity Commission and Forests Commission in Victoria. Excludes approximately 25,300 km of forestry roads in Western Australia. Forestry roads in Tasmania have been reclassified from cleared only to gravel. Excludes roads in towns and Local Government Areas.

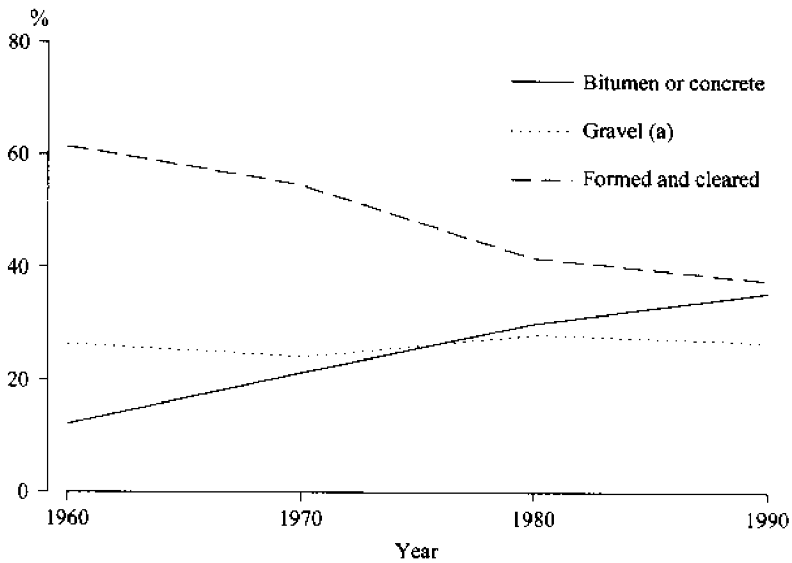
(d) Qld, WA, Tas data from 1992.

(e) Includes wood and stone.

(f) Distinction between 'formed only' and 'cleared only' not available for all years.

Sources: ABS (1301.0), various years; ABS, unpub.

12.2.1.10 Change in the composition of roads open for general traffic, 1960–90



(a) Gravel, crushed stone or other improved surface

Sources: ABS (1301.0), various years.

12.2.1.11 Lengths of roads open for general traffic, by State and Territory, 30 June, 1993

	NSW(a)	Vic.(b)	Qld (c)	SA	WA(c)(d)	Tas.(c)(e)	NT(f)	ACT
Surface of roads	*km*	*km*	*km*	*km*	*km*	*km*	*km*	*km*
Bitumen or concrete	84 200	69 504	60 701	25 042	43 134	9 515	6 018	2 345
Gravel, crushed stone or other improved surface	97 600	48 931	50 039	0	45 955	12 968	6 780	80
Formed only	(g)	41 433	48 611	69 773	36 328	233	4 846	0
Cleared only	na	(h)	15 078	0	17 726	1 874	2 688	0
Total	181 800	159 868	174 429	94 815	143 143	24 590	20 332	2 425

(a) Excludes Lord Howe Island, forestry controlled roads or crown roads.

(b) Excludes roads coming under the responsibility of the State Electricity Commission and Forests Commission.

(c) 1992.

(d) Excludes approximately 25,300 kilometres of forestry roads.

(e) Forestry roads have been reclassifies from cleared only to gravel.

(f) Excludes roads in towns and Local Government Areas since 1992, 8,200 kilometres of roads on Aboriginal land, and 1,400 kilometres of park roads.

(g) Included in gravel, crushed stone or other improved surface.

(h) Included with formed only.

Source: ABS 1996 (1301.0).

Agriculture

Approximately 470 million hectares of Australia (61%), is currently used for agriculture. It has had the most extensive, and probably the greatest, impact on the natural environment in terms of landscape restructuring.

Nationwide statistics of the total area of land used for agricultural purposes have been available since 1900 (Figure 12.2.1.12). Agricultural land use has gone through two periods of rapid expansion (1905 to 1925 and 1940 to 1975), three periods of retraction (1900 to 1905, 1930 to 1935 and 1975 to 1990) and two periods of no or little change (1925 to 1930 and 1935 to 1940). The area used has ranged from 353.3 million hectares in 1905 to 499.9 million hectares in 1975. In 1994-95 the area of land used for agriculture stood at 463.4 million hectares.

The expansion of the area of land used for agriculture has been accompanied by an expansion in the area of land cropped and sown to pasture or grasses (see Table 6.4.2), and the clearance and modification of native vegetation.

The clearance of native vegetation — especially for agriculture — has been, and continues to be, the major factor leading to a decline in biodiversity. In a recent report on land cover disturbance it was estimated that nearly 50% of the continent has been either substantially or significantly disturbed through clearing and/or grazing (Graetz, Wilson & Campbell 1995, p. 37). In the analysis for this report Australia was divided into two land use zones on the basis of the potential land cover disturbance: an Intensive Landuse Zone (ILZ) making up 39% of the continent and an Extensive Landuse Zone (ELZ) making up the remaining 61%.

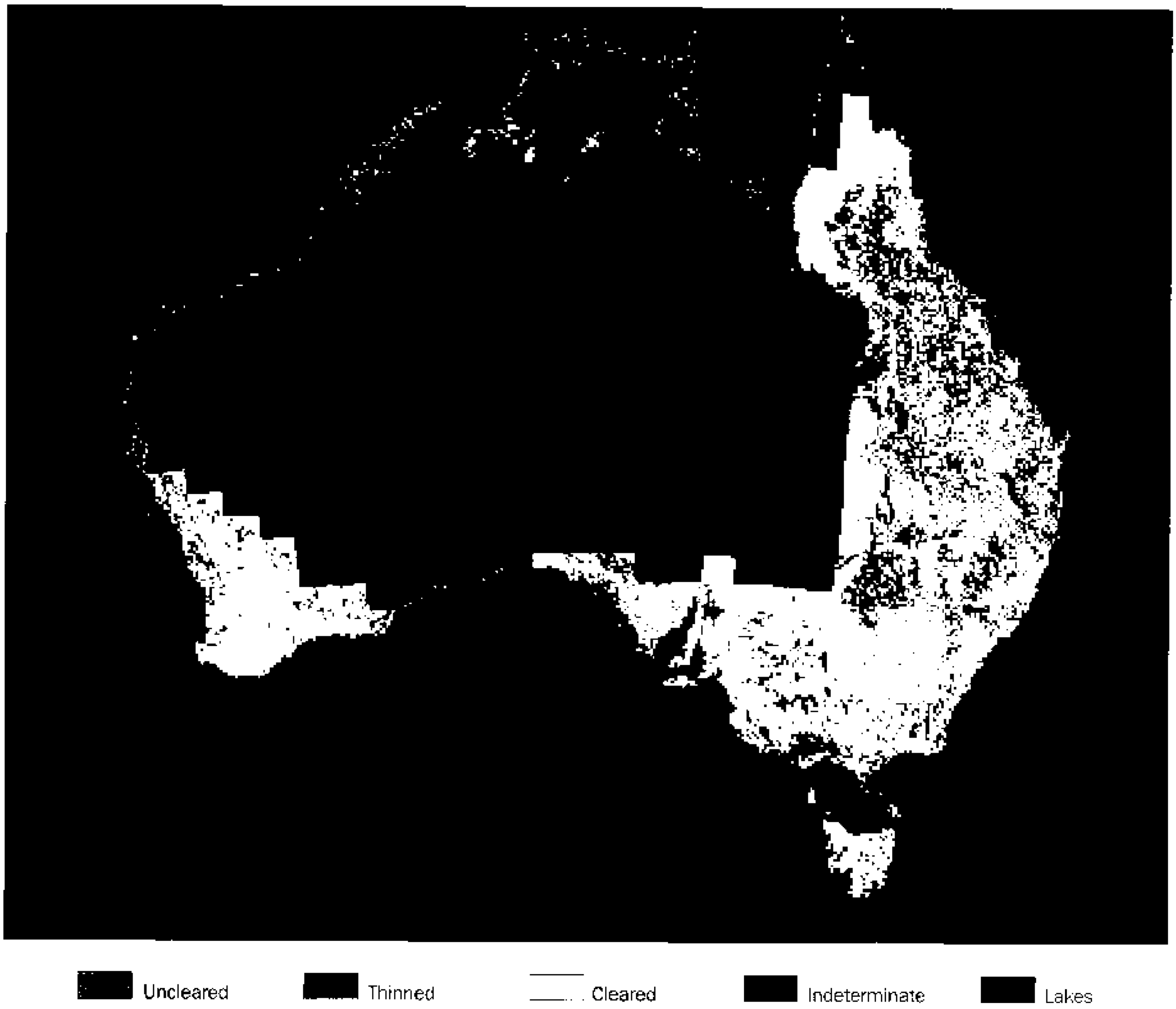
The principal disturbance threat to the ILZ is clearing, while land cover in the ELZ is threatened by grazing and burning. Graetz, Wilson & Campbell estimate that just over half the ILZ has been cleared or thinned of native vegetation, representing 20% of the continent as a whole (1995, p. 27). The spatial distribution of land clearing in the ILZ is shown in Figure 12.2.1.13. The pattern of assessed disturbance within the ELZ is shown in Figure 12.2.1.14.

The clearance of native vegetation from 1983 to 1993 has been most pronounced in Queensland

12.2.1.12 Land used for agricultural purposes 1900–95 (million hectares)

Sources: Vamplew (ed.) 1987; ABS (7221.0), various years; (7330.0), various years; ABS 1996 (7113.0).

12.2.1.13 The continental distribution of disturbance by clearing



Source: Graetz, Wilson & Campbell 1995, p. 28.

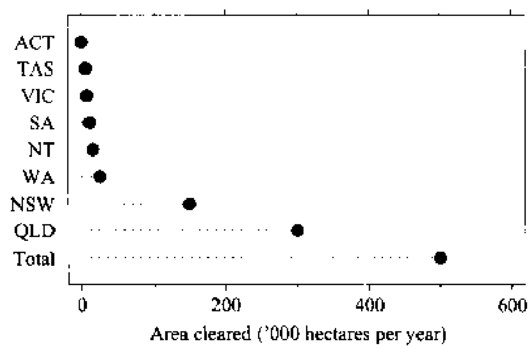
and New South Wales, where it is estimated that 300,000 and 150,000 hectares respectively have been cleared annually (Figure 12.2.1.15).

In a recent survey of about 2,000 broadacre and dairy farms across Australia it was found that, over the five years from 1994-95 to 1998-99, farmers in Queensland intend to clear a total area of 2,886,000 hectares. This amounts to almost 88% of the total intended clearing in Australia over this period. The average area of native forests and woodlands that farmers intend to clear annually over this period is shown in Figure 12.2.1.16 and its geographical distribution in Figure 12.2.1.17. This contrasts with the main areas of tree-planting in the three year period 1991–92 to 1993–94 (Figure 12.2.1.18).

12.2.1.14 The pattern of assessed disturbance within the Extensive Landuse Zone

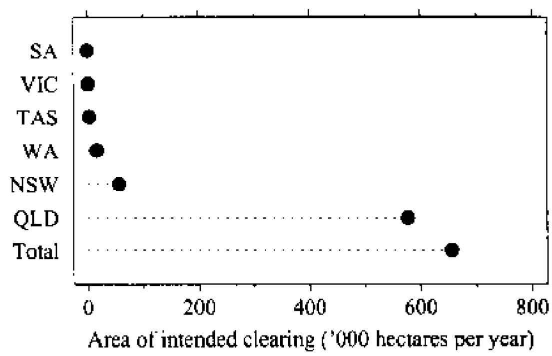
Note: The indeterminate class was allocated where no valid assessment could be made.
Source: Graetz, Wilson & Campbell 1995, p. 32.

12.2.1.15 Estimated annual clearance of native vegetation for agricultural purposes, 1983–93



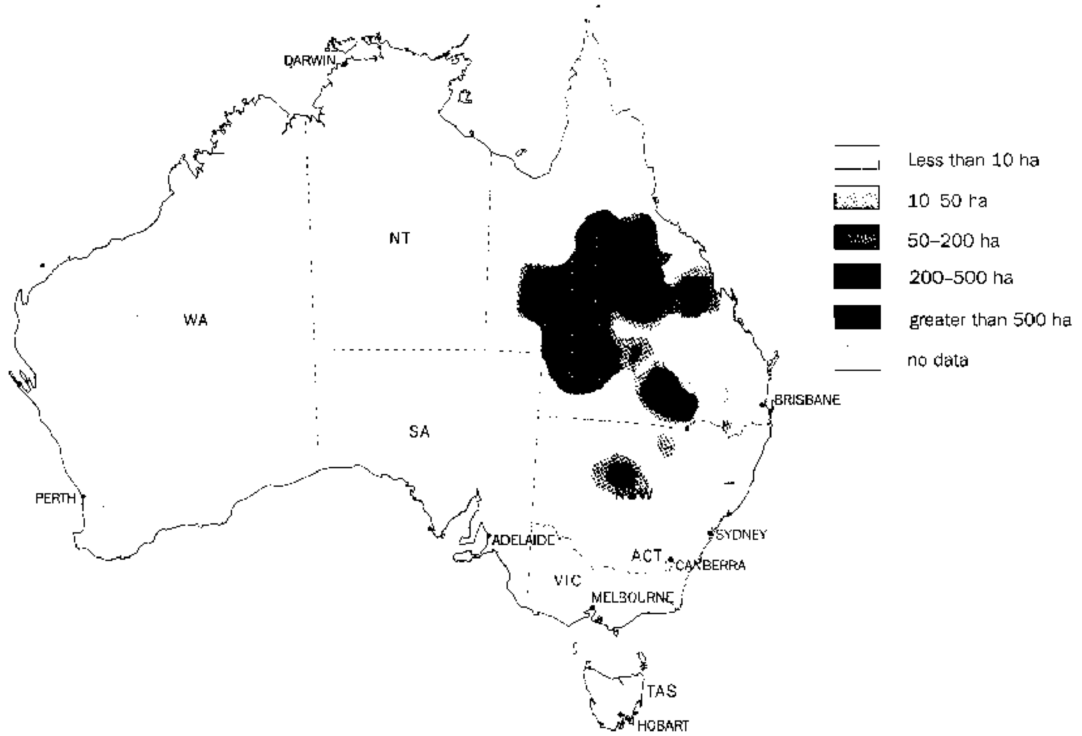
Source: DEST 1995, p. 17.

12.2.1.16 Area of native forests and woodlands that farmers intend to clear annually, 1994–95 to 1998–99



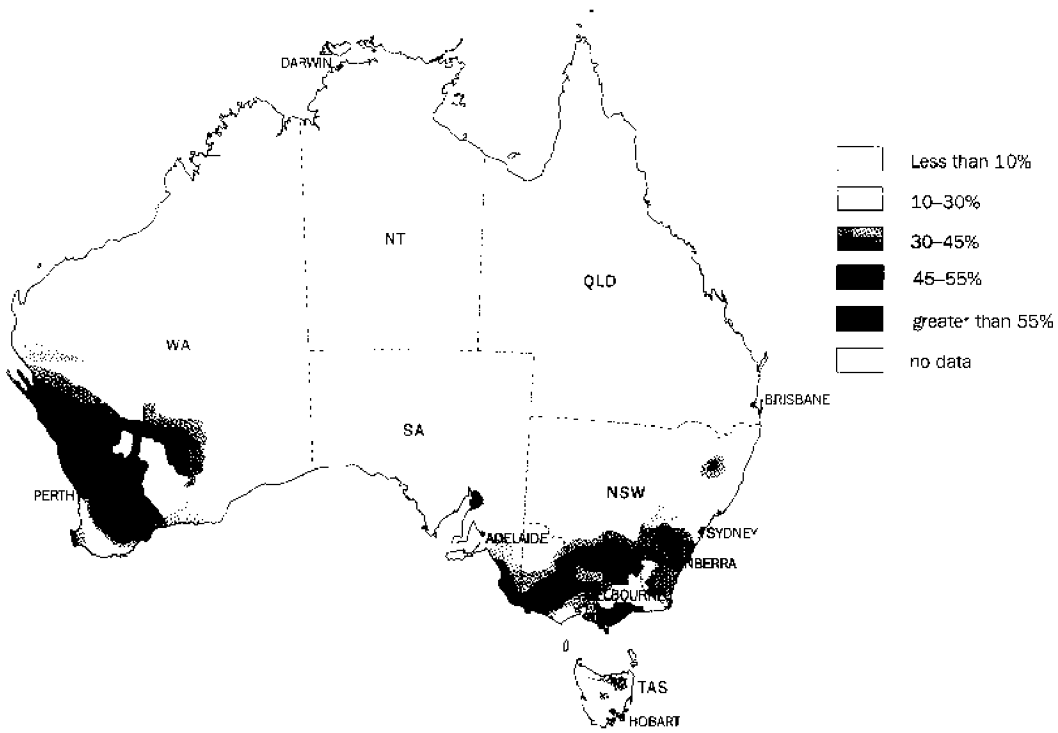
Note: No clearing is intended in the Northern Territory or the Australian Capital Territory over this period.
Source: Wilson et al. 1995, p. 48.

12.2.1.17 Average area per farm of planned clearing of native forests and woodlands, 1994–95 to 1998–99



Source: Wilson et al. 1995, p. 46.

12.2.1.18 Tree planting on farms 1991–92 to 1993–94



Source: Wilson et al. 1995, p. 17.

Mining

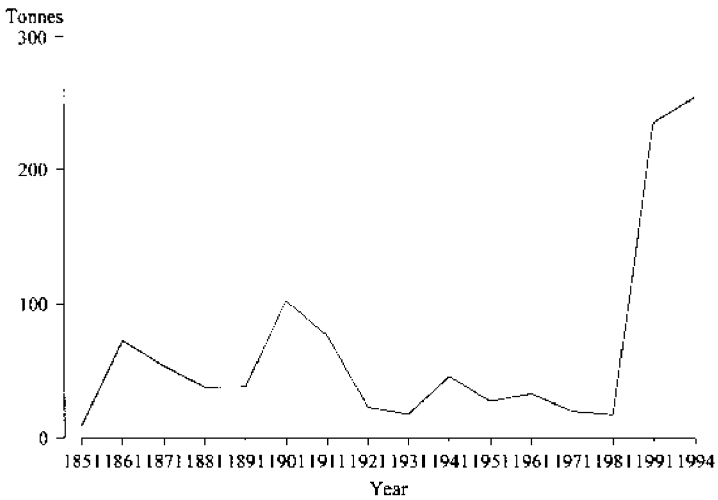
Less than 0.02% of the Australian continent is currently being mined (AMIC 1989, p. 12) . However, the accumulated impact of mining from prospecting, exploration, extraction and the infrastructure required to service this industry (e.g. pipe lines, roads, rail and settlements etc) can have a significant impact in land restructuring (Mackey, B. 1996, pers. comm.). The mineral industry has passed through three historical stages. In the first, from the 1840s until about 1910, gold was of pre-eminent importance. During this stage the mining of copper, tin, lead, zinc and silver minerals also became important (Vamplew (ed.) 1987, p. 86).

The second stage, beginning in about 1910, continued until the end of the Second World War and was characterised by a stabilising or decline in both the quantity and value of production of most minerals. The only major new mineral industry to develop was iron-ore mining and iron and steel production (Vamplew (ed.) 1987, p. 86).

The third stage, from the end of the Second World War to the present, has seen the rapid growth of the volume and value of mineral production. Much of the growth has resulted from a diversification in the range of mineral commodities produced, which include bauxite, alumina and aluminium metal, rutile, ilmenite and zircon.

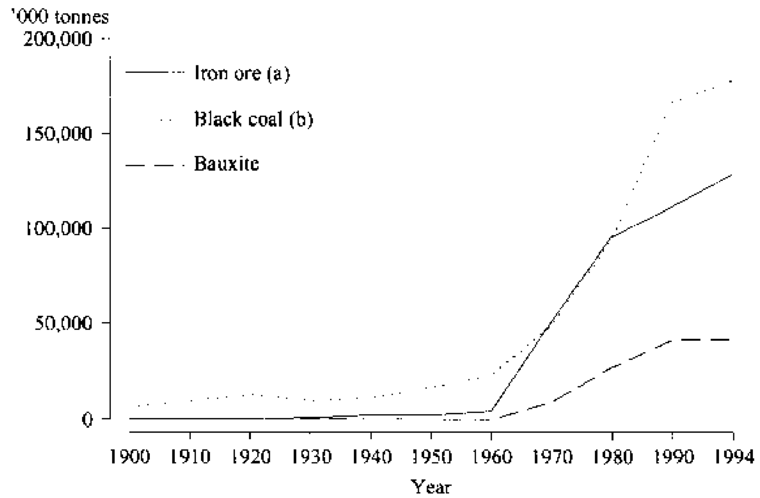
Figure 12.2.1.19 shows the growth pattern of gold production since 1851. The first peak in this time series followed the early discoveries of gold in the 1850s. The second resulted from the discovery and development of the Western

12.2.1.19 Growth in the production of gold since 1851



Sources: Vamplew (ed.) 1987; ABS 1995 (1301.1).

12.2.1.20 Growth in the production of iron ore, black coal and bauxite, 1900–94



(a) Quantity mined. (b) Raw coal (as mined).
Sources: Vamplew (ed.) 1987; ABS 1995 (1301.1); ABARE 1995.

12.2.1.21 Description of mining methods

Mining methods	*Description*
Surface mining	
Hydraulicking or sluicing	Method used for placer deposits where water is available and the bedrock is suitable. Water under pressure is directed through nozzles to break the ground and wash the mixture of ore and water to a concentrating plant.
Dredging	Method used for mining tin deposits and removing silt from rivers, improving harbours and reclaiming land. Generally used to recover material below the surface of the water.
Open cut mining	Method used for mining massive, thick-bedded or tabular deposits which extend more or less horizontally. Usually requires the removal of overlying rock (the 'overburden'). Most open-cut mines are multibench operations.
Strip mining	Special form of open cut mining used for mining coal and other deposits such as iron ores. Mining begins by using a dragline to uncover a strip of coal the full width of the deposit. The coal is then recovered at the same time as the overburden is being removed from a further strip of coal. The overburden is placed back into the area mined so that the area can be reclaimed as mining proceeds.
Quarrying	Method used to mine materials such as limestone, aggregate and building stone. The site selected is usually a hill or valley slope.
Underground mining	Numerous methods used to mine mineral deposits deep beneath the surface.

Source: Australian Academy of Science 1983, pp. 582-583.

12.2.1.22 Mining establishments using rehabilitation techniques by industry 1993–94

Technique	*Coal* %	*Oil & gas* %	*Metal ore* %	*Other mining* %	*Services to mining* %	*Total mining* %
Landfill	65	55	51	48	20	42
Revegetation	88	64	87	75	26	64
Rehabilitation	84	64	92	69	30	64
Restoration	72	82	68	56	41	57
Other	5	0	3	1	1	2
No method used	2	0	2	1	3	2
No method required	7	18	4	8	47	20

Source: ABS 1996 (8413.0).

Australian fields at the turn of the century. However, the most striking feature of this time series is the tremendous leap in production from 18.4 tonnes in 1981 to 259.6 tonnes in 1991-92.

Iron ore, black coal and bauxite are three other major mining commodities. Their production has accelerated markedly since the 1960s (Figure 12.2.1.20). This increase can be attributed to an improved knowledge of Australia's geology, an expanding world economy, and an influx of major overseas mining companies bringing with them new expertise, ideas and capital (ABS 1996, 8414.0, p. 7).

Mining methods vary in their impact on the landscape. The early gold rushes of the 1850s saw the complete upheaval of the surrounding countryside: "the country was usually honey-combed with shafts and sinkings, each with its windlass and mound of upturned earth" (Australian Geographic Society 1988, p. 1417; see Table 12.2.1.21 for a summary of mining methods).

In recent years rehabilitation of mine sites has gained increasing prominence. The aim of such programs is to return the mine site to its original or other agreed land use (AMIC 1989, p. 14). Rehabilitation programs generally have four stages. First the future land use of the disturbed area is determined. Earthworks are then carried out to prevent erosion, and measures to maximise surface suitability for plant growth are undertaken. Vegetation is then established by methods such as direct planting and artificial seeding. Finally monitoring and research are conducted to ensure that the ecosystems desired are obtained (AMIC 1989, p. 15). A high proportion establishments are now using rehabilitation techniques (see Table 12.2.1.22).

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12.2.2 Changes to water systems

Since European settlement Australians have changed their natural water systems (rivers, lakes, streams, groundwater and coastal) in order to use the resource economically and to sustain the population. This section outlines the nature of these changes and their environmental impacts.

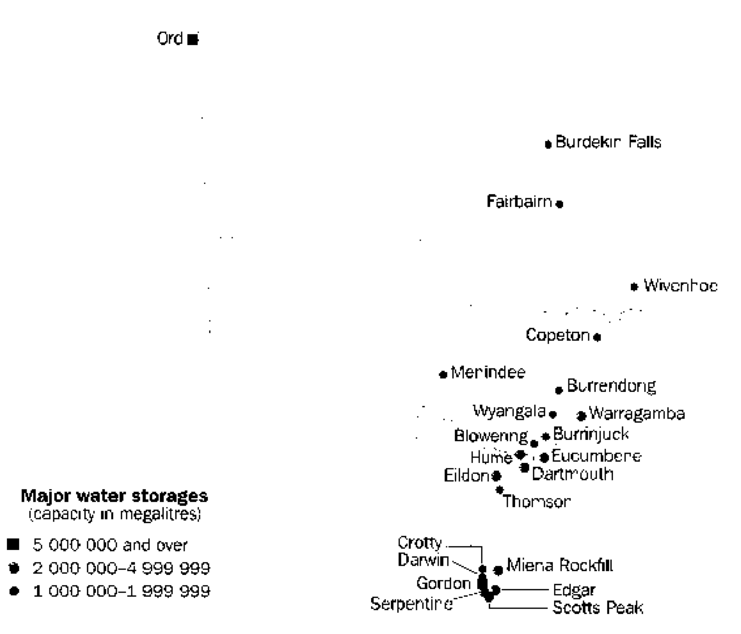
Regulation and storage

The discussion in Section 1.1 on the high variability of Australia's rainfall and runoff highlighted the need for wise management of water resources. To promote a reliable water supply and reduce stream flow fluctuations, measures have been taken to establish water storage, stream regulation and diversion schemes. As mentioned in Section 6.5, these measures have resulted in Australians having the highest per capita water storage in the world, and reduced the effects of flood and drought These works have not only assured the Australian population of water supply, but have also enhanced recreational opportunities, irrigation schemes and industrial needs.

In the Murray-Darling Basin, the first river regulation structures were constructed to overcome water shortages and improve navigability (see Section 1.1 for a discussion of the importance of the Murray-Darling river system to the Australian population). The history behind regulation and storage of water in Australia provides an insight into the country's development.

The Murray River system provided a crucial link for South Australian trade and communication with Victoria and New South Wales until the advent of the rail system in the early 1880s. Irrigation from the Murray began in the 1870s in Victoria but suffered around the turn of the century during a prolonged dry period. When the drought of 1902 occurred, negotiation between the States and the Federal government began in earnest to provide drought protection and develop water sharing principles. The result, the River Murray Waters Agreement, was ratified by Acts of Parliament of the Commonwealth and State governments in 1915. During the ensuing years the original agreement was modified to accommodate changes in the importance of river trade and irrigation.

12.2.2.1 Major water storages and lakes, and their capacities



Source: ANCOLD 1990.

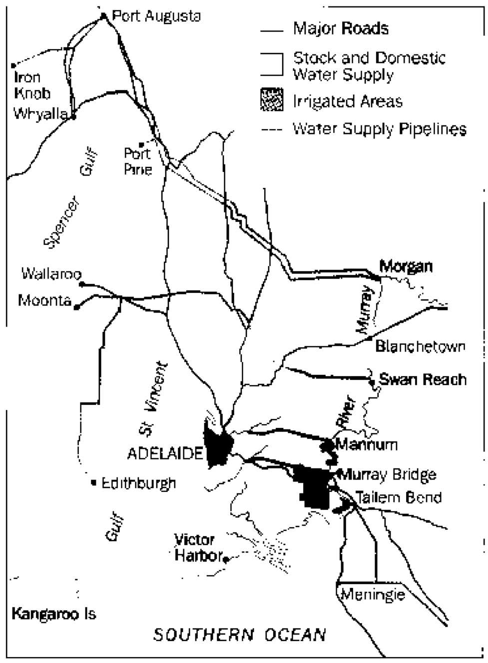
The resulting agreement provided for:

- 14 locks and weirs along the Murray;
- 2 flood diversion weirs on the Murrumbidgee;
- 5 barrages near the Murray mouth to prevent salt water intrusion to Lakes Alexandrina and Albert; and
- 2 storages, one at Lake Victoria and the other sited on the upper Murray at the Hume Reservoir (MDBC 1990, pp. 39–41).

The water sharing principles of the 1915 agreement remain virtually unchanged today, with both New South Wales and Victoria guaranteeing a minimum water entitlement to South Australia (MDBC 1990, p. 39).

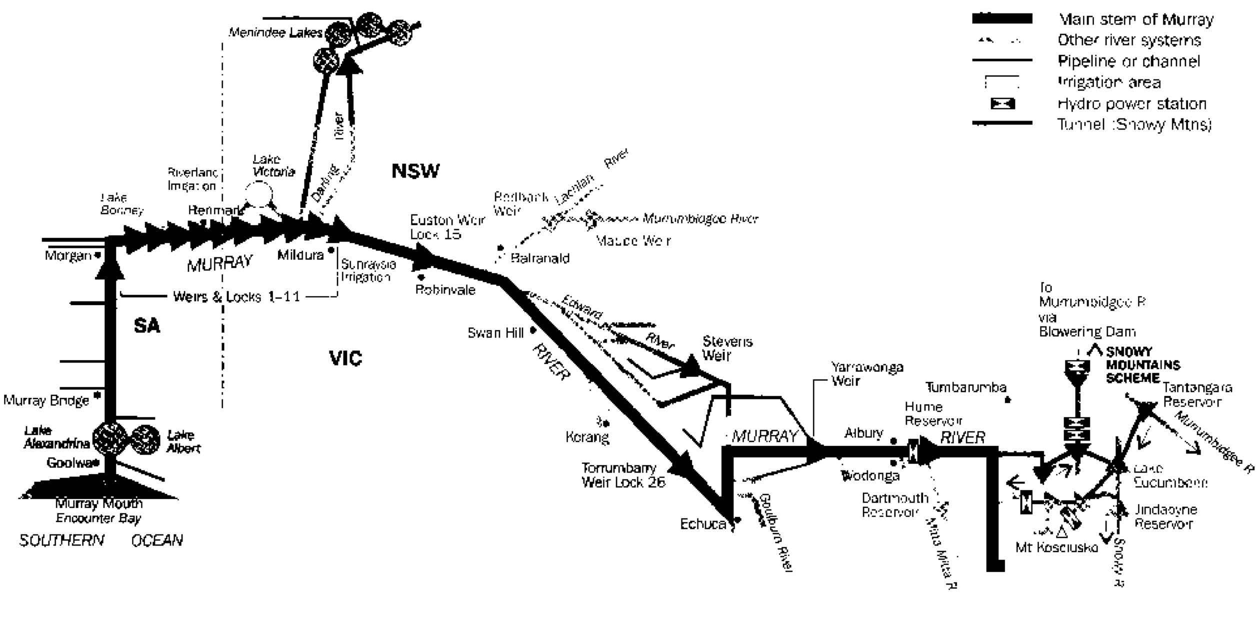
The Murray-Darling Basin Commission (MDBC) is responsible for regulating the flows of the Murray and Darling Rivers below the Menindee Lakes. It also considers other water management objectives in its operations, but its primary focus is to maintain efficient State allocations and supplies of water (MDBC 1990, p. 39). Figures 12.2.2.2 and 12.2.2.3 show the extent of regulating structures along the Murray and the pipelines feeding South Australian urban centres.

12.2.2.3 Pipelines from the Murray feeding South Australia



Source: MDBC 1990, p. 9.

12.2.2.2 Murray-Darling rivers flow regulation



Source: MDBC 1990, pp. 46–47.

12.2.2.4 Major Dams and Reservoirs in Australia

Name and year of completion	Location	Gross capacity (a) gigalitres	Wall Height (b) metres	Purpose (c)
NEW SOUTH WALES				
Eucumbene (1958)	Eucumbene River, near Cooma.	4 798	116	H/E, IR, R, U
Hume (1936, 1961)	Murray River, near Albury.	3 038	51	H/E, IR, R, U
Warragamba (1960)	Warragamba River.	2 057	142	H/E, U
Menindee Lakes (1960)	Darling River, near Menindee.	1 794	18	IR,R,U
Blowering (1968)	Tumut River, near Tumut.	1 628	112	H/E, IR, R
Copeton (1976)	Gwydir River, near Inverell.	1 364	113	IR, R, U
Wyangala (1936, 1971)	Lachlan River, near Cooma.	1 220	85	IR, R
Burrendong (1967)	Macquarie River, near Wellington.	1 188	76	F/C, IR, R, U
Burrinjuck (1927, 1956)	Murrumbidgee River, near Yass.	1 026	91	IR, R, H/E
Talbingo (1971)	Tumut River, near Tumut.	921	162	H/E, IR, R, U
Glenbawn (1958, 1987)	Hunter River, near Scone.	870	100	F/C, IN, IR, R, U
Jindabyne (1967)	Snowy River, near Cooma.	688	72	H/E, IR, R, U
Lake Victoria (1928)	Murray River, near SA border.	680	-	IR, R, U
Keepit (1960)	Namoi River, near Tamworth.	423	55	F/C, IR, U
Split Rock (1987)	Manilla River, Namoi Valley.	397	66	IR
Windamere (1984)	Cudgegong River, near Mudgee.	368	67	IR
Pindari (1969, 1994)	Seven River, Inverell.	312	85	IR
Glennies Creek (1983)	Hunter Valley, near Singleton.	283	67	IN, IR, R, U
Tantangara (1959)	Murrumbidgee River, near Cooma.	254	45	H/E, IR, R, U
Avon (1927)	Avon River, near Mittagong.	214	72	U
Mangrove Creek (1982)	Mangrove Creek, near Wyong.	189	80	U
Grahamstown (1969)	Off stream, near Newcastle.	153	12	IN, U
Liddell Cooling Water (1968)	Gardiner Creek, near Muswellbrook.	148	43	IN
Googong (1977)	Queanbeyan River.	123	67	U, F/C
VICTORIA				
Dartmouth (1979)	Mitta Mitta River, near Mitta Mitta.	4 000	180	F/C, H/E, IN, IR, R
Eildon (1927,1955)	Upper Goulburn River, Alexandra.	3 390	79	F/C, H/E, IN, IR, R
Thomson (1984)	Thomson River, near Moe.	1 122	166	IR, U
Waranga (1910)	Near Rushworth (Swamp).	411	12	IR, U
Mokoan (1971)	Winton Swamp, near Benalla.	365	10	IR
Rocklands (1953)	Glenelg River, near Hamilton.	348	28	R, U
Eppalock (1964)	Campaspe River, near Bendigo.	312	45	IR, U
Cardinia (1973)	Cardinia Creek, near Melbourne.	289	86	U
Upper Yarra (1957)	Yarra River, Melbourne.	207	89	U
Blue Rock (1984)	Tanjil River, near Moe.	200	75	IN, U
Glenmaggie (1927, 1958)	Macalister River, near Sale.	190	37	IR
Cairn Curran (1958)	Loddon River, near Maryborough.	148	44	IR
Yarrawonga Weir (1939)	Murray River, Yarrawonga.	117	22	IR
Winneke (1980)	Sugarloaf Creek, near Melbourne.	100	85	U
WESTERN AUSTRALIA				
Lake Argyle (Ord) (1972)	Ord River, near Kununurra.	10 760	99	F/C, H/E, IR, Nav, R/F
South Dandalup (1973)	South Dandalup River, near Pinjarra.	208	43	U
Wellington (1933,1944,1960)	Collie River, Collie.	185	37	IR, R
Serpentine (1961)	Serpentine River, near Perth.	185	55	U
Kununurra Diversion (1961)	Ord River, near Kununurra.	101	20	IR, F/C, Nav, RE

12.2.2.4 Major Dams and Reservoirs in Australia *(Continued)*

Name and year of completion	*Location*	*Gross capacity (a)* *gigalitres*	*Wall Height (b)* *metres*	*Purpose (c)*
QUEENSLAND				
Burdekin Falls (1987)	Burdekin River, near Townsville.	1 860	55	IR, U
Fairbairn (1972)	Nogoa River, near Emerald.	1 440	49	IN, IR, U
Wivenhoe (1985)	Brisbane River, near Ipswich.	1 150	59	F/C, H/E, U
Fred Haig (1975)	Kolan River, near Gin Gin.	586	52	IR
Peter Faust (1990)	Proserpine River, near Proserpine.	500	51	IR, F/C, U, RE
Tinaroo Falls (1958)	Barron River, near Mareeba.	407	47	H/E, IR, U, RE
Somerset (1953)	Stanley River, near Kilcoy.	369	50	H/E, F/C, U, RE
Awoonga High Dam (1986)	Boyne River, near Gladstone.	250	45	IN,U
Glenlyon (1976)	Pike Creek, near Stanthorpe.	254	62	IR
Boondooma (1983)	Boyne River, near Proston.	212	64	IN, IR
North Pine (1975)	North Pine, near Brisbane.	202	44	U, RE
Koombooloomba (1961)	Tully River, near Innisfail.	212	52	H/E
Wuruma (1968)	Nogo River, near Eidsvold.	194	46	IR
Hinze (1976)	Nerang River, Gold Coast.	165	64	F/C, U
Eungella (1968)	Broken River, near Eungella.	131	49	IN, U, IR
Callide Dam (II) (1965, 1987)	Callide Creek, near Bileola.	127	46	IR, U, IN
Julius (1976)	Leichhardt River, near Mt Isa.	127	38	IN, U
Leslie Dam (II) (1965, 1986)	Sandy Creek, near Warwick.	108	33	IR, U
Lake Moondarra (1957)	Leichhardt River, near Mt Isa.	107	27	IN, U
Beardmore (1972)	Balonne River, near St George.	101	17	IR, R, U
TASMANIA				
Lakes Gordon and Pedder (1974)				
Gordon	Gordon River.	12 450	140	H/E
Pedder	Off-stream, Huon and Serpentine Rivers.	2 960	43	H/E
Miena Rockfill (1967)	Shannon River, near Launceston.	3 356	28	H/E
Crotty (1990)	King River, near Queenstown.	1 065	83	H/E
Mackintosh (1981)	Mackintosh River, near Queenstown.	914	75	H/E
Tullibardine (1981)	Tullibardine River, near Queenstown.	949	25	H/E
Lake Echo (1956)	Dee River, near Queenstown.	725	19	H/E
Reece Dam (1985)	Pieman River, near Queenstown.	641	122	H/E
Lake King William (Clark) (1949, 1966)	Derwent River.	541	67	H/E
Arthur's Lake (1965)	Launceston.	511	17	H/E
Devil's Gate (1969)	Forth River, near Devonport.	180	84	H/E
Rowallan (1967)	Mersey River, near Devonport.	131	43	H/E
Bastyan (1983)	Pieman River, near Queenstown.	124	75	H/E
Cethana (1971)	Forth River, near Devonport.	109	110	H/E
NORTHERN TERRITORY				
Darwin River (1972)	Darwin River, Darwin.	259	31	U

(a) Includes water below the operational outlet of the reservoir.
(b) As a general rule, the figures shown for height of the wall refer to the vertical distance measured from the lowest point of the general foundation to the crest of the dam, i.e., the level of the roadway or walkway on the dam.
(c) Abbreviations: F/C— Flood control and/or mitigation, H/E — Hydro-electricity, IN — Industrial and/or mining, IR — Irrigation, R — Rural (stock and domestic), U — Urban supplies., Nav — Navigation, R/F — recreational fishing, RE — recreation.
Source: ANCOLD 1990; ABS 1992 (4140.0); ANCOLD 1996, unpub.

Figure 12.2.2.1 shows Australia's major water storages and lakes. Table 12.2.2.4 describes major (100 gigalitres or over) dams in Australia and their primary uses.

Major water diversions

Major changes to flow regimes of rivers and streams have occurred through clearing of native vegetation, storage and diversion of water to satisfy irrigation, water supply and hydro-electric needs.

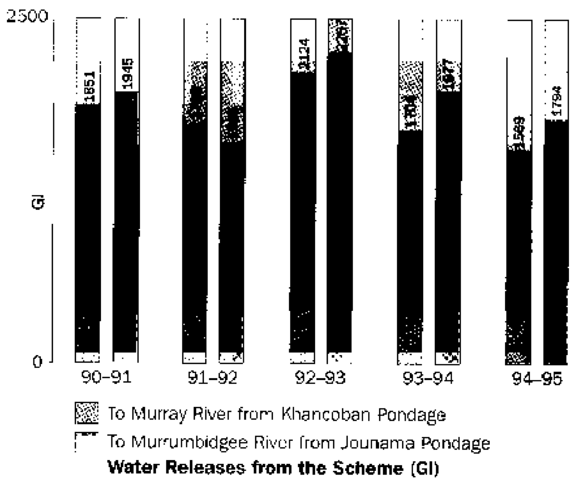
Remedial actions are to make inter-basin water transfers (for example recharging groundwater aquifers (see Section 6.5), or diversion of irrigation drainage waters and groundwater to evaporative salt pans and holding basins to reduce salt levels in water returned to the hydrological cycle) (MDBC 1990, p. 123).

Inter-basin transfers of note occur in the Snowy Mountains Hydro-electric Scheme. Figure 12.2.2.2 shows water from the Snowy River diverted to Lake Eucumbene. From there it either passes through the Murray or the Tumut power stations. From the Murray stations it flows to the Khancoban Pondage for release to the Murray and then on to the Hume Reservoir (managed by the Murray-Darling Basin Commission). If it is diverted through the Tumut power stations, it goes on to the Jounama Pondage for release to the Murrumbidgee River and the Blowering Reservoir (managed by the NSW Department of Land and Water Resources). In 1994–95 total releases to the Murray and Murrumbidgee Rivers were 3,363 gigalitres (Gl): 1,569 from Khancoban Pondage and 1,794 from Jounama (Snowy Mountains Hydro-electric Authority 1995, p. 22; see Figure 12.2.2.5).

The Scheme not only provided for the shoulder and peak electricity needs for NSW, Victoria and the ACT during 1994–95, but also met the water needs for irrigation in the drought-stricken eastern States by providing regulated releases. The main roles of the Scheme are to control and regulate releases into the Murray and Murrumbidgee rivers for irrigation, and to manage the rivers so as to mitigate flood flows when necessary and control salinity (Snowy Mountains Hydro-electric Authority 1995, p. 2). The Authority operates and performs these functions according to the Snowy Mountain Hydro-electric Power Act of 1949 and the Agreement of the same name (Snowy Mountains Hydro-electric Authority 1995, p. 22).

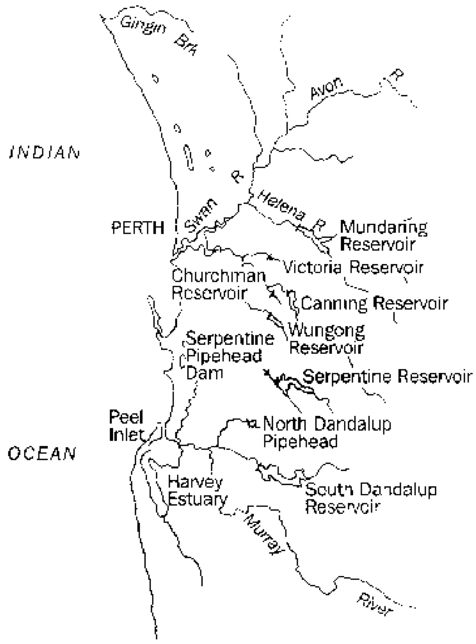
The water supplies of a number of major South Australian urban centres are yet another major inter-basin transfer, as shown in Figure 12.2.2.3. The Ord River Scheme has also made possible the development of irrigated agriculture in the east Kimberley region of Western Australia through diversions and storage. The Burdekin scheme has enhanced agricultural development and growth in northern Queensland.

12.2.2.5 Water releases from the Snowy Mountains Scheme 1990–91 to 1994–95



Source: Snowy Mountain Electric Authority 1995, p. 24.

12.2.2.6 Peel-Harvey Inlet Source



Department of Resources and Energy 1983 p. 202.

Channels and canals have been built to facilitate regulation and irrigation, or to ameliorate environmental problems. Several examples are:

- the Dawesville Cut in the Peel-Harvey Estuary in Western Australia (the Peel-Harvey Inlet is pictured in Figure 12.2.2.6) where a multi-million dollar canal was constructed to increase sea water circulation through the inlet This was designed to alleviate the Blue-green algae problem described in Section 1.1 under coastal water quality (Fleming, P.M. 1996, pers. comm.).
- the Mulwala and Wakool Canals in New South Wales, which divert about 10,000 and 2,400 Ml/day respectively.
- the Yarrawonga and National Channels in Victoria which divert about 3,300 and 4,500 Ml/day respectively (MDBC 1990, p. 55).

Impacts of human modification of natural waterways

While it was necessary to impound and modify our waterways to accommodate agricultural, industrial and urban water and transportation needs, there have frequently been costs in terms of changes to the natural environment, which have often resulted in issues for both human and environmental use (see Sections 1.1 and 6.5).

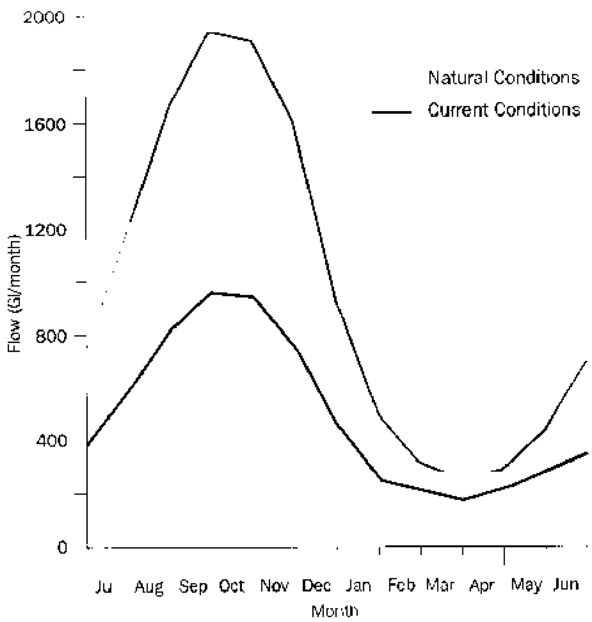
The extent to which Murray River outflow to the sea has been diminished as a result of diversion is shown in Figure 6.5.6. The resultant effects on water quality are also discussed in that section.

Water storage (or impoundment) and regulation, while reducing the variability and seasonality of stream flows, may adversely affect native species which rely on specific riverine wetland environments. Fish are prevented from moving beyond weir, levee and dam walls, thereby interrupting movements up and down stream. While areas above levees, dams and weirs may have been flooded and changed to a lacustrine (lake) environment, areas below may have reduced flow, and floodplains and billabongs could be cut off from the river system.

Figure 12.2.2.7 shows that both the extreme seasonal variability that existed under natural conditions and the mean monthly flows for the Murray River at Euston have been substantially reduced by the current regulatory conditions (MDBC 1990, p. 68).

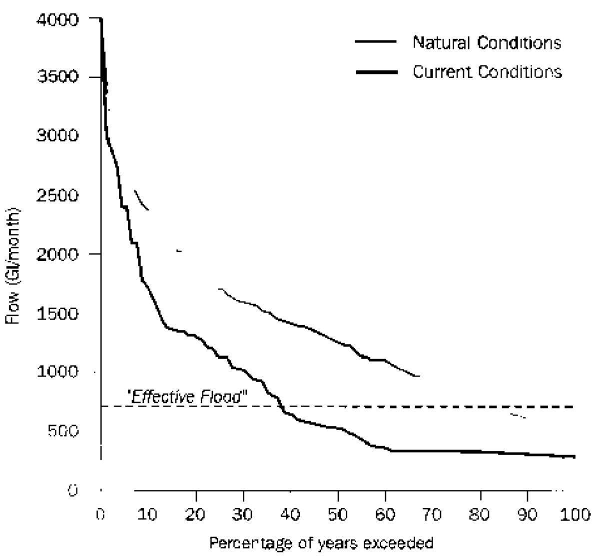
Changes to the frequency and magnitude of flood events affect not only the water areas but

12.2.2.7 Natural and current mean monthly flows of Murray River, Euston



Source: MDBC 1990, p. 69.

12.2.2.8 Peak monthly flow of Murray River in each year, Yarrawonga



Source: MDBC 1990, p. 71.

12.2.2.9 Estimated areas of known wetlands and the proportion compromised since European settlement

State	Wetland area (a)	Proportion compromised (b)
	'000 ha	%
NSW	4 500	50
Vic. (c)	400	33–50
Qld	7 798	na
SA	4 438	na
WA (d)	362	70–80
Tas.	3	na
NT	1 536	7

(a) States define wetlands differently — some according to the Ramsar convention (all waterways capable of supporting plant life) and others according to the traditional — marshes, bogs, swamps, floodplains, salt marshes etc. Wetlands may be permanently inundated, ephemeral or coastal. Environmentally important wetlands only are accounted for in most cases.
(b) "Compromised" may mean either lost or degraded.
(c) Wetland area based on areas surveyed to 1988.
(d) WA figures only include the Swan Coastal Plain.
Source: EPA (NSW) 1995; Office of the Commissioner for the Environment 1988, pp. 389 and 401; DPI (Qld) 1996, unpub.; DENR (SA) 1996, unpub.; Balla 1994, p. 11; Kirkpatrick, 1995; DLPE (NT) 1996, unpub.

also the surrounding dependent vegetation. Figure 12.2.2.8 shows the difference between natural forest watering events for the Barmah/Millewa forest and the current, regulated water availability. Whereas, prior to Murray regulation, the forest could expect effective flooding in 80% of years, it can now expect it in 35% (MDBC 1990, pp. 69–71).

Wetland areas are a natural part of water systems As mentioned in Section 1.1 they provide natural filtration to watercourses and specific habitats for various species of both animals and plants. Wetlands may be compromised by such human activities as draining and clearing for urban or agricultural use, pollution from human activities and river regulation. Table 12.2.2.9 shows the approximate areas of known wetlands by State and Territory and provides rough estimates of the proportion compromised, or lost, since European settlement.

Clearing and disturbance of riparian zones, de-snagging of waterways, agricultural activities and river regulation have all been responsible for increased erosion of river banks and resulted in sediment increases (see Section 1.1) (SoE 1996, p. 7-28). This has not only affected river and wetland ecologies but is also considered, in concert with increased nutrient levels, to be the major problem of the Australian marine environment. The main issues impacting on Australia's coastal environment stem from poor catchment management (Zann 1995, p. 96).

Straightening of river meanders and dredging to ease navigability also affect the flow regime, the flora and fauna of the area and benthic (river floor) communities. Not only does dredging directly affect the benthic communities, but increased erodion causes a process known as siltation which smothers bottom dwellers and fills holes in the river floor. This, coupled with de-snagging and removal of natural debris from rivers, affects the habitats and spawning activities of native fish (MDBC 1990, p. 330).

Releases from storages and industrial use of water for cooling result in changed water temperatures and oxygen levels which may affect downstream flora and fauna. While the bottom waters released from storages are cooler and contain less oxygen than the water system they join, water used in industrial processes is often of a higher temperature (SoE, 1996 p. 7-29).

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Chapter 13 — Reducing the Pressures of Economic Activity on the Environment

Chapter 12 presented statistics on a range of pressures exerted on the environment, that is, the impact of Economic Processes on the stock of Natural Assets in the PEP model. This chapter maintains the same perspective and examines several ways in which pressures of economic activity on the environment are reduced. The chapter presents information on:

- environmental legislation (Section 13.1);
- environmental expenditures (Section 13.2); and
- other environmental actions, such as recycling by businesses, which aim to reduce pressures on the environment (Section 13.3).

13.1 Environmental legislation

Introduction

Environmental legislation can be defined as any legislation controlling activities or conduct likely to impact on the environment. From a legal perspective the term 'Environment' generally comprises all natural resources and organisms, the various media (air, land and water), in addition to manufactured or modified structures and natural ecosystems.

Bates defines 'environmental law' as "any regulation or statute law or common law which affects the natural environment...; which declares the rights or duties of any person to take action to develop, use or protect the environment; or which might affect the scenic, historical, artistic or cultural beauty or appreciation of human efforts to harmonise the human-made or modified environment with natural environments" (Bates 1995, p. 7).

This section provides a brief summary of both Commonwealth and State legislation and outlines the administrative arrangements, as well as providing an international perspective on environmental law and treaties. Environmental legislation is continually evolving and as such the data in this section does not necessarily portray the most recent amendments and acts. Users should refer to the publication dates of sources used at the end of each table.

Early legislation

The Industrial Revolution and the growth of urban environments provided the impetus for government intervention. "Public health followed by pollution control legislation initially, and later environmental protection and management legislation in general, represents the progression of government activity to date" (Bates 1995 p. 76).

Governor King's Proclamation in 1803 prohibiting tree felling along the banks of the Hawkesbury River was an early but isolated instance of concern for the environment. In 1861 John Robertson, NSW Minister for Lands, introduced legislation on land settlement before survey. Other colonies followed with similar land settlement schemes.

With the exception of town planning and public health, early legislation was more concerned with rights to land, water use and minerals. It probably caused some of the greatest problems in terms of degradation because the land was used far beyond its capacity.

When the legislators drafted the Australian Constitution the environment was not identified as an issue warranting specific powers. The Australian Constitution does not include a reference to environment or conservation. The most pressing environmental issues of the day related to the Murray-Darling Basin and water rights for the various States seeking access to water for irrigation purposes.

Commonwealth legislation

Commonwealth powers in environmental protection, nature conservation and related fields arise from or are incidental to, other specified powers. These specific powers include the power to legislate with respect to territories of the Commonwealth, overseas and interstate trade and commerce, foreign affairs, corporations, taxation, defence, quarantine and granting of financial assistance to States. As an example, the World Heritage Properties Conservation Act 1983 arose from the Commonwealth legislation relying on the foreign affairs power (International Treaty Obligations). This legislation implements the International Convention for the Protection of the World Cultural and National Heritage Areas into Australian domestic law. Effectively the powers relating to environment and conservation are divided among the Commonwealth Government and the State/Territory and local governments. In practical terms, however, most decisions on environmental protection, nature conservation, land use and land management in the States are the responsibility of the State and local governments.

The Environment Protection (Impact of Proposals) Act 1974 was the first piece of Commonwealth legislation to address specific environmental issues. The Act defined the environment as comprising "all aspects of the surroundings of human beings, whether affecting them as individuals or in social groupings", and set up procedures to review the environmental impact of development proposals that involved Commonwealth Government decisions. Other legislation currently administered by the Commonwealth portfolio is listed, along with State legislation, in Table 13.1.1.

State and Territory legislation

In New South Wales, a number of State agencies have responsibility for environmental matters. These include the Department of Land and Water Conservation, the National Parks and Wildlife Service, and the Environment Protection Authority.

In Victoria, the Department of Conservation and Natural Resources is responsible for wildlife, fisheries, national parks, land protection, water resources, flora and fauna. The Environment Protection Authority is responsible for protecting and improving the air, land and water environments through management of wastes, control of noise and control of pollution.

The Queensland Department of Environment and Heritage is responsible for environment protection, nature conservation and the management of national parks. Responsibilities for planning and development are shared among a number of other departments.

In South Australia, the Department of Environment and Natural Resources is responsible for conservation and land management, national parks, planning and environment management. Several statutory bodies, such as the Coast Protection Board, the Environmental Protection Council, the Pastoral Board of South Australia and the Land Services Group, report to the Minister for Environment and Natural Resources.

The Environment Protection Authority in Western Australia is an autonomous body with the dual role of providing independent advice to the Government and the public on environmental protection, and of implementing government powers on pollution control. Other government departments have responsibility for environmental management, which must be exercised within the policies and according to advice of the EPA.

Environmental management in Tasmania is the responsibility of the Department of Environment and Land Management. An independent body, the Environment Protection Advisory Council, which has a majority of members from outside government, also advises the Minister.

In the Northern Territory, the Department of Lands, Planning and Environment has responsibility for the environment and planning issues, while the Parks and Wildlife Commission of the Northern Territory is responsible for park management and wildlife conservation.

The National Capital Planning Authority administers planning and environmental management within the Australian Capital Territory for areas of Commonwealth concern. The remaining area is administered by the ACT Government. The Environment and Land Bureau is responsible for environment protection, conservation and associated administration in the Australian Capital Territory, while planning is the responsibility of the ACT Planning Authority.

Local Government legislation

Local Governments are empowered through a variety of local government and environmental protection legislation to participate in the development and delivery of environmental programs. The United Nations Conference on Environment and Development held at Rio de Janeiro, Brazil in 1992 clearly acknowledged the work that local communities undertake in maintaining environmental infrastructure. In the action plan Agenda 21 it included a chapter on local government and also provided these communities with a framework for consultation and formulation of strategies to "think globally and act locally".

Apart from the recognised areas of planning for land use, waste disposal and sewerage, local governments also assist in the control, prevention and management of a wide range of activities. Examples of this are: control of noxious weeds, heritage preservation orders and land degradation programs. Local governments are committed to the principles of ESD through participation in the Inter-Governmental Agreement on the Environment (IGAE).

This agreement was signed in 1992 by the Commonwealth Government, and State, Territory and local governments. It provides for interaction on environmental issues and sets out cooperative arrangements on a wide range of specific issues. The Agreement provides for:

- the endorsement of a common set of principles for the conduct of environmental impact assessments; and
- the establishment of a mechanism for developing nationally enforceable measures for the protection and management of the Australian environment.

To achieve its objectives, the IGAE has set up a ministerial council with representatives from each of the States and Territories, and the Commonwealth, to direct the Commonwealth Environment Protection Authority (CEPA) on the implementation of national environment measures.

CEPA is responsible for:

- establishing nationally applied measures for environmental protection matters;
- agreement on national environmental quality standards, such as standards for air quality;
- providing a reviewed environmental impact assessment process, which will better recognise industry and government needs and simplify the application of legislation;
- providing a vital link between businesses in Australia and overseas, and establishing a clearing house for the dissemination of general information, research and industry contacts, and information on technology; and
- coordinating information about the state of the environment and ensuring that this information is easily accessible to the general community.

Other issues covered in the schedules of the IGAE are:

- data collection and handling, which are coordinated by the Australia and New Zealand Land Information Council;
- resource assessment, land use details and approval processes;
- environmental impact assessment;
- climate change;
- biological diversity;
- National Estate — Australia Heritage Commission;
- World Heritage; and
- nature conservation.

13.1.1 Federal, State and Territory environmental legislation (a)

Jurisdiction	*Legislation*
Environmental Planning	
Federal	Aboriginal and Torres Strait Islander Commission Act 1989; Aboriginal and Torres Strait Islanders (Queensland Reserves and Communities) Self-Management Act 1978; Aboriginal Land Rights (Northern Territory) Act 1976; Antarctic (Environment Protection) Legislation Amendment Act 1992; Antarctic Treaty Act 1960 and Antarctic Treaty (Environment Protection) Act 1980; Australian Capital Territory (Planning and Land Management) Act 1988; Endangered Species Act 1992; Environment (Financial Assistance) Act 1977; Environment Protection (Alligator Rivers Region) Act 1978; Environment Protection (Impact of Proposals) Act 1974; Environment Protection (Northern Territory Supreme Court) Act 1978; Great Barrier Reef Marine Park Act 1975; Koongarra Project Area Act 1981; Murray-Darling Basin Act 1993; National Parks and Wildlife Conservation Act 1975; Native Title Act 1993; Resource Assessment Commission Act 1989; Seas and Submerged Lands Act 1973; Sea Installations Act 1987; Urban and Regional Development (Financial Assistance) Act 1974; Wet Tropics of Queensland World Heritage Area Conservation Act 1994; World Heritage Properties Conservation Act 1983.
NSW	Blue Mountains Land Development (Special Provisions) Act 1985; Catchment Management Act 1989; Centennial and Moore Park Trust Act 1983; Coastal Protection Act 1979; Community Land Development Act 1989; Crown Lands Act 1989; Darling Harbour Authority Act 1984; Environmental Offences and Penalties Act 1989; Environmental Education and Environmental Research Trust Acts 1990; Environmental Planning and Assessment Act 1979; Environmental Restoration and Rehabilitation Trust Act 1990; Land and Environment Court Act 1979; Local Government Act 1979; Local Government Act 1993; Lord Howe Island Act 1953; Mining Act 1992; Mine Subsidence Compensation Act 1992; Murray-Darling Basin Act 1992; National Parks and Wildlife Act 1974; Pollution Control Act, 1970; Protection of the Environment Administration Act 1991; Rivers and Foreshores Improvement Act 1948; Rural Adjustment Scheme Agreement Act 1993; Rural Lands Protection Act 1989; State Owned Corporations Act 1989; Unhealthy Building Land Act 1990; Western Lands Act 1901.
Vic.	Alpine Resorts Act 1983; Building Act 1993; Conservation, Forests and Lands Act 1987; Crown Land (Reserves) Act 1987; Drainage Areas Act 1958; Environment Effects Act 1978; Environment Protection Act 1970; Environment Protection (Fees and Penalties) Act 1990; Groundwater (Border Agreement) Act 1985; Land Conservation Act 1970; Land Title Validation Act 1993; Local Government Act 1989; Melbourne and Metropolitan Board of Works Act 1958; Melbourne Lands Act 1987; Murray-Darling Basin Act 1993; National Parks Act 1975; National Parks (Alpine National Parks) Act 1989; National Parks (Wilderness) Act 1992; Planning and Environment Act 1987; Planning Appeals Act 1980; Reference Areas Act 1978; Renewable Energy Authority Victoria Act 1990; Royal Botanic Gardens Act 1991; Snowy Mountains Engineering Corporation Act 1971; Soil Conservation and Land Utilisation Act 1958; Victorian Conservation Trust Act 1972; Water Act 1989.
Qld	Contaminated Land Act 1991; Electricity Act 1976; Fauna Conservation Act 1974; Gurulmundi Secure Landfill Agreement Act 1992; Integrated Resorts Development Act 1987; Irrigation Areas (Land Settlement) Act 1962; Land Act 1962; Local Government Act 1993; Local Government (Planning and Environment) Act 1990; Marine Parks Act 1982; Mixed Use Development Act 1993; Native Title (Queensland) Act 1993; Nature Conservation Act 1992; Nerang River Entrance Development Act 1984; New South Wales-Queensland Borders Rivers Act 1946; Recreation Areas Management Act 1988; Rural Lands Protection Act 1985; Sanctuary Cove Resort Act 1985; State Development and Public Works Organisation Act 1971; State Environment Act 1988; Wet Tropics World Heritage Protection and Management Act 1993.
SA	Coast Protection Act 1972; Crown Lands Act 1929; Development Act 1993; Environment Protection Act, 1993; Golden Grove Indenture Ratification Act 1984; Land Acquisition Act 1969; Local Government Act 1934; MFP Development Act 1992; Murray-Darling Basin Act 1993; National Parks and Wildlife Act 1972; Pastoral Land Management and Conservation Act 1989; Public Parks Act 1943; Soil Conservation and Land Care Act 1989; West Beach Recreation Reserve Act 1987.
WA	Aboriginal Affairs Planning Authority Act 1972; Conservation and Land Management Act 1984; Environmental Protection Act 1986; Land (Titles and Traditional Usage) Act 1993; Local Government Act 1960; Main Roads Act 1930; Metropolitan Region Town Planning Scheme Act 1959; Parks and Reserves Act 1895; Pilbara Development Commission Act 1992; Public Works Act 1902; Reserves and Land Revestment Act 1991; Rural Adjustment and Financial Corporation Act 1993; Soil and Land Conservation Act 1945; State Planning Commission Act 1985; Town Planning and Development Act 1928; Western Australian Development Corporation Act 1983; Western Australian Land Authority Act 1992.
Tas.	Approvals (Deadlines) Act 1993; Abandoned Land Act 1973; Crown Lands Act 1978; Environmental Management and Pollution Control Act 1994; Forest Practices Act 1985; Hydro-Electric Commission Act 1944; Lands Acquisition Act 1993; Land Use Planning and Approvals Act 1993; Local Government Act 1993; National Parks and Wildlife Act 1970; Public Land (Administration and Forests) Act 1991; Resource Management and Planning Appeal Tribunal Act 1993; Rural Adjustment Act 1990; State Policies and Projects Act 1993; Tamar Improvement Act 1912; Wellington Park Act 1993.

13.1.1 Federal, State and Territory environmental legislation (a) ***(continued)***

Jurisdiction	*Legislation*
Environmental Planning (continued)	
NT	Confirmation of Titles to Land (Request) Act 1993; Conservation Commission Act 1980; Crown Lands Act 1992; Environmental Assessment Act 1982; Fisheries Act 1988; Jabiru Town Development Act 1979; Lands Acquisition Act 1979; Land Acquisition Act (Pastoral Leases) Act 1982; Local Government Act 1993; Pastoral Land Act 1992; Planning Act 1993; Soil Conservation and Land Utilisation Act 1970; Territory Parks and Wildlife Conservation Act 1977; Water Act 1991; Yulara Village Management Act 1984.
ACT	Buildings (Design and Siting) Act 1964; Commissioner for the Environment Act 1993; Interim Territory Planning Act 1990; Land (Planning and Environment) Act 1991; National Land Ordinance 1989; Protection of Lands Act 1937; Public Parks Act 1928; Recovery of Lands Act 1929.
Air Pollution	
Federal	Antarctic (Environment Protection) Legislation Amendment Act 1992; Environment Protection (Impact of Proposals) Act 1974; Motor Vehicles Standards Act 1989; National Road Transport Act 1992; Ozone Protection Act 1981, Ozone Protection Act 1989, Ozone Protection (Licence Fees – Imports) Act 1989, and Ozone Protection (Licence Fees – Manufacture) Act 1989; Urban and Regional Development (Financial Assistance) Act 1974.
NSW	Clean Air Act 1961; Environmental Offences and Penalties Act 1989; Land and Environment Act 1979; Local Government Act 1993; Ozone Protection Act 1989; Pollution Control Act 1970; Protection of the Environment Administration Act 1991; Recreation Vehicles Act 1983; Traffic Act 1909.
Vic.	Agricultural and Veterinary Chemicals Act 1992; Environment Protection Act 1970; Environment Protection (Air Pollution Control) Act 1982; Environment Protection (Clean Air) Act 1981; Environment Protection (Fee and Penalties) Act 1990; Environment Protection (Lead in Petrol) Act 1982 and Environment Protection (Unleaded Petrol) Act 1984; Environment Protection (Ozone Layer) Act 1989; Extractive Industries Act 1966; Local Government Acts 1958 and 1989; Renewable Energy Authority Act 1990; Road Safety Act 1986.
Qld	Agricultural Chemicals Distribution Control Act 1966; Clean Air Act 1963; Environment Protection Legislation (proposed 1994); Health Act 1937; Motor Vehicles Control Act 1975.
SA	Environment Protection Act 1993; Public and Environmental Health Act 1987; Road Traffic Act 1961; Unleaded Petrol Act 1985.
WA	Aerial Spraying Control Act 1966; Environmental Protection Act 1986; Health Act 1911; Local Government Act 1960 Road Traffic Act 1974; Unleaded Petrol Act 1984.
Tas.	Approvals (Deadlines) Act 1993; Chlorofluorocarbons and Other Ozone Depleting Substances Control Act 1988; Environment Protection Act 1973; Public Health Act 1962.
NT	Dangerous Goods Act 1988; Darwin Port Authority Act 1983; Environmental Assessment Act 1982; Mine Management Act 1990; Motor Vehicles Act 1949; Ozone Protection Act 1990; Planning Act 1979; Public Health Act; Traffic Act 1949.
ACT	Air Pollution Act 1984; Land (Planning and Environment) Act 1991; Motor Traffic Act 1936; Ozone Protection Act 1991; Public Health Act 1928.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Noise Pollution	
Federal	Environment Protection (Impact of Proposals) Act 1974; Motor Vehicle Standards Act 1989; National Road Transport Commission Act 1992.
NSW	Environmental Offences and Penalties Act 1989; Land and Environment Court Act 1979; Local Government Act 1993; Noise Control Act 1975; Pollution Control Act 1970; Protection of the Environment Administration Act 1991; Recreation Vehicles Act 1983; Traffic Act 1909.
Vic.	Environment Protection Act 1970; Environment Protection (Fees and Penalties) Act 1990; Extractive Industries Act 1966; Local Government Act 1958; Marine Act 1988; Planning and Environment Act 1987; Road Safety Act 1986.
Qld	Environment Protection Legislation (proposed 1994); Fig Tree Pocket Noise Emission Act 1984; Local Government (Planning and Environment) Act 1990; Motor Vehicles Control Act 1983; Noise Abatement Act 1978; Recreational Areas Management Act 1988.
SA	Environment Protection Act 1993; Harbours and Navigation Act 1993; Public and Environmental Health Act 1987; Road Traffic Act 1961; Statutes Repeal Amendment (Places of Public Entertainment) Act 1993.
WA	Environmental Protection Act 1986; Occupational Health, Safety and Welfare Act 1989; Road Traffic Act 1974.
Tas.	Approvals (Deadlines) Act 1993; Environment Protection Act 1973; Public Health Act 1962.
NT	Darwin Port Authority Act 1983; Environmental Assessment Act 1982; Local Government Act 1993; Motor Vehicles Act 1949; Planning Act 1979; Summary Offences Act 1923; Tenancy Act; Traffic Act 1949.
ACT	Animal Nuisance Control Act 1975; Land (Planning and Environment) Act 1991; Motor Traffic Act 1936; Noise Control Act 1988.
Solid Waste	
Federal	Antarctic Treaty (Environment Protection) Act 1980; Environment Protection (Sea Dumping) Act 1982; Great Barrier Reef Marine Park Act 1975; Heard Island and McDonald Islands Act 1953; National Parks and Wildlife Conservation Act 1975; Navigation Act 1912; Protection of the Sea (Prevention of Pollution from Shipping) Act 1983.
NSW	Fertilisers Act 1985; Hunter Water Board (Corporatisation) Act 1991; Local Government Act 1993; Pipelines Act 1967; Pollution Control Act 1970; Public Health Act 1902; Waste Disposal Act 1970; Water Supply Authorities Act 1987.
Vic.	Environment Protection Act 1970; Environment Protection (Industrial Waste) Act 1985; Environment Protection (Resource Recovery) Act 1992; Harbour Boards Act 1958; Litter Act 1987; Local Government Act 1958; Marine Act 1988; Pipelines Act 1967; Planning and Environment Act 1987; Port of Geelong, Port of Melbourne and Port of Portland Authority Acts 1958; Water Act 1989.
Qld	Environment Protection Legislation (proposed 1994); Health Act 1937; Litter Act 1971; Local Government (Planning and Environment) Act 1990; Marine Parks Act 1982; Queensland Marine (Sea Dumping) Act 1985; Sewerage and Water Supply Act 1949; State Environment Act 1988.
SA	Environment Protection Act 1993; Environment Protection (Sea Dumping) Act 1984; Harbours and Navigation Act 1993; Local Government Act 1934; Mining Act 1971; Places of Public Entertainment Act 1913; Police Offences Act 1953; Public and Environmental Health Act 1987; Sewerage Act 1929; South Eastern Water Conservation and Drainage Act 1992; Water Resources Act 1990.
WA	Country Towns Sewerage Act 1948; Environment Protection Act 1986; Health Act 1911; Litter Act 1979; Local Government Act 1960; Main Roads Act 1930; Marine and Harbours Act 1981; Police Act 1892; Rights in Water and Irrigation Act 1914.
Tas.	Approvals (Deadlines) Act 1993; Disposal of Uncollected Goods Act 1968; Environment Protection Act 1973; Litter Act 1973; Local Government Act 1993; Marine Act 1976; Police Act 1935; Pollution of Waters by Oils and Noxious Substances Act 1987; Sewers and Drains Act 1954.
NT	Abattoirs and Slaughtering Act 1973; Caravan Act 1975; Control of Roads Act 1953; Dangerous Goods Act 1981; Darwin Post Authority 1983; Litter Act 1972; Local Government Act 1993; Mine Management Act 1990; Mine (Gove Peninsula Nabalco Agreement) Act 1968; Public Health Act 1952; Stock Routes and Travelling Stock Act 1954; Summary Offences Act 1923; Water Act 1992; Water Supply and Sewerage Act 1983.
ACT	Building and Services Act 1924; Clinical Waste Act 1990; Electricity and Water Act 1988; Land (Planning and Environment) Act 1991; Litter Act 1977.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Pollution of Internal Waters	
Federal	Canberra Water Supply (Googong Dam) Act 1974; Captains Flat (Abatement of Pollution) Agreement Act 1975; Environment Protection (Alligator Rivers Region) Act 1978; Environment Protection (Impact of Proposals) Act 1974; Koongarra Project Area Act 1981; Murray-Darling Basin Act 1993; National Parks and Wildlife Conservation Act 1975.
NSW	Catchment Management Act 1989; Clean Waters Act 1970; Crown Lands Act 1989; Drainage Act 1938; Environmental Offences and Penalties Act 1989; Fish Rivers Water Supply and Administration Act 1985; Googong Dam Catchment Area Act 1975; Hunter Water Board (Corporatisation) Act 1991; Irrigation Act 1912; Land and Environment Court Act 1979; Local Government Act 1993; Murray-Darling Basin Act 1992; National Parks and Wildlife Act 1974; New South Wales – Queensland Borders Rivers Agreement Act 1946; Pollution Control Act 1970; Protection of the Environment Administration Act 1991; Rivers and Foreshores Improvement Act 1948; Water Act 1912, Water Administration Act 1986, Water Board Act 1987 and Water Supply Authorities Act 1987; Wilderness Act 1987; Wentworth Irrigation Act 1890; Western Lands Act 1901.
Vic.	Alpine Resorts Act 1983; Crimes Act 1958; Drainage Areas Act 1958; Environment Protection Act 1970; Environment Protection (Fees and Penalties) Act 1990; Groundwater (Border Agreement) Act 1985; Melbourne Water Authority Act 1992; Mines Act 1958; Murray-Darling Basin Act 1993; National Parks (Alpine National Parks) Act 1989 and National Parks (Wilderness) Act 1992; Planning and Environment Act 1987; Pollution of Waters by Oil and Noxious Substances Act 1986; Water Act 1989; Water (Rural Water Corporation Act 1992.
Qld	Brisbane and Area Water Board Act 1979; Clean Waters Act 1971; Environment Protection Legislation (proposed 1994); Health Act 1937; Irrigation Area (Land Settlement) Act 1962; Nature Conservation Act 1992; New South Wales – Queensland Borders Rivers Agreement Act 1946; Pollution of Waters by Oil Act 1973; Queensland Building Services Authority Act 1991; River Improvement Trust Act 1940; Sewerage and Water Supply Act 1949; South-East Queensland Water Board Act 1979; Water Resources Act 1989.
SA	Environment Protection Act 1993; Groundwater (Border Agreement) Act 1985; Harbours and Navigation Act 1993; Irrigation Act 1930; Local Government Act 1934; Metropolitan Drainage Act 1935; Murray-Darling Basin Act 1993; National Parks and Wildlife Act 1972; Pollution of Waters by Oil and Noxious Substances Act 1987; Public and Environmental Health Act 1987; River Torrens Acquisition Act 1970; River Torrens (Prohibition of Excavation) Act 1927; River Torrens Protection Act 1949; Sewerage Act 1929; South-Eastern Water Conservation and Drainage Act 1992; Water Resources Act 1990; Waterworks Acts 1932; Wilderness Protection Act 1992.
WA	Country Areas Water Supply Act 1947; Country Towns Sewerage Act 1948; Environmental Protection Act 1986; Land Drainage Act 1925; Health Act 1935; Local Government Act 1960; Metropolitan Water Authority Act 1982; Metropolitan Water Supply, Sewerage and Drainage Act 1902; Municipal Water Supply Preservation Act 1892; Pollution of Waters by Oil and Noxious Substances Act 1987; Rights in Water and Irrigation Act 1914; Swan River Trust Act 1988; Water Authority Act 1984; Waterways Conservation Act 1976; Western Australia Water Resources Council Act 1982.
Tas.	Approvals (Deadlines) 1993; Environment Protection Act 1973; Farm Water Development Act 1985; Groundwater Act 1985; Hobart Regional Water Act 1984; Local Government Act 1993; National Parks and Wildlife Act 1970; North Esk Regional Water Act 1960, North-West Regional Water Act 1987; Rossarden Water Act 1954 and West Tamar Water Act 1960; Police Act 1935; Pollution of Waters by Oil and Noxious Substances Act 1987; Sewers and Drains Act 1954; Water Act 1957 and Water Resources Investigation Act 1937; Waterworks Clauses Act 1952.
NT	Darwin Port Authority Act 1983; Environmental Assessment Act 1982; Fisheries Act 1988; Litter Act 1972; Local Government Act 1993; Mine Management Act 1990; Power and Water Authority Act 1987; Prevention of Pollution of Water by Oil Act 1962; Public Health Act 1952; Summary Offences Act 1923; Territory Parks and Wildlife Conservation Act 1977; Water Act 1991; Water Supply and Sewerage Act 1988.
ACT	Canberra Water Supply (Googong Dam) Act 1974; Cotter River Act 1914; Electricity and Water Supply Act 1988; Lakes Ordinance 1976; Land (Planning and Environment) Act 1991; Water Pollution Act 1984.
Pollution of Marine Waters	
Federal	Antarctic (Environmental Protection) Legislation Amendment Act 1992, Antarctic Marine Living Resources Conservation Act 1981 and Antarctic Treaty (Environmental Protection) Act 1980; Australian Institute of Marine Science Act 1972; Australian Maritime Safety Authority Act 1990; Carriage of Goods by Sea Act 1991; Control of Naval Waters Act 1918; Environmental Protection (Sea Dumping) Act 1981; Great Barrier Reef Marine Park Act 1975; Heard Island and McDonald Islands Act 1953; National Parks and Wildlife Conservation Act 1975; Navigation (Protection of the Sea) Amendment Act 1983; Petroleum (Submerged Lands Act 1967; Protection of the Sea (Civil Liability) Act 1981; Protection of the Sea (Oil Pollution Compensation Fund) Act 1993; Protection of the Sea (Powers of Intervention) Act 1981; Protection of the Sea (Prevention of Pollution from Ships) Act 1983; Protection of the Sea (Shipping Levy) Act 1981; Protection of the Sea (Shipping Levy Collection) Act 1981; Seas and Submerged Lands Act 1973; Sea Installations Act 1987 and Sea Installations Levy Act 1987; South Pacific Nuclear Free Zone Treaty Act 1986; Torres Strait Fisheries Act 1984.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Pollution of Marine Waters (continued)	
NSW	Clean Waters Act 1970; Coastal Protection Act 1979; Environmental Offences and Penalties Act 1989; Fisheries and Oyster Farms Act 1935; Marine Administration Act 1989; Marine Pollution Act 1987; Maritime Services Act 1935; Navigation Act 1901; Petroleum (Submerged Lands) Act 1982; Pollution Control Act 1970; Protection of the Environment Administration Act 1991.
Vic.	Crown Land (Reserves) Act 1978; Environment Protection Act 1970; Fisheries Act 1968; Marine Act 1988; Petroleum (Submerged Lands) Act 1982; Planning and Environment Act 1987; Pollution of Waters by Oil and Noxious Substances Act 1986; Port of Geelong, Port of Melbourne and Port of Portland Authority Acts 1958; Victorian Institute of Marine Sciences Act 1974.
Qld	Beach Protection Act 1968; Environmental Protection Legislation (proposed 1994); Harbours Act 1955; Marine Parks Act 1982; Off-Shore Facilities Act 1986; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil Act 1973; Queensland Marine Act 1958; Queensland Marine (Sea Dumping) Act 1985; Sewerage and Water Supply Act 1949.
SA	Coast Protection Act 1972; Environment Protection Act 1993; Environment Protection (Sea Dumping) Act 1984; Fisheries Act 1983; Harbours and Navigation Act 1993; Petroleum Act 1940; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil and Noxious Substances Act 1987; Public and Environmental Health Act 1987.
WA	Albany Port Authority Act 1926, Dampier Port Authority Act 1985, Fremantle Port Authority Act 1902 and Geraldton Port Authority Act 1968; Environmental Protection Act 1986; Marine and Harbours Act 1981; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil and Noxious Substances Act 1987; Port Hedland Port Authority Act 1970; Port Kennedy Development Agreement Act 1992; Shipping and Pilotage Act 1967 and Western Australian Coastal Shipping Commission Act 1965; Western Australian Marine Act 1982; Western Australian Marine (Sea Dumping) Act 1981.
Tas.	Environment Protection Act 1973; Environment Protection (Sea Dumping) Act 1987; Marine Act 1976; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil and Noxious Substances Act 1987.
NT	Darwin Port Authority Act 1983; Environmental Assessment Act 1982; Fisheries Act 1988; Litter Act 1972; Local Government Act 1993; Marine Act 1956; Off-Shore Waters (Application of Territory Laws) Act 1985; Petroleum (Submerged Lands) Act 1982; Prevention of Pollution of Waters by Oil Act 1962; Water Act 1992.
ACT	Water Pollution Act 1984.
Toxic and Hazardous Substance	
Federal	Agricultural and Veterinary Chemicals Act 1988 and Agricultural and Veterinary Chemicals (Administration) Act 1992; Antarctic Treaty Act 1960 and Antarctic Treaty (Environment Protection) Act 1980; Atomic Energy Act 1953; Australian Nuclear Science and Technology Act 1987; Carriage of Goods by Sea Act 1991; Environment Protection (Alligator Rivers Region) Act 1978; Environment Protection (Nuclear Codes) Act 1978; Hazardous Waste (Regulation of Exports and Imports) Act 1989; Industrial Chemicals (Notification and Assessment) Act 1989; Koongarra Project Area Act 1981; National Residue Survey Administration Act 1992; Nuclear Non–Proliferation (Safeguards) Act 1987; Ozone Protection, Ozone Protection (Licence Fees – Imports) and Ozone Protection (Licence fees – Manufacture) Acts 1989; Petroleum (Submerged Lands) Act 1967; Pipeline Authority Act 1973; Protection of the Sea (Civil Liability) Act 1981, Protection of the Sea (Powers of Intervention) Act 1981 and Protection of the Sea (Prevention of Pollution from Ships) Act 1983; South Pacific Nuclear Free Zone Treaty Act 1986.
NSW	Clean Air Act 1961; Clean Waters Act 1970; Dangerous Goods Act 1975; Environmental Offences and Penalties Act 1989; Environmental Planning and Assessment Act 1979; Environmentally Hazardous Chemicals Act 1985; Fertilisers Act 1985; Fire Brigades Act 1989; Navigation Act 1901; Ozone Protection Act 1989; Pesticides Act 1978; Petroleum (Onshore) Act 1991; Petroleum (Submerged Lands) Act 1982; Pipelines Act 1967; Public Health Act 1991; Radiation Control Act 1990; Stock (Chemical Residues) Act 1975; Unhealthy Building Land Act 1990; Uranium Mining and Nuclear Facilities (Prohibition) Act 1986; Waste Disposal Act 1970.
Vic.	Agricultural and Veterinary Chemicals Act 1992; Dangerous Goods Act 1985; Drugs, Poisons and Controlled Substances Act 1981; Environment Protection Act 1970; Environment Protection (Fees and Penalties) Act 1990; Fisheries Act 1968; Health Act 1958; Nuclear Activities (Prohibitions) Act 1983; Petroleum Act 1958; Petroleum (Submerged Lands) Act 1982; Pipelines Act 1967; Pollution of Waters by Oil and Noxious Substances Act 1986.
Qld	Agricultural Chemicals Distribution Control Act 1966; Agricultural Standards Act 1952; Carriage of Dangerous Goods by Road Act 1984; Chemical Usage (Agricultural and Veterinary) Control Act 1988; Clean Air Act 1953; Contaminated Land Act 1991; Gurulmundi Secure Landfill Agreement Act 1992; Health Act 1937; Petroleum Act 1923; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil Act 1973; Radioactive Substances Act 1958; Sea Carriage of Goods (State) Act 1930; State Development and Public Works Organisation Act 1971; State Environment Act 1988.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Toxic and Hazardous Substances (continued)	
SA	Agricultural Chemicals Act 1955; Controlled Substances Act 1984; Dangerous Substances Act 1979; Environment Protection Act 1993; Environment Protection (Sea Dumping) Act 1984; Explosives Act 1936; Occupational Health, Safety and Welfare Act 1986; Petroleum Act 1940; Petroleum (Submerged Lands) Act 1982; Pipeline Authority Act 1967; Pollution of Waters by Oil and Noxious Substances Act 1987; Public and Environmental Health Act 1987; Radiation Protection and Control Act 1982; Roxby Downs (Indenture Ratification) Act 1982.
WA	Aerial Spraying Control Act 1966; Agricultural Produce (Chemical Residues) Act 1983; Environment Protection Act 1986; Explosives and Dangerous Goods Act 1961; Fertilisers Act 1977; Health Act 1911; Occupational Health, Safety and Welfare Act 1984; Petroleum Act 1967; Petroleum Pipelines Act; Petroleum (Submerged Lands) Act 1982; Poisons Act 1964; Radiation Safety Act 1975; Veterinary and Animal Feeding Stuffs Act 1974; Western Australian Marine Act 1982.
Tas.	Approvals (Deadlines) Act 1993; Chlorofluorocarbons and Other Ozone Depleting Substances Control Act 1988: Dangerous Goods Act 1976; Fertilizers Act 1993; Local Government Act 1993; Pesticides Act 1968; Poisons Act 1971; Police Act 1935; Pollution of Waters by Oil and Noxious Substances Act 1987; Radiation Control Act 1977; Sewers and Drains Act 1954.
NT	Dangerous Goods Act 1981; Energy Pipelines Act 1982; Mine Management Act 1990; Ozone Protection Act 1990; Petroleum Act 1984; Petroleum (Submerged Lands) Act 1982; Poisons and Dangerous Drugs Act 1983; Prevention of Pollution of Waters by Oil Act 1962; Public Health Act 1952; Radiation (Safety Control) Act 1978; Radioactive Ores and Concentrates (Packaging and Transport) Act 1980; Uranium Mining (Environment Control) Act 1979.
ACT	Building Act 1972; Building and Services Act 1924; Business Franchise (Tobacco and Petroleum Products) Act 1984; Clinical Waste Act 1990; Dangerous Goods Act 1984; Fertilizers Act 1904; Fuels Control Act 1979. Ozone Protection Act 1991; Pesticides Act 1989; Poisons Act 1933; Radiation Act 1983.
Nature Conservation – Terrestrial	
Federal	Aboriginal and Torres Strait Islanders Commission Act 1989; Aboriginal and Torres Strait Islanders (Queensland Reserves and Communities Self-Management) Act 1978; Agricultural and Veterinary Chemicals Act 1988 and Agricultural and Veterinary Chemicals (Administration) Act 1992; Antarctic Treaty Act 1960; Antarctic Treaty (Environment Protection) Act 1980 and Antarctic (Environment Protection) Legislation Amendment Act 1992; Atomic Energy Act 1953; Australian Capital Territory (Planning and Land Management) Act 1988; Australian Heritage Commission Act 1975; Biological Control Act 1984; Blowering Water Storage Works Agreement Act 1963; Canberra Water Supply (Googong Dam) Act 1974; Cocos (Keeling) Islands Act 1955; Endangered Species Protection Act 1992; Environment Protection (Alligator Rivers Region) Act 1978; Environment Protection (Nuclear Codes) Act 1978; Exotic Animal Diseases Control Act 1989; Forest Industries Research Export Charge Act 1993, Forest Industries Research Imports Charge Act 1993, Forest Industries Research Levy Charge Act 1993; Forestry and Timber Bureau Act 1930; Great Barrier Reef Marine Park Act 1975; Heard Island and McDonald Islands Act 1953; Horticultural Research and Development Corporation Act 1987; Hunter Valley Flood Mitigation Act 1956; Income Tax Assessment Act 1936; Livestock Diseases Act 1978; Murray-Darling Basin Act 1993; National Parks and Wildlife Conservation Act 1975; National Residue Survey Administration Act 1992; Native Title Act 1993; Natural Resources Management (Financial Assistance) Act 1992; Primary Industries and Energy Research and Development Act 1989; Quarantine Act 1908; Resource Assessment Commission Act 1989; Snowy Mountains Engineering Corporation Act 1970; States Grants (Nature Conservation) Act 1974; Wet Tropics of Queensland World Heritage Area Conservation Act 1994; Wildlife Protection (Regulation of Exports and Imports) Act 1982; World Heritage Properties Conservation Act 1983.
NSW	Agricultural Tenancies Act 1990; Balranald Irrigation Act 1902; Bicentennial Park Trust Act 1987; Biological Control Act 1985; Bush Fires Act 1949; Carlingford Drainage Improvement (Land Exchange) Act 1992; Catchment Management Act 1989; Centennial and Moore Parks Trust Act 1983; Coastal Protection Act 1979; Commons Management Act 1989; Crown Lands Act 1989; Endangered Fauna (Interim Protection) Act 1991; Environmental Education Trust Act 1990; Environmental Planning and Assessment Act 1979; Environmental Restoration and Rehabilitation Trust Act 1990; Exotic Diseases of Animals Act 1991; Fertilizers Act 1985; Fire Brigades Act 1989; Forestry Act 1916; Googong Dam Catchment Area Act 1975; Hay Irrigation Act 1902; Heritage Act 1977; Irrigation Act 1912; Lake Illawarra Authority Act 1987; Lord Howe Island Act 1953; Mine Subsidence Compensation Act 1992; Mining Act 1992; Murray-Darling Basin Act 1992; National Parks and Wildlife Act 1974; Navigation Act 1901; New South Wales – Queensland Border Rivers Act 1947; Noxious Weeds Act 1993; Petroleum (Onshore) Act 1991; Plant Diseases Act 1924; Pollution Control Act 1970; Prickly Pear Act 1987; Protection of the Environment Act 1991; Recreation Vehicles Act 1983; Rivers and Foreshores Improvement Act 1948; Royal Botanic Gardens and Domain Trust Act 1980; Snowy Mountains Hydro-Electric Agreements Act 1958; Soil Conservation Act 1938; Stock (Chemical Residues) Act 1975; Stock Diseases Act 1923; Timber Industry (Interim Protection) Act 1992; Water Board Act 1987 and Water Supply Authorities Act 1987; Western Lands Act 1901; Wilderness Act 1987; Zoological Parks Board Act 1973.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Nature Conservation – Terrestrial (continued)	
Vic.	Agricultural and Veterinary Chemicals Act 1992; Alpine Resorts Act 1983; Biological Control Act 1986; Conservation, Forests and Lands Act 1987; Country Fire Authority Act 1958; Crown Lands (Reserves) Act 1978; Cultural and Recreational Lands Act 1963; Environment Protection (Fees and Penalties) Act 1990; Environment Protection (Resource Recovery) Act 1992; Extractive Industries Act 1966; Flora and Fauna Guarantee Act 1988; Forests Act 1958; Groundwater (Border Agreement) Act 1985; Heritage Rivers Act 1992; Land Act 1958; Land Conservation Act 1970; Land Conservation (Vehicle Control) Act 1972; Land Title Validation Act 1993; Litter Act 1987; Mineral Resources Development Act 1990; Mines Act 1958; Murray-Darling Basin Act 1993; National Parks Act 1975; National Parks (Alpine National Parks) Act 1989; National Parks (Wilderness) Act 1992; Petroleum Act 1958; Rain-making Control Act 1967; Reference Areas Act 1978; Royal Botanic Gardens Act 1991; Soil Conservation and Land Utilization Act 1958; Stock Diseases Act 1969; Urban Land Authority Act 1979; Vegetation and Vine Diseases Act 1958; Vermin and Noxious Weeds Act 1958; Victoria Conservation Trust Act 1972; Water Act 1989 and Water (Rural Water Corporation) Act 1992; Wildlife Act 1975; Zoological Parks and Gardens Act 1967.
Qld	Agricultural Standards Act 1952; Animal Protection Act 1991; Beach Protection Act 1968; Biological Control Act 1987; Brisbane River Tidal Lands Improvement Act 1927; Chemical Usage (Agricultural and Veterinary) Control Act 1988; City of Brisbane Water Supply Act 1959; Contaminated Land Act 1991; Currumbin Bird Sanctuary Act 1976; Diseases in Timber Act 1975; Exotic Diseases in Animals Act 1982; Fire Services Act 1990; Forestry Act 1959; Health Act 1937; Irrigation Areas (Land Settlement) Act 1962; Land Act 1962; Local Government (Planning and Environment) Act 1990; Meaker Trust (Raine Island Research) Act 1981; Metropolitan Water Supply and Sewerage Act 1949; Mineral Resources Act 1989; Mines Regulation Act 1964; Mining (Fossicking) Act 1985; Motor Vehicles Control Act 1975; National Trust of Queensland Act 1963; Native Plants Protection Act 1930; Native Title (Queensland) Act 1993; Nature Conservation Act 1992; New South Wales – Queensland Border Rivers Act 1947; Property Law Act 1974; Recreation Areas Management Act 1988; Rural Lands Protection Act 1985; Soil Conservation Act 1986; State Environment Act 1988; Stock Act 1915; Timber Utilisation and Marketing Act 1987; Townsville/Thuringowa Water Supply Board Act 1987; Water Resources Act 1989; Wet Tropics World Heritage Protection and Management Act 1993.
SA	Agricultural Chemicals Act 1955; Animal and Plant Control (Agricultural and Other Purposes) Act 1986; Biological Control Act 1986; Botanic Gardens Act 1978; Carrick Hill Trust Act 1985; Coast Protection Act 1972; Country Fires Act 1989; Crown Lands Act 1929; Dog Fence Act 1946; Foot and Mouth Disease Eradication Fund Act 1958; Forestry Act 1983; Fruit and Plant Protection Act 1992; Groundwater (Border Agreement) Act 1985; Heritage Act 1993; Highways Act 1926; Irrigation Act 1930; Local Government (Forestry Resources) Act 1944; Lower River Broughton Irrigation Trust Act 1938; Metropolitan Drainage Act 1935; Mining Act 1971; Murray-Darling Basin Act 1993; National Parks and Wildlife Act 1972; National Trust of South Australia Act 1955; Native Vegetation Act 1991; Noxious Insects Act 1934; Pastoral Land Management and Conservation Act 1989; Planning Act 1982; Public Parks Act 1943; Renmark Irrigation Trust Act 1936; River Torrens Acquisition — Act 1970; River Torrens (Prohibition of Excavations) Act 1927; River Torrens Protection Act 1949; Sandalwood Act 1930; Soil Conservation and Land Care Act 1989; South Australian Timber Corporation Act 1979; South Eastern Water Conservation and Drainage Act 1992 and Water Conservation Act 1936; West Beach Recreation Reserve Act 1987; Wilderness Protection Act 1992.
WA	Aerial Spraying Control Act 1966; Agricultural Act 1988; Agricultural Produce (Chemical Residues) Act 1983; Agricultural and Related Resources Protection Act 1976; Agricultural Protection Board Act 1950; Animal Resources Authority Act 1987; Argentine Ant Act 1968; Biological Control Act 1986; Bush Fires Act 1954; Conservation and Land Management Act 1984; Control of Vehicles (Off-Road Areas) Act 1978; Environment Protection Act 1986; Exotic Diseases of Animals Act 1993; Fertilisers Act 1977; Land Act 1933; Land Drainage Act 1925; Main Roads Act 1930; Mines Regulation Act 1946 and Mining Act 1978; National Trust of Australia (W.A.) Act 1964; Parks and Reserves Act 1895; Plant Diseases Act 1914; Reserves and Land Revestment Act 1991; Rottnest Island Authority Act 1987; Rural Adjustment and Finance Corporation Act 1993; Sandalwood Act 1929; Skeleton Weed and Resistant Grain Insects (Eradication Funds) Act 1974; Soil and Land Conservation Act 1945; Stock Diseases (Regulations) Act 1918; Swan River Trust Act 1988; Veterinary Preparations and Animal Feeding Stuffs Act 1976; Water Supply, Sewerage and Drainage Act 1912 and Waterways Conservation Act 1976; Wildlife Conservation Act 1950; Zoological Gardens Act 1972.
Tas.	Abandoned Land Act 1973; Animal Welfare Act 1993; Biological Control Act 1986; Botanic Gardens Act 1950; Crown Lands Act 1978; Disposal of Uncollected Goods Act 1968; Farm Water Development Act 1985; Fertilisers Act 1993; Fire Services Act 1079; Forest Practices Act 1985; Forest Act 1920; Irrigation Clauses Act 1973; Lakes Sorell and Cresent Conservation Act 1901; Mining Act 1929; National Parks and Wildlife Act 1970; Noxious Insects and Molluscs Act 1951; Noxious Weeds Act 1964; Pesticides Act 1968; Plant Diseases Act 1930; Public Land (Administration and Forests) Act 1991; Softwood Forestry Act 1978; Water Act 1957 and Waterworks Clauses Act 1952; Wellington Park Act 1993.
NT	Ayres Rock Resort Corporation Act 1992; Biological Control Act 1986; Bush Fires Act 1980; Cobourg Peninsular Aboriginal Land and Sanctuary Act 1981; Conservation Commission Act 1980; Crown Lands Act 1992; Exotic Diseases (Animals) Compensation Act 1958; Heritage Commission Act 1991; Jabiru Town Development Act 1979; Lands Acquisition Act 1979 and Lands Acquisition (Pastoral Leases) Act 1982; Mining Act 1982; National Trust (Northern Territory) Act 1976; Nitmiluk (Katherine Gorge) National Park Act; Noxious Weeds Act 1963; Pastoral Land Act 1992; Plant Diseases Control Act 1979; Soil Conservation and Land Utilisation Act 1970; Stock Diseases Act 1954; Stock Routes and Travelling Stock Act 1954; Territory Parks and Wildlife Conservation Act 1977; Water Act 1992 and Water Supply and Sewerage Act 1983; Yulara Village Management Act 1984.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Nature Conservation – Terrestrial (continued)	
ACT	Animal Diseases Act 1993; Animal Nuisance Control Act 1975; Animal Welfare Act 1992; Bushfire Act 1936; Canberra Water Supply (Googong Dam) Act 1974; Cotter River Act 1914; Enclosed Lands Protection Act 1943; Fertilisers Act 1904 (NSW, in its application in the ACT); Fishing Act 1967; Lakes Ordinance 1976 Land (Planning and Environment) Act 1991 and National Land Ordinance 1989; Nature Conservation Act 1980; Noxious Weeds Act 1921; Pesticides Act 1989; Plant Diseases Act 1934; Prevention of Cruelty to Animals Act 1959; Protection of Lands Act 1937; Public Parks Act 1928; Rabbit Destruction Act 1914; Roads and Public Places Act 1937; Soil Conservation Act 1960.
Nature Conservation – Marine	
Federal	Antarctic Marine Living Resources Conservation Act 1981; Antarctic Treaty Act 1960; Antarctic Treaty (Environment Protection) Act 1980 and Antarctic (Environment Protection) Legislation Amendment Act 1992; Australian Heritage Commission Act 1975; Australian Institute of Marine Science Act 1972; Continental Shelf (Living Natural Resources) Act 1968; Environment Protection (Sea Dumping) Act 1982; Fisheries Acts 1991; Great Barrier Reef Marine Park Act 1975; Heard Island and McDonald Islands Act 1953; Minerals (Submerged Lands) Act 1981; National Parks and Wildlife Conservation Act 1975; Petroleum (Submerged Lands) Act 1967; Protection of the Sea (Civil Liability) Act 1981, Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and Protection of the Sea (Powers of Intervention) Act 1981; Protection of the Sea (Oil Pollution Compensation Fund) Act 1993; Sea and Submerged Lands Act 1973; Sea Installations Act 1987 and Sea Installations Levy Act 1987; South Pacific Nuclear Free Zone Treaty Act 1986; Torres Strait Fisheries Act 1984; Whale Protection Act 1980; Wildlife Protection (Regulation of Exports and Imports) Act 1982; World Heritage Properties Conservation Act 1983.
NSW	Coastal Protection Act 1979; Fisheries and Oyster Farm Act 1935; Marine Pollution Act 1987; Maritime Services Act 1935; National Parks and Wildlife Act 1974; Petroleum (Submerged Lands) Act 1982; Sea Carriage of Goods (State) Act 1921.
Vic.	Crown Lands (Reserves) Act 1978; Environment Protection Act 1970; Fisheries Act 1968; Fisheries (Abalone) Act 1987; Flora and Fauna Guarantee Act 1988; Marine Act 1988; Planning and Environment Act 1987; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil and Noxious Substances Act 1986; Underseas Mineral Resources Act 1963; Victorian Institute of Marine Sciences Act 1974; Wildlife Act 1975; Wildlife (Protection of Whales) Act 1981.
Qld	Beach Protection Act 1968; Fisheries Act 1976; Marine Parks Act 1982; Mineral Resources (Adjacent Submerged Areas) Act 1964; Nature Conservation Act 1992; Off-Shore Facilities Act 1986; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil Act 1973; Queensland Marine Act 1958; Queensland Marine (Sea Dumping) Act 1985; Sea Carriage of Goods (State) Act 1930.
SA	Coast Protection Act 1972; Environment Protection (Sea Dumping) Act 1984; Fisheries Act 1983; Fisheries (Gulf of St Vincent Prawn Fishing Rationalisation) Act 1987; Fisheries (Southern Zone Rock Lobster Fishery Rationalisation) Act 1987; Harbors and Navigation Act 1993; Marine Environment Protection Act 1990; National Parks and Wildlife Act 1972; Native Vegetation Act 1991; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil and Noxious Substances Act 1987.
WA	Conservation and Land Management Act 1984; Fisheries Act 1905; Fisheries Adjustment Schemes Act 1987; Marine and Harbours Act 1981; Oyster Fisheries Act 1881; Pearling Act 1990; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil and Noxious Substances Act 1987; Shipping and Pilotage Act 1967; Western Australian Marine Act 1982; Western Australian Marine (Sea Dumping) Act 1981; Whaling Act 1937; Wildlife Conservation Act 1950.
Tas.	Environment Protection (Sea Dumping) Act 1987; Fisheries Act 1959; Marine Act 1976; Noxious Insect and Molluscs Act 1951; Petroleum (Submerged Lands) Act 1982; Pollution of Waters by Oil and Noxious Substances Act 1987; Salt-Water Salmonid Culture Act 1985; Sea Fisheries Licence Act 1989; Whales Protection Act 1988.
NT	Fisheries Act 1988; Petroleum (Submerged Lands) Act 1982; Prevention of Pollution of Waters by Oil Act 1962; Territory Parks and Wildlife Conservation Act 1977.
Cultural Environment Conservation	
Federal	Aboriginal and Torres Strait Islanders Commission Act 1989; Aboriginal and Torres Strait Islander Heritage Protection Act 1984; Aboriginal and Torres Strait Islanders (Queensland Reserves and Communities Self–Management) Act 1978; Aboriginal Land Grant (Jervis Bay Territory) Act 1986; Aboriginal Land Rights (Northern Territory) Act 1976; Australian Heritage Commission Act 1975; Great Barrier Reef Marine Park Act 1975; Historic Shipwrecks Act 1976; National Parks and Wildlife Conservation Act 1975; Native Title Act 1993; Urban and Regional Development (Financial Assistance) Act 1974; Wet Tropics of Queensland World Heritage Area Conservation Act 1994; World Heritage Properties Conservation Act 1983.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Cultural Environment Conservation (continued)	
NSW	Aboriginal Land Rights Act 1983; Bicentennial Park Trust Act 1987; Centennial and Moore Park Trust Act 1983; Development Areas Act 1973; Heritage Act 1977; Historic Homes Act 1980; Mining Act 1992; National Parks and Wildlife Act 1974; National Trust of Australia (NSW) Act 1990; Parramatta Park (Old Government House) Act 1967; Royal Botanic Gardens and Domain Trust Act 1980; Sydney Harbour Trust Act 1900.
Vic.	Aboriginal Lands Act 1970; Archaeological and Aboriginal Relics Preservation Act 1972; Building Act 1993; Chinatown Historic Precinct Act 1984; Cultural and Recreation Lands Act 1963; Heritage Rivers Act 1992; Historic Buildings Act 1981; Historic Shipwrecks Act 1981; Land Titles Validation Act 1993; Melbourne Market and Park Lands Act 1933, Melbourne Market and Park Lands Act 1955, Melbourne Land and Market Sites Act 1991, Melbourne Market and Park Lands Act 1992; Planning and Environment Act 1987; Royal Botanic Gardens Act 1991; Victoria Park Land Act 1992; Victorian Conservation Trust Act 1972.
Qld	Aboriginal Land Rights Act 1991 and Torres Strait Islanders Act 1991; Cultural Record (Landscapes Queensland and Queensland Estates) Act 1987; Heritage Buildings Protection Act 1990; Local Government (Aboriginal Lands) Act 1978; National Trust of Queensland Act 1963; Native Title (Queensland) Act 1993; Queensland Heritage Act 1992; Queensland Museum Act 1970; Wet Tropics World Heritage Protection and Management Act 1993.
SA	Aboriginal Heritage Act 1988; Aboriginal Lands Trusts Act 1966; Botanic Gardens and State Herbarium Act 1978; Carrick Hill Trust Act 1985; Development Act 1993; Heritage Act 1993; Historic Shipwrecks Act 1981; Maralinga Tjarutja Land Rights Act 1984; Mining Act 1971; National Trust of South Australia Act 1955; Pitjantjatjara Land Rights Act 1981; Planning Act 1982; Statutes Amendments (State Heritage Conservation) Orders Act 1991; Water Resources Act 1990.
WA	Aboriginal Affairs Planning Authority Act 1972 and Aboriginal Communities Act 1979; Aboriginal Heritage Act 1972 and Aboriginal Heritage (Marandoo) Act 1992; East Perth Redevelopment Act 1991; Heritage of Western Australia Act 1990; Lands (Titles and Traditional Usage) Act 1993; Maritime Archaeology Act 1973; Metropolitan Region Town Planning Scheme Act 1959; National Trust of Australia (W.A.) Act 1964.
Tas.	Aboriginal Relics Act 1975; National Parks and Wildlife Act 1970; National Trust Australia (Tasmania) Act 1975; Port Arthur Historic Site Management Authority Act 1987.
NT	Aboriginal Land Act 1978; Cobourg Peninsula Aboriginal Land and Sanctuary Act 1981; Confirmation of Titles to Land (Request) Act 1993; Heritage Conservation Act 1991; Miscellaneous Acts Amendment (Aboriginal Community Living Areas) Act 1989; National Trust (Northern Territory) Act 1976; Nitmiluk (Katherine Gorge) National Park Act 1989; Northern Territory Aboriginal Sacred Sites Act 1989; Planning Act 1993.
ACT	Land (Planning and Environment) Act 1991 and Heritage Objects Act 1991.
Resource Allocation	
Federal	Antarctic Marine Living Resources Conservation Act 1981; Antarctic (Environment Protection) Legislation Amendment Act 1992; Continental Shelf (Living Natural Resources) Act 1968; Environment Protection (Alligator Rivers Region) and (Northern Territory Supreme Court) Acts 1978; Fisheries Act 1991; Forest Industries Research Export Charge Act 1993, Forest Industries Research Imports Charge Act 1993, Forest Industries Research Levy Charge Act 1993; Forestry and Timber Bureau Act 1930; Great Barrier Marine Park Act 1975; Koongarra Project Area Act 1981; Minerals (Submerged Lands) Act 1981; Murray-Darling Basin Act 1993; Native Title Act 1993; Natural Resources Management (Financial Assistance) Act 1992; Petroleum (Submerged Lands) Act 1967; Primary Industries and Energy Research and Development Act 1989; Resource Assessment Commission Act 1989; Torres Strait Fisheries Act 1984; Wet Tropics of Queensland World Heritage Area Conservation Act 1994.
NSW	Balranald Irrigation Act 1902; Crown Lands Act 1989; Drainage Act 1939; Environmental Planning and Assessment Act 1979; Farm Water Supplies Act 1946; Fisheries and Oyster Farms Act 1935; Fish River Water Supply and Administration Act 1985; Forestry Act 1916; Hay Irrigation Act 1902; Hunter Water Board (Corporatisation) Act 1991; Irrigation Act 1912; Mining Act 1992; Murray-Darling Basin Act 1993; New South Wales – Queensland Border Rivers Act 1947; Petroleum (On-Shore) Act 1991; Public Health Act 1902; Rivers and Foreshores Improvement Act 1948; South-West Tablelands Water Supply Administration Act 1941; Snowy Mountains Engineering Corporation Act 1972; Timber Industry (Interim Protection) Act 1992; Water Act 1912; Water Administration Act 1986, Water Supply Authorities Act 1987 and Water Board Act 1987; Wentworth Irrigation Act 1890.

13.1.1 Federal, State and Territory environmental legislation (a) ***(continued)***

Jurisdiction	*Legislation*
Resource Allocation (continued)	
Vic.	Conservation, Forests and Lands Act 1987; Environment Protection (Resource Recovery) Act 1992; Extractive Industries Act 1966; Fisheries Act 1968; Fisheries (Abalone) Act 1987; Forests Act 1958; Forests (Timber Harvesting) Act 1992; Groundwater (Border Agreement) Act 1985; Land Title Validation Act 1993; Melbourne and Metropolitan Board of Works Act 1958; Melbourne Water Corporations Act 1992; Mineral Resources Development Act 1990; Mines Act 1958; Murray-Darling Basin Act 1993; Petroleum Act 1958; Petroleum (Submerged Lands) Act 1982; Settled Land Act 1958; Soils Conservation and Land Utilization Act 1958; Victorian Plantations Corporation Act 1993; Water Act 1989; Water (Rural Water Corporation) Act 1992.
Qld	Brisbane and Area Water Board Act 1979; Canals Act 1958; City of Brisbane Water Supply Act 1959; Fisheries Act 1976; Forestry Act 1959; Harbours Act 1955; Irrigation Areas (Land Settlement) Act 1962; Metropolitan Water Supply and Sewerage Act 1909; Mineral Resources Act 1989; Mineral Resources (Adjacent Submarine Areas) Act 1965; Mines Regulation Act 1964 and Mining (Fossicking) Act 1985; New South Wales – Queensland Border Rivers Act 1947; Petroleum Act 1923; Petroleum (Submerged Lands) Act 1982; River Improvement Trust Act 1940; Sewerage and Water Supply Act 1949; Soil Conservation Act 1986; South-East Queensland Water Board Act 1979; Timber Utilisation and Marketing Act 1987; Townsville/ Thuringowa Water Supply Board Act 1987; Water Resources Act 1989.
SA	Citrus Industry Act 1991; Fisheries Act 1983; Fisheries (Gulf of St Vincent Prawn Fishing Rationalisation) and (Southern Zone Rock Fishery Rationalisation) Acts 1987; Forestry Act 1950; Groundwater (Border Agreement) Act 1985; Irrigation Act 1930; Loans for Water Conservation Act 1948; Local Government (Forestry Resources) Act 1944; Lower River Broughton Irrigation Trust Act 1938; Mines and Works Inspection Act 1920; Mining Act 1971; Murray-Darling Basin Act 1993; National Parks and Wildlife Conservation Act 1972; Native Vegetation Act 1991; Pastoral Land Management and Conservation Act 1936; Petroleum Act 1940; Petroleum (Submerged Lands) Act 1982; Renmark Irrigation Trust Act 1936; River Torrens Acquisition Act 1970; Sandalwood Act 1930; Soil Conservation and Land Care Act 1989; South Australian Timber Corporation Act 1979; South-Eastern Water Conservation and Drainage Act 1992; Water Conservation Act 1936; Water Resources Act 1990; Waterworks Act 1932; Wilderness Protection Act 1992.
WA	Agriculture Act 1988; Agricultural and Related Resource Protection Act 1976; Albany Hardwood Plantation Agreement Act 1993; Conservation and Land Management Act 1984; Country Areas Water Supply Act 1947; Fisheries Act 1905; Geraldton-Mid-West Development Authority Act 1988; Health Act 1911; Land Act 1933; Land Drainage Act 1925; Metropolitan Water Authority Act 1982; Metropolitan Water Supply, Sewerage and Drainage Act 1909; Mining Act 1978; Municipal Water Supply Preservation Act 1892; Oyster Fisheries Act 1881; Petroleum Act 1967; Petroleum (Submerged Lands) Act 1982; Rights in Water and Irrigation Act 1914; Sandalwood Act 1929; Soil and Land Conservation Act 1945; State Energy Commission Act 1979; Swan River Trust Act 1988; Water Boards Act 1904; Water Supply, Sewerage and Drainage Act 1912; Waterways Conservation Act 1976; Western Australia Water Resources Council Act 1982.
Tas.	Farm Water Development Act 1985; Fisheries Act 1959; Forestry Act 1920; Forest Practices Act 1985; Groundwater Act 1985; Hobart Regional Water Act 1984, North Esk Regional Water Act 1960, North-West Regional Water Act 1987, Rossarden Water Act 1954 *and* West Tamar Water Act 1960; Hydro-Electric Commission Act 1944; Irrigation Clauses Act 1973; Lakes Sorell and Cresent Conservation Act 1901; Mineral Resources Act 1951; Mining Act 1929; Petroleum (Submerged Lands) Act 1982; Public Lands (Administration and Forests) Act 1991; Rural Adjustment Act 1990; Salt-Water Salmonid Cultures Act 1985; Sea Fisheries Licence Act 1989; Softwood Forestry Act 1978; Water Act 1957; Water Resources Investigation Act 1937.
NT	Crown Lands Act 1992; Energy resources Consumption Levy Act 1985; Fisheries Act 1988; Lands Acquisition (Pastoral Leases) Act 1982; McArthur River Project Agreement Ratification Act 1992; Mining Act 1982; Mining (Gove Peninsula Nabalco Agreement) Act 1968; Mt Todd Project Agreement Ratification Act 1993; Petroleum Act 1984; Petroleum (Submerged Lands) Act 1982; Power and Water Authority Act 1987; Soil Conservation and Land Utilization Act 1970; Territory Parks and Wildlife Conservation Act; Uranium Mining (Environmental Control) Act 1979; Water Act 1991; Water Supplies Development Act 1961 and Water Supply and Sewerage Act 1983.
ACT	Appropriation (ACT Forests Trust Account) Act 1993; Electricity and Water Act 1988; Fishing Act 1967; Fuels Control Act 1979; Mining Act 1930; Soil Conservation Act 1960.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Development	
Federal	Antarctic Treaty (Environment Protection) Act 1980 and Antarctic (Environment Protection Legislation Amendment Act 1992; Australian Capital Territory (Planning and Land Management) Act 1988; Australian Heritage Commission Act 1975; Endangered Species Act 1992; Environment (Financial Assistance) Act 1977; Environment Proposals (Impact of Proposals) Act 1974; Great Barrier Marine Park Act 1975; Koongarra Project Area Act 1981; National Parks and Wildlife Act 1975; Native Title Act 1993; Snowy Mountains Electricity Corporation Act 1970; Urban and Regional Development (Financial Assistance) Act 1974; World Heritage Properties Conservation Act 1983.
NSW	Albury-Wodonga Development Act 1974; Blue Mountains Land Development (Special Provisions) Act 1985; Carlingford Drainage Improvement (Land Exchange) Act 1992; Centennial and Moore Park Trust Act 1983; Coastal Protection Act 1979; Community Land Development Act 1989; Crown Lands Act 1989; Darling Harbour Authority Act 1984; Endangered Fauna (Interim Protection) Act 1991; Environmental Planning and Assessment Act 1979; Lake Illawarra Authority Act 1987; Land and Environment Court Act 1979; Local Government Act 1919; Lord Howe Island Act 1953; Marine Administration Act 1989; National Parks and Wildlife Act 1974; Navigation Act 1901; Pollution Control Act 1970; Regional Development Commissions Act 1993; Rural Adjustment Scheme Agreement Act 1993; Rural Lands Protection Act 1989; Soil Conservation Act 1938; Snowy Mountains Engineering Corporation Act 1972; Snowy Mountains Hydro-Electric Agreements Act 1958; State Owned Corporations Act 1989; Sydney Cove Redevelopment Authority Act 1968; Sydney Harbour Trust Act 1900; Unhealthy Building Land Act 1990; Water Act 1912 and Water Board Act 1987; Water Administration Act 1986 *and* Water Supply Authorities Act 1987; Wilderness Act 1987.
Vic.	Albury-Wodonga Agreement Act 1973; Alpine Resorts Act 1983; Building Act 1993; Chinatown Historic Precincts Act 1984; Conservation, Forests and Land Act 1987; Crown Land (Reserves) Act 1978; Development Areas Act 1973; Economic Development Act 1981; Environment Effects Act 1978; Environment Protection Act 1970; Flora and Fauna Guarantee Act 1988; Land Title Validation Act 1993; Local Government Acts 1958 and Local Government Act 1989; Melbourne and Metropolitan Board of Works 1958; Melbourne Market and Park Lands Act 1933, Melbourne Market and Park Lands Act 1955, Melbourne Land and Market Sites Act 1991, Melbourne Market and Park Lands Act 1992; Mineral Resources Development Act 1990; National Parks Act 1975; National Parks (Alpine National Parks) Act 1989; Planning and Environment Act 1987; Ports of Geelong, Melbourne and Portland Authority Acts 1958; Renewable Energy Authority of Victoria Act 1990; Public Lands and Works Act 1964; Snowy Mountains Engineering Corporations Act 1971; South Melbourne Land Act 1986; State Owned Enterprises Act 1992; Town and Country Planning Act 1961; Urban Land Authority Act 1979; Victorian Conservation Trust Act 1972; Victorian Plantations Corporations Act 1993; Water Act 1989 and Water (Rural Water Corporation) Act 1992; Zoological Parks and Gardens Act 1967.
Qld	Aboriginal Land *and* Torres Strait Islander Acts 1991; Brigalow and Other Lands Development Act 1985; Canals Act 1958; Contaminated Land Act 1991; Harbours Act 1955; Integrated Resort Development Act 1987; Irrigation Areas (Land Settlement) Act 1962; Land Act 1962; Local Government Act 1993; Local Government (Planning and Environment) Act 1990; Marine Parks Act 1982; Mixed Use Development Act 1993; National Parks and Wildlife Conservation Act 1975; Native Title (Queensland) Act 1993; Nature Conservation Act 1992; Nerang River Entrance Development Act 1984; Port of Brisbane Authority Act 1976; Queensland Building Services Authority Act 1991; Queensland Heritage Act 1992; River Improvement Trust Act 1940; Robertson Park Trust Variation Act 1991; Rockhampton Harbour Board and the Council of the City of Rockhampton Act 1990; Sanctuary Cove Resort Act 1985; Sewerage and Water Supply Act 1949; South Bank Corporation Act 1989; State Development and Public Works Organisation Act 1971; Water Resources Act 1989; Wet Tropics World Heritage Protection and Management Act 1993.
SA	Crown Lands Act 1929; Development Act 1993; Economic Development Act 1993; Environment Protection Act 1993; Golden Grove Indenture Ratification Act 1984; Harbors Act 1936; Land Acquisition Act 1969; Local Government Act 1934; MFP Development Act 1992; National Parks and Wildlife Act 1972; Native Vegetation Act 1991; Outback Areas Community Development Trust Act 1978; Pastoral Land Management and Conservation Act 1989; Public and Environment Health Act 1987; Public Parks Act 1943; South-Eastern Water and Drainage Conservation Act 1992; Urban Land Trust Act 1981; Water Resources Act 1990; Waterworks Act 1932; West Beach Recreation Reserve Act 1987; West Lakes Development Act 1969; Wilderness Protection Act 1992.

13.1.1 Federal, State and Territory environmental legislation (a) *(continued)*

Jurisdiction	*Legislation*
Development (continued)	
WA	Aboriginal Affairs Planning Authority Act 1972; Albany Port Authority Act 1926 *and* Dampier Port Authority Act 1985; Conservation and Land Management Act 1984; East Perth Redevelopment Act 1991; Environmental Protection Act 1986; Fremantle Port Authority Act 1902 *and* Geraldton Port Authority Act 1968; Geraldton Foreshore and Marina Development Act 1990; Geraldton Mid-West Development Authority Act 1988; Great Southern Development Authority Act 1987; Land Act 1933; Land (Titles and Traditional Usage) Act 1993; Local Government Act 1960; Metropolitan Region Town Planning Scheme Act 1959; Metropolitan Water Supply Sewerage and Drainage Act 1909; Parks and Reserves Act 1895; Pilbara Development Commission Act 1992; Port Hedland Authority Act 1970; Port Kennedy Development Agreement Act 1992; Public Works Act 1902; Regional Development Commission Act 1993; Reserves Act 1984 *and* Reserves and Land Revestment Act 1991; Rottnest Island Authority Act 1987; Rural Adjustment and Financial Corporation Act 1993; South-West Development Authority Act 1984; State Planning Commission Act 1985; Town Planning and Development Act 1928; Waterways Conservation Act 1976; Western Australian Development Corporation Act 1983; Western Australian Land Authority Act 1992.
Tas.	Approvals (Deadlines) Act 1993; Crown Lands Act 1978; Environment Protection Act 1973; Lands Acquisition Act 1993; Landuse Planning and Approvals Act 1993; Local Government Act 1993; National Parks and Wildlife Act 1970; Public Land (Administration and Forests) Act 1991; Resource Management and Planning Appeal Tribunal Act 1993; Rural Adjustment Act 1990; State Policies and Projects Act 1994; Tasmanian Development Act 1983; Water Act 1957 *and* Waterworks Clauses Act 1952; Wellington Park Act 1993.
NT	Ayers Rock Resort Corporation Act 1992; Building Act 1955; Cobourg Peninsula Aboriginal Land and Sanctuary Act 1981; Conservation Commission Act 1980; Crown Lands Act 1992; Cullen Bay Marina Act 1992; Darwin Port Authority Act 1983; Environmental Assessment Act 1982; Heritage Commission Act 1991; Jabiru Town Development Act 1979; Lands Acquisition Act 1975; Local Government Act 1993; McArthur River Project Agreement Ratification Act 1992; Mining (Gove Peninsula Nabalco Agreement) Act 1968; Mt Todd Project Agreement Ratification Act 1993; Northern Territory Land Corporation Act 1986; Pastoral Land Act 1992; Petroleum Act 1984; Petroleum (Submerged Lands) Act 1982; Planning Act 1993; Territory Parks and Wildlife Conservation Act 1977; Uranium Mining (Environmental Control) Act 1979; Water Act 1992 *and* Water Supply and Sewerage Act 1983; Yulara Village Management Act 1984.
ACT	Australian Capital Territory (Planning and Land Management) Act 1988; Building Act 1972 *and* Building and Services Act 1924; Buildings (Design and Siting) Act 1964; Interim Territory Planning Act 1988; Land (Planning and Environment) Act 1991; National Land Ordinance 1989; Nature Conservation Act 1980; Protection of Lands Act 1937; Public Parks Act 1928; Recovery of Lands Act 1929.

(a) Note that the information provided in this table is drawn from a publication released in March 1994. Legislation may have changed since that time.

Source: ANZECC 1994, pp 1–106.

International Cooperation

There are many international agreements concerning the environment and conservation. These treaties and conventions have been prompted by the need for regulation arising from problems such as:

- loss of bio-diversity and rainforests;
- acid rain;
- the greenhouse effect; and
- the transboundary impact of disasters such as the nuclear accident at Chernobyl in 1987 and the 1984 chemical accident at Bhopal in India.

Tables 13.1.2 and 13.1.3 lists the international multilateral and bilateral treaties related to the environment to which Australia is a party. The relevant associated Commonwealth legislation is presented in Table 13.1.4.

International Conferences

The United Nations Conference on the Human Environment at Stockholm in 1972 was the starting point in the development and formulation of policies dealing with international cooperation on environmental issues. As a result of this conference the Stockholm Declaration and Action Plan were adopted. A major initiative arising from this conference was the establishment of the United Nations Environment Program (UNEP), which was charged with the responsibility of international environmental action.

The next major international conference was convened in Nairobi in 1982, where it was recognised that very little progress had been made on the Stockholm Action Plan. In addition, the UN General Assembly proclaimed the World Charter for Nature in 1982. These actions reaffirmed important elements in the Stockholm Declaration.

As mentioned earlier, one of the largest conferences on the environment and development was held in Rio de Janeiro from 1 to 12 June 1992. The United Nations Conference on Environment and Development (UNCED) brought together 178 governments, thousands of delegates and members of non-government organisations and journalists. Four documents were agreed by many governments at the sessions in Brazil. These were the Rio Declaration, Agenda 21 and two conventions, one on climate change and one on biodiversity. A Declaration of Forest Principles was also agreed. Although not strictly binding under international law, Agenda 21 is an action plan to implement the principles found in the Rio Declaration. This substantial document contains about 40 chapters on a wide range of issues, including:

- protection of the atmosphere by combating climate change, depletion of the ozone layer and transboundary air pollution;
- protection of the quality and supply of fresh water resources;
- protection of the oceans and coastal areas;
- protection and management of land resources by combating deforestation, desertification and drought;
- conservation of biological diversity;
- environmentally sound management of biotechnology;
- environmentally sound management of wastes, particularly hazardous wastes and toxic chemicals, as well as prevention of illegal international traffic in toxic and dangerous products and wastes;
- improvement of the living and working environment of the poor in urban slums and rural areas; and
- protection of human health conditions and improvement of the quality of life.

Subsequent to the UNCED, the United Nations created the Commission for Sustainable Development to progress various international discussions. Member countries have a responsibility to report annually on aspects of their implementation of Agenda 21. Australia presented its first report in December 1993.

The Berlin Mandate, adopted at the Conference of the Parties to the Convention on Climate Change in March 1995, provides a new process which will consider all greenhouse gases, for strengthening developed countries' commitments towards climate change after the year 2000. It set a 1997 deadline for adopting the results of this process. It will also consider setting quantified objectives for limiting and reducing emissions within specified time frames, such as the years 2005, 2010, and 2020. It does not introduce any new commitments for developing countries, although it reaffirms the existing ones and will advance their implementation.

13.1.2 International environmental multilateral treaties to which Australia is a signatory

Date and place of instrument	*Description*	*Entry into force generally*	*Notes*
25 January 1924, Paris	International Agreement for the Creation at Paris of an International Office dealing with Contagious Diseases of Animals	12 January 1925	The Agreement established the International Office of Epizootics. Acceded to by Australia 9 February 1924 under Article 6.
2 December 1946, Washington	International Convention for the Regulation of Whaling (International Whaling Convention)	10 November 1948	Established the International Whaling Commission located in the UK. Signed for Australia 2 December 1946. Instrument of ratification deposited for Australia 1 December 1947.
11 October 1947, Washington	Convention of the World Meteor–ological Organization (WMO), and Protocol concerning Spain	23 March 1950	Signed for Australia 11 October 1947. Instrument of ratification deposited for Australia 14 March 1949. Extended to Norfolk Island from 26 October 1950 and Australian Antarctic Territory from 16 June 1955.
26 February 1948, Baguio	Agreement for the Establishment of the Indo-Pacific Fisheries Council (under the auspices of FAO)	9 November 1948	Renamed the Indo-Pacific Fisheries Commission in 1976. Instrument of acceptance deposited for Australia 10 March 1949. Entry into force for Australia 10 March 1949.
6 March 1948, Geneva	Convention on the International Governmental Maritime Consultative Organization (IMCO, later IMO)	17 March 1958	Signed for Australia 6 March 1948. Instrument of acceptance deposited for Australia 13 February 1952. Title of Convention amended to "Convention on the International Maritime Organization" in 1975, with effect from 22 May 1982.
6 December 1951, Rome	International Plant Protection Convention (under the auspices of FAO)	3 April 1952	Signed for Australia 30 April 1952. Instrument of ratification deposited for Australia 27 August 1952. Entry into force for Australia 27 August 1952.
14 May 1954, The Hague	Convention for the Protection of Cultural Property in the Event of Armed Conflict (under the auspices of UNESCO)	7 August 1956	Signed for Australia 14 May 1954. Instrument of ratification deposited for Australia 19 September 1984. Entry into force for Australia 19 September 1984.
27 February 1956, Rome	Plant Protection Agreement for South– East Asia and Pacific Region (under the auspices of FAO)	2 July 1956	Signed for Australia, without reservation as to ratification, 27 February 1956. Title of Agreement was amended to "Plant Protection Agreement for the Asia and Pacific Region" by Amendments of 15 June 1979 with effect from 16 February 1983.
1 December 1959, Washington	The Antarctic Treaty	23 June 1961	Signed for Australia 1 December 1959. Instrument of ratification deposited for Australia 23 June 1961.
5 August 1963, Moscow	Treaty banning Nuclear Weapon Testing in the Atmosphere, in Outer Space and Under Water (Partial Test Ban Treaty)	10 October 1963	Original parties to and depository governments for the Treaty, were the UK, USSR and the USA. Signed for Australia 8 August 1963. Instruments of ratification and entry into force for Australia 12 November 1963.
27 January 1967, London, Moscow, Washington	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies.	10 October 1967	Signed for Australia at Washington 27 January 1967. Instruments of ratification deposited for Australia at London, Moscow and Washington 10 October 1967.

13.1.2 International environmental multilateral treaties to which Australia is a signatory *(continued)*

Date and place of instrument	*Description*	*Entry into force generally*	*Notes*
29 November 1969, Brussels	International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969 (under the auspices of IMO)	6 May 1975	Signed for Australia 17 December 1970. Instrument of ratification, with declaration on coastal protection, deposited for Australia 7 November 1983. Entry into force for Australia 5 February 1984.
17 November 1970, Paris	Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property	24 April 1972	Adopted by UNESCO General Conference on 14 November 1970. Instrument of acceptance, with reservation to Article 10 regarding the maintenance of registers by antique dealers, deposited for Australia 30 October 1989. Entry into force for Australia 30 January 1990.
2 February 1971, Ramsar (Iran)	Convention on Wetlands of International Importance especially as Waterfowl Habitat	21 December 1975	This Convention is administered by the Inter– national Union for Conservation of Nature and Natural Resources (IUCN), Gland, Switzerland. UNESCO is depository for ratifications, accession, etc. Signed for Australia without reservation as to ratification 8 May 1974.
11 February 1971, London, Moscow, Washington	Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-bed and the Ocean Floor and in the Subsoil Thereof.	18 May 1972	Signed for Australia at London, Moscow and Washington 11 February 1971. Instruments of consent deposited for Australia 23 January 1973. Entry into force for Australia 23 January 1973.
18 December 1971, Brussels	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (under the auspices of IMO)	16 October 1978	Instrument of accession deposited for Australia 10 October 1994. Entry into force for Australia 10 October 1995.
29 March 1972, London, Moscow, Washington	Convention on International Liability for Damage Caused by Space Objects	1 September 1972	Instrument of accession deposited for Australia at London, Moscow and Washington 20 January 1975. Entry into force for Australia 20 January 1975.
10 April 1972, London, Moscow, Washington	Convention on the Prohibition of the Development, Production and Stock– piling of Bacteriological (Biological) and Toxin Weapons and on their Destruction	26 March 1975	Signed for Australia at London, Moscow and Washington 10 April 1972. Instruments of ratification deposited for Australia at London, Moscow and Washington 5 October 1977. Entry into force for Australia 5 October 1977.
1 June 1972	Convention for the Conservation of Antarctic Seals	11 March 1978	Signed for Australia 5 October 1972. Instrument of ratification deposited for Australia 1 July 1987. Entry into force for Australia 31 July 1987.
23 November 1972, Paris	Convention for the Protection of the World Cultural and Natural Heritage (under the auspices of UNESCO)	17 December 1975	Adopted by UNESCO General Conference 16 November 1972 by which date it is sometimes cited. Instrument of ratification deposited for Australia 22 August 1974.
29 December 1972, London, Mexico City, Moscow, Washington	International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention)	30 August 1975	Known as London Dumping Convention until 1993. Signed for Australia, with declaration regarding Article VII(i)(c), at London, Mexico City, Moscow, and Washington 10 October 1973. Instrument of ratification deposited for Australia at London, Mexico City, Moscow and Washington 21 August 1985. Entry into force for Australia 20 September 1985.

13.1.2 International environmental multilateral treaties to which Australia is a signatory *(continued)*

Date and place of instrument	*Description*	*Entry into force generally*	*Notes*
3 March 1973, Washington	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	1 July 1975	Signed for Australia 21 September 1973. Instrument of ratification deposited for Australia 29 July 1976. Entry into force for Australia 27 October 1976.
2 November 1973, London	International Convention for the Prevention of Pollution from Ships (MARPOL 1973) and Protocols I and II)		Signed for Australia, with declaration and subject to ratification 24 December 1974. convention did not enter into force, but relating Protocol — 17 February 1978 exists.
18 November 1974, Paris	Agreement on International Energy Program, as amended 5 February 1975 (under the auspices of OECD)	18 November 1974 (provisionally) 19 January 1976 (definitively)	The Agreement established the International Energy Agency. Instrument of accession, with explanatory statement, deposited for Australia 17 May 1979, Entry into force for Australia 27 May 1979.
12 June 1976, Apia (Western Samoa)	Convention on the Conservation of Nature in the South Pacific	26 June 1990	Instrument of accession deposited for Australia 28 March 1990. Federal statement deposited for Australia 15 November 1990.
18 May 1977, Geneva	Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques (under the auspices of the UN)	5 October 1978	Adopted by UN General Assembly 10 December 1976 by which date it is sometimes cited. Signed for Australia 31 May 1978. Instrument of ratification deposited for Australia 7 September 1984. Entry into force for Australia 7 September 1984.
23 October 1978, Geneva	International Convention for the Protection of New Varieties of Plants of 2 December 1961	8 November 1981	Instrument of accession deposited for Australia 1 February 1989. Entry into force for Australia 1 March 1989.
23 June 1979, Bonn	Convention on the Conservation of Migratory Species of Wild Animals	1 November 1983	Instrument of accession, with Federal statement deposited for Australia 26 June 1991. Entry into force for Australia 1 September 1991.
10 July 1979, Honiara	South Pacific Forum Fisheries Agency Convention	9 August 1979	Accepted by signature for Australia 13 September 1979. Entry into force for Australia 13 October 1979.
18 December 1979, New York	Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (under the auspices of the UN)	11 July 1984	Adopted by the UN General Assembly 5 December 1979, by which date it is sometimes cited. Instrument of accession deposited for Australia 7 July 19186. Entry into force Australia 6 August 1986.
3 March 1980, Vienna	Convention on the Physical Protection of Nuclear Material (under the auspices of IAEA)	6 February 1987	Signed for Australia 22 February 1984. Instrument of ratification deposited for Australia 22 September 1987. Entry into force for Australia 22 October 1987.
20 May 1980, Canberra	Convention on the Conservation of Antarctic Marine Living Resources	7 April 1982	Signed for Australia 11 September 1980. Instrument of ratification deposited for Australia 6 May 1981. Australia is the depository for the Convention.
10 December 1982, Montego Bay	United Nations Convention on the Law of the Sea	16 November 1994	The Convention was adopted by the third UN Conference on the Law of the Sea. Signed for Australia 10 December 1982. Instrument of ratification for Australia 5 October 1994.
18 November 1983, Geneva	International Tropical Timber Agreement, 1983	1 April 1985 (provisionally)	The Agreement established the International Tropical Timber Organization with headquarters at Yokohama. Instrument of accession deposited for Australia 16 February 1988. Entry into force for Australia 16 February 1988.

13.1.2 International environmental multilateral treaties to which Australia is a signatory *(continued)*

Date and place of instrument	*Description*	*Entry into force generally*	*Notes*
22 March 1985, Vienna	Vienna Convention for the Protection of the Ozone Layer	22 September 1988	Instrument of accession deposited for Australia 16 September 1987.
6 August 1985, Rarotonga	South Pacific Nuclear Free Zone Treaty (SPNFZ)	11 December 1986	Also known as the Treaty of Rarotonga. Signed for Australia 6 August 1985. Instrument of ratification deposited for Australia 11 December 1986.
26 September 1986, Vienna	Convention on the Assistance in the Case of a Nuclear Accident or Radiological Emergency (under the auspices of the IAEA)	26 February 1987	Signed for Australia 26 September 1986. Instrument of ratification, with declaration pursuant to Article 8.9 that Australia would not be bound by Articles 8.2 and 8.3, deposited for Australia 22 September 1987. Entry into force for Australia 23 October 1987.
16 September 1987, Montreal	Montreal Protocol on Substances that Deplete the Ozone Layer	1 January 1989	Signed for Australia 8 June 1988. Instrument of ratification deposited for Australia 19 May 1989. Entry into force for Australia 17 August 1989, pursuant to Article 16.3
22 March 1989, Basel, Switzerland	Basel Convention on the Control of Transboundary Movements of Haz–ardous Wastes and their Disposal	5 May 1992	Instrument of accession deposited for Australia 5 February 1992.
24 November 1989, Wellington	Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific	17 May 1991	Signed for Australia at Auckland 2 February 1990. Instrument of ratification deposited for Australia 6 July 1992. Entry in force for Australia 6 July 1992.
10 September 1990, Washington	Agreement concerning the Continuation of Marine Geoscientific Research and Mineral Research Studies in the South Pacific Region (Tripartite Phase II Extended Agreement)	10 September 1990	The Agreement, concluded with New Zealand and the United States of America, was signed for Australia and entered into force on signature. Due to expire 9 September 1995.
30 November 1990, London	International Convention on Oil Pol–lution Preparedness, Response and Co-operation (under the auspices of IMO)	13 May 1995	Instrument of Accession deposited for Australia 6 July 1992.
9 May 1992, New York	United Nations Framework Convention on Climate Change	21 March 1994	Signed for Australia at Rio de Janeiro, 4 June 1992. Instrument of ratification deposited for Australia 30 December 1992.
5 June 1992, Rio de Janiero	Convention on Biological Diversity	29 December 1993	Signed for Australia 5 June 1992. Instrument of ratification deposited for Australia 8 June 1993.
9 July 1992, Honiara	Niue Treaty on Cooperation in Fish–eries Surveillance and Law Enforce–ment in the South Pacific Region.	20 May 1993	Signed for Australia 9 July 1992. Instrument of ratification deposited for Australia 3 September 1993. Entry into force for Australia 3 September 1993.
13 January 1993, Paris	Convention on the Prohibition of the Development, Production, Stock–piling and Use of Chemical Weapons and on their Destruction		Signed for Australia 13 January 1993. Instrument of ratification deposited for Australia 6 May 1994.
10 May 1993, Canberra	Convention on the Conservation of Southern Bluefin Tuna	20 May 1994	Signed for Australia, Japan and New Zealand 10 May 1993. Instrument of ratification deposited for Australia 20 May 1994. Australia is depository for Convention.
17 June 1994	United Nations Convention to Combat Desertification in those Countries experiencing Serious		Signed for Australia, subject to ratification 14 October 1994.

13.1.2 International environmental multilateral treaties to which Australia is a signatory *(continued)*

Date and place of instrument	*Description*	*Entry into force generally*	*Notes*
17 December 1994, Lisbon	Energy Charter Treaty	17 December 1994 (provisionally, for signatories accepting such application); Part VII: 17 December 1994 (provisionally for all signatories)	Signed for Australia, subject to ratification, 17 December 1994, with declaration pursuant to Article 45(2)(a) not accepting provisional application of the Treaty, and declaration concerning trade-related investment measures. The Treaty is not yet in force definitively.
16 September 1995, Port Moresby	Regional Convention on Hazardous Wastes (Waigini Convention)		Also known as Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific Region. Signed for Australia, subject to ratification, 16 September 1995. The convention is not yet in force.

Source: Department of Foreign Affairs, 1996

Sustainable Development

The World Conservation Strategy introduced the concept of 'sustainable development' at the international level. The principles of sustainable development were central to the ideas in 'Our Common Future' — the Bruntland Report, by the World Commission on Environment and Development (WCED) which was released in 1987. This report has received wide publicity in many countries, with Australian debate focusing on the meaning of ecologically sustainable development.

The Bruntland Report commented that:

"National and international law has traditionally lagged behind events. Today, legal regimes are being rapidly outdistanced by the accelerating pace and the expanding scale of impacts on the environmental base of development. Human laws must be reformulated to keep human activities in harmony with the unchanging and universal laws of nature" (p. 331).

Another report was also published in the same year, 'Environment Perspectives to the Year 2000 and Beyond', under the auspices of the UNEP Governing Council. This report furthered the international debate on the concept of ecologically sustainable development.

International and regional agreements on the environment

Environment issues occupy an important place in Australia's regional and bilateral relationships. Australia has environmental cooperation arrangements with France, Germany, the Russian Federation, the European Union, Indonesia, Japan, the United States of America, China, Korea and Singapore. Some international conventions are concerned with the protection of the environment on a global basis. Examples of this concept are the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer. International treaties and conventions relating to the environment to which Australia is a signatory are presented in Tables 13.1.2 and 13.1.3.

The South Pacific region countries have worked together to develop policies on the environment. Australia is a party to regional environmental treaties in the South Pacific. The two major treaties are:

- the South Pacific Convention for the Protection of Natural Resources and the Environment of the South Pacific Region (SPREP Convention); and
- the Convention on Conservation of Nature in the South Pacific (Apia Convention).

13.1.3 International environmental bilateral treaties to which Australia is a signatory

Date of instrument	Place of instrument	Description	Entry into force generally	Notes
China				
20/10/1986	Canberra	Agreement for the Protection of Migratory Birds and their Environment	1/9/1988	Also known as CAMBA. The Agreement entered into force when Notes were exchanged 26 December 1986 and 1 September 1988 pursuant to Article VI(I).
Indonesia				
11/12/1989	Timor Sea	Treaty on the Zone of Cooperation in an Area between the Indonesian Province of East Timor and Northern Australia (Timor Gap Treaty)	9/2/1991	The Treaty entered into force 30 days following an exchange of Notes of 10 January 1991 pursuant to Article 32.
22/4/1992	Jarkata	Agreement relating to Cooperation in Fisheries	29/5/1993	The Agreement entered into force when Notes were exchanged 24 June 1992 and 29 May 1993 pursuant to Article 13.1.
International Organisations				
8/9/1986	Hobart	Headquarters Agreement with the Commission for the Conservation of Antarctic Marine Living Resources	8/9/1986	The Agreement concerning the Commission's headquarters in Hobart, entered into force on signature pursuant to Article 26.1.
Japan				
6/2/1974	Tokyo	Agreement for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment	30/4/1981	Also known as JAMBA. The Agreement entered into force when instruments of ratification were exchanged at Canberra 30 April 1981 pursuant to Article IX.2.
17/10/1979	Canberra	Agreement on Fisheries	1/11/1979	The Agreement entered into force on the date specified in Article XII.1 (due to expire 31/10/95).
21/12/1994	Melbourne	Subsidiary Agreement (to Agreement of 27 October 1979) concerning Japanese Tuna Long-Line Fishing	21/12/1994	The Subsidiary Agreement entered into force on signature pursuant to Article IX.
Korea, Republic of				
23/11/1983	Canberra	Agreement on Fisheries, and Exchange of Letters	24/11/1983	The Agreement entered into force on the date specified in an exchange of Notes of 24 November 1983 pursuant to Article XII. The Exchange of Letters entered into force on the same date.
Papua New Guinea				
18/12/1978	Sydney	Treaty concerning Sovereignty and Maritime Boundaries in the Area between the Two Countries, including the Area known as the Torres Strait, and Related Matters	15/2/1985	Also known as the Torres Strait Treaty. The Agreement entered into force when instruments of ratification were exchanged at Port Moresby 15 February 1985, pursuant to Article 32.
Russia				
15/2/1990	Canberra	Agreement (with the Union of Soviet Socialist Republics) on Cooperation in the Field of Protection and Enhancement of the Environment	15/2/1990	The Agreement entered into force on signature pursuant to Article X.1
United States of America				
2/4/1987	Port Moresby	Exchange of Notes constituting an Agreement on Access to the Australian Fishing Zone	2/4/1987	The Agreement entered into force on the date of the Note in reply.

Source: Department of Foreign Affairs, 1996.

13.1.4 International environmental treaties and related Federal legislation (a)

International Treaty	*Federal Legislation*
Convention on the International Shelf	Continental Shelf (Living Natural Resources) Act 1968
Convention on the Territorial Sea and the Contiguous Zone; Convention on the Continental Shelf	Seas and Submerged Lands Act 1973
Agreement between The Netherlands and Australia concerning old Dutch Shipwrecks	Historic Shipwrecks Act 1976
The Antarctic Treaty	Antarctic Treaty (Environment Protection) Act 1980(b)
Convention on the Continental Shelf	Petroleum (Submerged Lands) Amendment Act 1980
Convention on the Continental Shelf	Minerals (Submerged Lands) Act 1981
Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties; Protocol relating to Intervention on the High Seas in relation to Pollution by Substances Other than Oil	Protection of the Sea (Powers of Intervention) Act 1981
Convention on the Civil Liability of Oil Pollution Damage	Protection of the Sea (Civil Liability) Act 1981
Convention on the Civil Liability of Oil Pollution Damage	Environment Protection (Sea Dumping) Act 1981
Convention on the Conservation of Antarctic Marine Living Resources	Antarctic Marine Living Resources Conservation Act 1981
Convention on International Trade in Endangered Species of Wild Flora and Fauna	Wildlife Protection (Regulation of Exports and Imports) Act 1982
Convention for the Prevention of Pollution from Ships	Protection of the Sea (Prevention of Pollution from Ships) Act 1983
Convention on the World Cultural and Natural Heritage	World Heritage Properties Conservation Act 1983
Vienna Convention for the Protection of the Ozone Layer	Ozone Protection Act 1989
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Hazardous Wastes (Regulation of Exports and Imports) Act 1989
Antarctic Treaty 1959; Protocol on Environmental Protection 1991	Antarctic Mining Prohibition Act 1991 (c)
Convention on the Conservation of Migratory Species of Wild Animals	Endangered Species Protection Act 1992

(a) Note that the information provided in this table is drawn from a 1995 publication. Legislation and treaties may have changed since that time.
(b) The 1980 adjunct gave effect to the 1960 Antartic Treaty.
(c) This was subsumed into a 1992 amendment.
Source: Bates 1995.

An example of cooperation among the countries of the Pacific region was the banning of driftnet fishing. A Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific was signed on 24 November 1989.

The countries of the South Pacific have also developed greater regional environmental awareness with the establishment of the South Pacific Regional Environmental Programme (SPREP) based in Apia, West Samoa. SPREP coordinates environmental policy for governments in the region.

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Bates, G. 1995, *Environmental Law in Australia*, 4th edition, Butterworths, Sydney.

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World Commission on Environment and Development (WCED) 1990, *Our Common Future*, Oxford University Press, Melbourne.

13.2 Environmental expenditures

Environmental expenditures reflect some of the efforts to reduce the pressure of economic activity on the environment. This section deals with those efforts where they have been valued in monetary terms. Other efforts aimed at reducing the pressure of economic activity, which have not been valued in economic terms, are presented in Section 13.3.

Table 13.2.1 presents a partial estimate of the costs incurred by Australian governments, industries and households in protecting the environment. The estimate is 'partial' because it does not yet cover expenditures from all sectors of the economy, or all expenditures aimed at environment protection within those sectors.

The estimate of $5.1 billion spent protecting the environment is composed of two types of expenditure: pollution abatement and control, and other environmental costs.

Pollution abatement and control (as defined by the OECD in 1994) includes ". . . all purposeful activities directly aimed at the prevention, reduction and elimination of nuisances arising as a residual from production processes or from the consumption of goods and services" (OECD 1994). 'Other environment protection expenditures' are also presented for the public sector and the household sector. These items represent expenditures which protect the environment in ways other than abating pollution. For example, in the case of the public sector, this category covers in part the costs relating to management of national parks.

The estimates of pollution abatement costs for industry have been compiled from ABS surveys. Estimates of pollution abatement expenditures for the public sector were obtained from ABS public sector accounts. Estimates for 'other environment expenditures' in the public sector were based on Commonwealth and State budget papers. It should also be noted that these estimates have been compiled to ensure as far as possible that double counting does not occur. This means that where industry has received grants or subsidies from government, these are counted in the government estimates, while being excluded from the industry estimates. Likewise, where fees and charges have been paid to the public sector, these have been valued in the sector where they have been paid, and not included in public sector estimates. See 'Cost of Environment Protection, Australia, 1991-92' (ABS 1995, 4603.0) for further explanations of the data, their constraints and the collection methodology.

Public sector expenditures

Table 13.2.2 presents public sector pollution abatement expenditures. The first part of the table contains outlays on activities for protection of the environment, as defined in the Government Purpose Classification (GPC). The transactions recorded by this classification represent the current and capital outlays of general government and the capital outlays and income transfers of public trading enterprises. Additional environment outlays also exist under a variety of government purpose classifications (agricultural land management, forests etc) but it is not possible to separate out the environmental component on the basis of the present classification.

Pollution abatement and control expenditures of gas and electricity authorities, included in Table 13.2.2, represent the capital and current expenditures of public sector electricity and gas utilities to abate pollution being emitted at their own locations. These expenditures are not

13.2.1 Partial estimate of Australia's environment protection costs, 1991–92

Sector	*Pollution abatement costs* $m	*Other environmental costs* $m	*Total cost of environment protection* $m
Public sector	1 766.7	1 086.0	2 852.7
Agriculture	na	na	285.4
Mining	151.7	na	151.7
Manufacturing	1 005.2	na	1 005.2
Retail /wholesale	27.2	na	27.2
Household	118.7	709.8	828.5
Total (a)	na	na	5 152.7

Note: where figures have been rounded, discrepancies may occur between totals and the sums of component items.
(a) Includes $2 million of pollution abatement and control expenditures by electricity and gas utilities in the private sector.
Source: ABS 1995 (4603.0).

13.2.2 Public Sector pollution abatement activities, Australia, 1991–92

Expenditure type	Common-wealth $m	State $m	Local $m	Total Government $m	Total public sector(a) $m
Sanitation and protection of the environment — GPC transactions (b)	**28**	**1 050**	**556**	**1 640**	**1 640.0**
Household garbage	0	0	136	136	136.0
Other sanitation	0	32	160	192	192.0
Sewerage	– 2	771	132	905	905.0
Urban stormwater drainage	0	27	114	143	143.0
Other(c)	30	220	14	264	264.0
Other identified pollution abatement and control costs	na	na	**na**	**22**	**126.7**
Gas and electricity utilities	. .	. .	. .	. .	104.7
Water management costs(d)	na	na	na	22	22.0
Total	**28**	**1050**	**558**	**1662(e)**	**1 766.7**

Note: where figures have been rounded, discrepancies may occur between totals and the sums of component items.
(a) Includes expenditures by public sector electricity and gas utilities, in addition to expenditures by all levels of government.
(b) Outlays on activities for protection of the environment, as defined in the Government Purpose Classification.
(c) Includes administration, regulation, support and operation of other specific activities.
(d) This item is not separately identifiable through the Government Purpose Classification. Data has been taken from Commonwealth and State Budget papers.
(e) Includes some transfers unable to be separately identified, hence component items do not add to total.
Source: ABS 1995 (4603.0).

included in the expenditures recorded in the first part of the table. An estimate is also included in Table 13.2.2 for water management costs. This category, compiled through separate research (of Commonwealth and State budget papers), identifies some other water quality management costs which are not separately identifiable in the GPC system. These expenditures aim at improving the quality of water in the natural environment through reduction of pollution. Such expenditures may include programmes to control Blue-green algae and eutrophication, salinity control or erosion control. Data availability problems meant that expenditures undertaken by local councils were not available. Consequently, these estimates are partial only, pending further work in this area.

Table 13.2.3 provides estimates for environment protection expenditure by government not specifically attributable to 'pollution abatement

13.2.3 Partial (a) estimates of general government other environment protection expenditures, 1991–92

Level of government	National parks, reserves & wildlife protection $m	Soil conservation and land management $m	Water resources protection & conservation $m	Conservation of fisheries resources $m	Energy conversation and / or management $m	Administration and other environment protection $m	Total $m
NSW	146	57	22	19	1	104	349
Vic.	133	6	23	4	3	44	212
Qld	111	79	0	1	0	0	192
SA	38	11	11	2	0	2	65
WA	32	34	4	3	1	1	75
Tas.	20	1	0	0	0	5	26
NT	21	4	0	1	0	8	35
ACT	2	2	0	0	0	0	5
Commonwealth	61	2	3	3	0	59	128
Total	**563**	**198**	**63**	**33**	**5**	**223**	**1 086**

Note: where figures have been rounded, discrepancies may occur between totals and the sums of component items.
(a) The statistics have been compiled from Commonwealth and State Budget papers, and as such, provide a partial preliminary estimate only of other environment expenditures undertaken by the Australian public sector.
Source: ABS 1995 (4603.0).

13.2.4 Agriculture environmental expenditures, Australia, 1991-92

Expenditure type	Expenditure $ million	Standard error (b) %
Preventing / controlling land degradation	85.5	na
Eradication or extermination of animals or insects and destruction of weed or plant growth (a)	61.1	13.0
Tree or shrub establishment or protection to control or prevent land degradation	14.2	17.0
Erection of fences to separate different land classes to prevent land degradation and or to exclude livestock or vermin from areas affected by land degradation	19.2	11.0
Sub total	180.0	na
Water storage and reticulation systems	135.2	6.0
Costs incurred to prepare farm plan	* 4.5	29.0
Expenses for self-education	1.4	19.0
Minus environmental grants and subsidies received	35.7	
Total	285.4	na

Note: where figures have been rounded, discrepancies may occur between totals and the sums of component items.

(a) The figure for eradication or extermination of animals or insects and destruction of weed or plant growth detrimental to the land is estimated for the Queensland component of the national total. Therefore, it is not possible to calculate a standard error at the national level.

(b) The standard error indicates the extent to which an estimate might have varied by chance because only a sample of agricultural establishments was included. There are about two chances in three that a sample estimate will differ by less than one standard error from the number that would have been obtained if all agricultural establishments had been included and about nineteen chances in twenty that the difference will be less than two standard errors. The relative standard error (expressed as a percentage) is obtained by expressing the standard error as a percentage of the estimate.

Source: ABS 1995 (4603.0).

13.2.5 Mining industry expenditures by type of expenditure, 1991–92

Expenditure type	Ferrous metals $m	Non-ferrous metals $m	Coal $m	Oil & gas $m	Total $m
Current expenditure					
Payments to government	0.0	0.1	0.4	0.3	0.8
Payments to non-government	0.2	12.8	3.5	1.0	17.4
Other costs	1.0	39.3	21.1	7.1	68.5
Intramural R&D	0.2	2.4	0.3	0.1	3.1
Extramural R&D	0.0	0.7	0.3	0.1	1.1
Environment impact assessment	0.5	1.3	3.5	0.8	6.1
Environmental audits	0.1	0.9	0.3	0.2	1.4
Energy audits	0.0	0.0	0.0	0.0	0.1
Total	**1.8**	**57.4**	**29.4**	**9.6**	**98.3**
Capital Expenditure					
Land rehabilitation	2.6	4.0	3.4	1.3	11.3
Water pollutants	0.2	7.1	7.8	7.6	22.8
Solid non-hazardous	0.1	1.3	0.8	0.0	2.2
Solid hazardous	0.1	3.0	0.0	0.4	3.5
Air pollutants	0.7	9.3	2.8	0.3	13.1
Noise pollutants	0.1	0.2	0.2	0.0	0.5
Total	**4.0**	**25.0**	**15.0**	**9.7**	**53.0**

Note: Where figures have been rounded, discrepancies may occur between totals and the sums of component items.
Source: ABS 1995 (4603.0).

13.2.7 Manufacturing industry expenditures for selected industries (end of line and change in production expenditures), Australia, 1991–92

	Air		*Water*		*Solid non-hazardous*		*Solid hazardous*		*Noise*		*Other (c)*		*Total end of line*		*Total estabs*
Description	*No.*	*$m*	*No.*	*$m*	*No.*	*$m*	*No.*	*$m*	*No.*	*$m*	*No.*	*$m*	*No.*	*$m*	*No.*
End of line expenditures															
Pulp, paper and paperboard	2	np	9	4.3	3	np	1	0	3	0.4	5	1.7	14	7.1	63
Basic chemicals	44	19.5	52	8.9	14	0.5	16	8.7	12	0.4	10	0.6	74	38.7	274
Other chemical products	55	1.4	79	5.5	34	0.3	19	0.9	12	0.5	21	0.3	119	8.9	617
Petroleum refining	8	15.8	9	7.5	1	0.0	2	np	3	np	5	0.8	12	25.3	22
Petroleum and coal products n.e.c.	2	np	5	0.1	2	0.0	1	np	0	0.0	2	np	7	0.7	24
Glass and glass products	2	np	1	0	0	0.0	0	0	1	np	1	np	3	np	113
Clay products and refractories	15	0.7	13	0.4	3	0.2	0	0	4	0.0	4	0.1	26	1.5	245
Cement and concrete products	72	1.9	68	2.2	21	np	1	np	19	0.3	12	np	103	4.6	618
Other non-metalic mineral products	22	0.7	14	0.7	9	0.1	0	0	10	0.1	5	0.1	32	1.7	253
Basic iron and steel	35	12.5	22	13.4	16	2.9	2	np	17	0.7	4	np	60	32.2	434
Basic non-ferrous metals	22	77.3	18	10.8	8	3.5	10	60.3	3	0.1	6	0.7	30	152.7	91
Rubber products	10	np	3	0	3	0	1	0	3	0.0	3	np	17	np	202
Plastic and related products	44	1.6	19	0.9	29	1.1	4	0	14	0.1	3	0	83	3.8	996
Total	**333**	**132.7**	**312**	**54.7**	**143**	**9**	**57**	**72.7**	**101**	**3.8**	**81**	**5**	**580**	**277.9**	**3 952**
Change in Production Expenditures															
Pulp, paper and paperboard	0	0.0	6	3.5	4	np	0	0.0	0	0.0	1	np	9	4.2	63
Basic chemicals	17	0.9	21	2.6	7	0.3	5	0.2	6	np	2	np	34	4.1	274
Other chemical products	19	0.7	43	4.4	14	0.2	4	0.2	4	0.1	10	0.1	51	5.6	617
Petroleum refining	4	3.8	5	20.2	0	0.0	0	0.0	2	np	1	np	6	24.2	22
Petroleum and coal products n.e.c.	2	0.0	1	0.0	0	0.0	0	0.0	0	0.0	1	0.0	3	0.0	24
Glass and glass products	1	np	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	np	113
Clay products and refractories	7	0.1	0	0.0	0	0.0	1	0.0	2	0.0	0	0.0	7	0.1	245
Cement and concrete products	14	1.0	12	0.4	8	0.1	1	0.0	4	0.0	3	0.0	23	1.6	618
Other non-metalic mineral products	5	np	2	0.0	3	np	0	0.0	1	0.0	2	0.0	12	0.2	253
Basic iron and steel	13	9.9	9	9.1	5	0.4	1	np	6	0.4	5	np	20	20.7	434
Basic non-ferrous metals	8	5.6	6	7.3	4	0.1	1	np	0	0.0	1	np	12	15.6	91
Rubber products	5	np	0	0.0	2	0.0	1	0.0	3	0.0	1	0.0	7	np	202
Plastic and related products	14	0.2	3	0.0	8	0.1	2	0.0	5	0.1	4	0.1	27	0.4	996
Total	**109**	**22.1**	**109**	**47.4**	**55**	**1.9**	**16**	**2.9**	**33**	**0.9**	**31**	**1.6**	**213**	**76.8**	**3 952**

Note: Where figures have been rounded, discrepancies may occur between totals and the sums of component items.
Source: ABS 1995 (4603.0).

pollutants and wastes". This expenditure could be on either remedial or preventative measures and was collected with respect to water, hazardous and non-hazardous solid wastes, air, noise and other environments. Current pollution abatement expenditure is defined as "expenditure to operate or maintain plant and equipment to abate pollution; additional energy, wage and salary costs incurred to operate abatement processes; payment for waste removal; related research and development expenditure; and outlays on either environmental impact assessments or audits."

For the manufacturing industry, additional data were collected from some industries known to have higher levels of expenditure on pollution abatement and control. Table 13.2.7 shows expenditures for these industries in terms of 'end of line' and 'change in production' expenditures. The former refers to the treatment of pollutants after they have been generated by installing distinct abatement facilities. 'Change in production' activities reduce or eliminate the production of pollution by preventing its occurrence. This can be achieved by material substitution, modified production processes or equipment alteration. These two methods are and control' activities. These statistics have been compiled from Commonwealth and State Budget papers and, as such, provide a partial estimate only of other environment protection expenditures undertaken by general government. Complete coverage would also require inclusion of local government and public sector non-budget agencies such as water boards.

Environmental expenditures in agriculture

Table 13.2.4 shows the amounts reported by farm businesses on specific measures to prevent or control land degradation in Australia in 1991-92. Because it was not possible to clearly distinguish between pollution abatement and other environmental expenditures in the agricultural sector, the approach has been to provide a single aggregate for all environmental expenditures in this sector. This was estimated at $285.4 million in 1991-92.

Environmental expenditures in the Mining industry

For 1991-92 total pollution abatement and control expenditure in the mining industry was estimated at $151.7 million. Current expenditure accounted for 65% of total pollution abatement expenditure while capital expenditure accounted for 35% (see Table 13.2.5).

Capital expenditure in the mining industry was defined as expenditure on any element of the production process specifically concerned with protecting the environment by reduction or elimination of pollutants and wastes. Current expenditure was defined as: expenditure to operate or maintain land and equipment to abate pollution; payments to operate or maintain plant and equipment to abate pollution, payments to contractors to remove and dispose of waste; costs associated with wind and water erosion; on-going mine-site rehabilitation; regular sampling tests; related research and development expenditure and outlays in either environmental impact assessments or audits.

Spending on measures to abate water pollution accounted for 43% of spending ($22.8 million). Measures to abate air pollution accounted for a further 24% ($13.1 million) of capital expenditure, while land rehabilitation represented 21% ($11.3 million).

Environment expenditures in the manufacturing industry

Table 13.2.6 presents a summary of expenditure on pollution abatement and control for the financial year 1991-92. Total expenditure was estimated at $1,006.4 million. Of the total, $484 million was capital expenditure (48%) and $522 million was current expenditure (52%). The basic metal products sub-division accounted for 35% of total pollution abatement and control expenditure ($347 million) while the chemical, petroleum and coal products sub-division accounted for 24% (238.6 million).

Capital expenditure on pollution abatement and control in the manufacturing sector is defined as "expenditure on any element of the production process specifically attributable to protecting the environment by reduction or elimination of

13.2.6 Manufacturing industry pollution abatement expenditures, Australia, 1991-92

Description	*Capital expenditure* $m	*Current expenditure* $m	*Total* $m
Food, beverages and tobacco	76.5	70.2	146.7
Textiles	3.4	10.2	13.6
Clothing and footwear	1.7	3.2	4.9
Wood, wood products and furniture	6.3	16.8	23.1
Paper products, printing and publishing	21.2	47.0	68.2
Chemical petroleum and coal products	107.4	131.2	238.6
Non-metallic mineral products	10.3	37.6	47.9
Basic metal products	222.7	124.4	347.1
Fabricated metal products	6.8	19.6	26.4
Transport equipment	10.3	12.7	23.0
Other machinery and equipment	8.7	20.5	29.2
Miscellaneous manufacturing	8.7	29.1	37.8
Total Manufacturing	**484.0**	**522.4**	**1 006.4**

Note: Where figures have been rounded, discrepancies may occur between totals and the sums of component items.
Source: ABS 1995 (4603.0).

13.2.9 Household environmental expenditures (a) Australia, 1991-92

	Estimate
Item	*$m*
Charcoal filters for vehicles	8.7
Catalytic converters for vehicles	65.5
Septic systems (a)	44.5
Environmental component of local government rates	495.0
Special environment levies (a)	92.8
Insulation (b)	122.0
Environmental expenditures by the household sector	828.5

Note: Where figures have been rounded, discrepancies may occur between totals and the sums of component items.
(a) Partial estimate only.
(b) Derived from 1988-89 HES data, CPI adjusted and adjusted for number of households in 1991-92.
Source: ABS 1995 (4603.0).

million), food, drink and tobacco wholesalers ($5.3 million) and the minerals, metals and chemical wholesalers ($4 million). In the retail sector, much lower levels of expenditure on waste removal were recorded; highest levels occurred in the specialised food retailing and the clothing and soft good retailing groups.

Environmental expenditure by households

The household sector can also contribute to environmental expenditures in the economy, through activities that aim at the prevention, reduction and elimination of pollution and nuisances, as well as environment conservation measures. Households also contribute to pollution abatement activities undertaken by the public sector, through payments of charges for activities such as sewage and garbage disposal services.

Motor vehicles are a major source of atmospheric pollutants. A catalytic converter can reduce emission of carbon monoxide by about 85% and NOx by about 60% (World Resources Institute 1993). Catalytic converters vary considerably in price due to the precious metals used as a coating. Consultation with manufacturers of converters and motor vehicles resulted in a figure of $150 being selected as an average price for these items. Multiplying this figure by the number of new passenger vehicles registered during 1991-92 (437,075) led to an estimate of $65.5 million.

Another pollution abatement device is a charcoal filter which is designed to reduce emission of fuel vapours. Industry investigations with producers and car retailers indicated an average cost of $20, representing a total expenditure of $8.7 million in 1991–92.

The cost of private sewage treatment systems is specifically identified by the OECD as a pollution abatement expenditure for the household sector. Industry investigations determined an approximate cost for such systems at $3,500. Aerobic systems are more expensive and, although becoming increasingly popular, account for only 10% of the market. An estimate for the number of systems is difficult to obtain, because jurisdiction lies, in most States, with individual councils. The environmental health departments in most States, however, have provided estimates, and an approval figure for Australia (excluding WA and Qld, for which figures were not available) of 12,700 approvals was determined. This represented $44.5 million.

Insulation is required in all new dwellings in a number of States under the Building Code of Australia. For 1991-92 this represented $122 million in costs.

An estimate for government fees and charges of $496 million received from households was obtained through ABS public finance data. In addition to these charges, a number of local governments raise funds for special environmental purposes. Several examples, including Brisbane City Council, Sydney Water Board and the Geelong Water Board, of additional funding raised through this measure totalled $92.8 million in 1991-92. However it should be noted that this is only an experimental estimate, and will fall far short of the total expenditures of this kind Australia-wide.

The estimates of environmental expenditures by households are brought together in Table 13.2.9.

References

ABS 1995, *Cost of Environment Protection, Australia, Selected Industries , 1991–92* (4603.0), AGPS, Canberra.

Organisation for Economic Co-operation and Development (OECD) 1993. *Pollution Abatement and Control Expenditure in OECD Countries.*

OECD 1994, *Group on the State of the Environment Pollution Control Expenditures 1994 Questionnaire.*

presented in terms of the environmental media to which the expenditures are targeted.

End of line techniques accounted for 78% of capital expenditure while change in production accounted for the remaining 22% for those selected industries providing this disaggregation of their capital expenditures.

End of line measures to protect the air exceeded measures to protect other environmental media with a 48% share of expenditures. The amount spent to abate solid hazardous waste pollutants accounted for a further 26% of expenditure, while measures to protect water accounted for 20%. In industry terms, the basic non-ferrous metals industry incurred the most 'end of line' expenditure to abate pollutants to the air.

In the case of change in production activities, measures intended to control water pollution accounted for 62% of expenditure. Measures applied to air pollution accounted for 29% of expenditure. The highest level of spending to abate water pollution occurred in the petroleum refining industry ($20 million) while the highest level spent on abating air pollution occurred in the basic iron and steel industry ($9.9 million).

Environmental expenditures in the Retail and Wholesale industries

In the ABS collection, major pollution abatement and control expenditures collected in respect of the wholesale and retail industries were payments to government contractors and private contractors for waste removal. Pollution abatement capital expenditure was considered negligible and not collected.

Total expenditure in these two industries on waste removal expenses was $27.2 million in 1991-92 (see Table 13.2.8). Seventy-nine per cent of waste removal expenses ($21.4m) were paid to private contractors. This ratio was similar for the retail and wholesale sectors.

Within the wholesale industry, the highest level of expenditure on waste removal occurred in machinery and equipment wholesalers ($5.7

13.2.8 Retail and Wholesale Industries pollution abatement expenditures, Australia, 1991-92

	Waste levies paid to government	*Waste levies paid to private contractors*
Description	*$m*	*$m*
Wholesale Industries		
Farm produce	0.7	0.8
Minerals, metals and chemicals	0.5	3.5
Builders supplies	* 0.4	* 2.9
Machinery and equipment	1.0	4.6
Motor vehicles	* *	0.7
Food drink and tobacco	* 1.9	3.4
Textiles, clothing and footwear	0.1	0.5
Household goods	0.2	0.5
Other wholesaling	0.3	2.2
Total wholesale	**5.3**	**19.2**
Retail Industries		
Supermarket and grocery stores	0.0	0.2
Specialised food retailing	0.0	0.2
Department stores	0.3	0.2
Clothing and soft good retailing	0.0	0.1
Furniture houseware and appliance retailing	0.1	0.4
Recreational good retailing	0.0	0.0
Other personal and household good retailing	0.0	0.0
Household equipment repair services	0.0	0.0
Motor vehicle retailing	0.0	0.1
Motor vehicle services	0.0	0.6
Total retail	**0.5**	**2.2**
Total Retail and Wholesale	**5.8**	**21.4**

Note: Where figures have been rounded, discrepancies may occur between totals and the sums of component items.
Source: ABS 1995 (4603.0).

13.3.2 Examples of action taken by government bodies to reduce the direct restructuring of natural assets by the economy

Sponsoring body	*Scheme*	*Aims and objectives*
ANZECC, Ministerial Councils on Fisheries, Forestry and Aquaculture	National Forest Policy Statement (NFPS)	To provide a basis for Departmental policies and programs for the sustainable use and management of Australia's forests.
Australian Chamber of Commerce and Industry	Environmental Management and Audit Manual	A handbook giving practical advice to small and medium sized enterprises as to how to make their companies more environmentally sound.
Australian Heritage Commission (AHC)	National Estate Grants Program (NEGP)	To foster community involvement in, and support for, projects which identify, conserve and promote places of heritage significance throughout Australia.
Australian Nature Conservation Agency (ANCA)	Save the Bush Program (STB)	To encourage, facilitate and support programs and activities associated with the protection, management and study of remnant native vegetation.
	Waterwatch Program (WW)	To provide a national focus for the involvement of community groups and local government for projects focusing on water quality monitoring.
	Conservation through reserves	To protect, conserve and manage specific areas of scientific, cultural and educational significance for the benefit of the present and future generations.
	Conservation of Australian Species and Ecological Communities Threatened with Extinction: the National Strategy	To enable Australia's species and ecological communities threatened with extinction to survive and thrive in their natural habitats, to retain their genetic diversity and potential for evolutionary development, and to prevent additional species and ecological communities from becoming threatened.
	Contract Employment Program for Aboriginals in Natural and Cultural Resource Management (CEPANCRM)	To encourage greater involvement and participation of Aboriginal and Torres Strait Islander people in nature conservation.
	Endangered Species Program (ESP)	To prevent further extinctions of Australian fauna and flora, and to restore endangered species and ecological communities to a secure status in the wild.
	Feral Pest Program	To develop and implement projects in cooperation with other Commonwealth authorities and State/Territory agencies to reduce the impact of feral animals pests on native species and/or the natural environment, particularly in areas important for the recovery of endangered species.
	Migratory Species Program	To conserve migratory species that spend time in Australia or in Australian waters, and thereby fulfil Australia's international obligations to the conservation of migratory species.
	National Wetlands Conservation and Management Program	To promote the conservation and wise use of wetlands in accordance with Australia's obligations under the Ramsar convention.
	State Co-operative Assistance Program	Cooperative conservation projects of national or international significance related to wildlife, national parks and reserves in States and Territories.
	Wildlife Protection	To ensure that all trade in wildlife is carried out in a sustainable manner which is not detrimental to the survival of the species or the ecosystem in which it occurs.
ANCA/ Greening Australia	One Billion Trees Program (OBT)	To conserve and re-establish native trees and associated vegetation in the interests of sustainable land use and biological diversity, through a focus on education, information, extension support and practical participation from all sectors in urban and rural communities.
Bureau of Resource Sciences	National Weeds Strategy	To protect agricultural productivity and the biodiversity of natural ecosystems, by management of weeds which pose a threat or potential threat to Australia's natural and agricultural ecosystems.
	Vertebrate Pest Program	To demonstrate 'best practice' pest management; and identify better pest management strategies which are based on reliable information.
Department of Arts and Administrative Services	Energy Management Plan	To reduce energy by 15% over the next 5 years, and 25% over the next 10 years in all Commonwealth occupied buildings.
	Purchasing Australia	To provide a part of a strategy which will involve the publication of a range of guidance booklets providing practical advice on how to address particular environmental problems when buying goods or services.

13.3 Other Environmental Actions

Introduction

As identified in Chapter 12, economic activity places several restructuring pressures on the environment. These comprise the generation of wastes, such as an increase in effluents to water (discussed in Section 12.1.1), emissions to air (Section 12.1.2) and solid and special waste generation (Sections 12.1.3 and 12.1.4), and changes to landscape (Section 12.2). Voluntary behaviour change by industry and the community can alter patterns of resource use, and thus reduce these pressures. Government can initiate legislation to enforce a change of behaviour (discussed in Section 13.1). Industry and other groups themselves, either through compliance with these laws or through economic incentive, can put in place control mechanisms (discussed in Section 13.2).

The aims are to:

- reduce the direct restructuring of natural assets by the economy;
- reduce waste and leakage, and increase recycling; and
- increase available information, education and research.

The former two involve more direct interaction between the economy and natural assets.

The data presented in this section represent a view of what types of 'on the ground' action are being generated by legislation and economic incentive. The difficulties associated with measuring actions are numerous. In particular, a consistent and thorough framework is not in place to measure actions at the national level. Available are only various 'snapshot' views of what industry and government bodies are doing to reduce the impact of the economy on the environment.

Data on economy-wide industry action are sparse, and usually limited to particular activities, such as recycling, or a particular industry group, such as mining. National and comprehensive data on the actions taken by all industry groups are not available at present. Because it is impossible to capture all the actions being taken by individual businesses to reduce the impact of the economy on the environment it has been necessary to identify a particular case study for each aim.

Reducing the direct restructuring of natural assets by the economy

The economy benefits directly from the use of natural assets (see Section 5.1). However, the pattern of use now appears to be threatening the resources that the economy relies on (see Section 12.2.1 and 12.2.2). Increasing population, urbanisation, agricultural production and mining are examples of factors that have placed pressure on limited resources, causing land and water degradation and loss of biodiversity.

Part of the Commonwealth Government's charter is to preserve Australia's natural heritage. Through the Australian Heritage Commission (AHC), areas of aboriginal, historic and natural value are identified, and listed for preservation on the National Estate (see Table 13.3.1). In 1995, 11,031 areas were listed on the National Estate, the greater proportion being historic sites. NSW had the largest listing, 3,287 sites in 1994–95, while ACT/Jervis Bay had 160 sites.

13.3.1 Register of National Estate

	Aboriginal		*Historic*		*Natural*		*Total*	
State/Territory	1993–94	1994–95	1993–94	1994–95	1993–94	1994–95	1993–94	1994–95
NSW	204	208	2 655	2 671	392	408	3 251	3 287
Vic.	100	101	2 108	2 166	191	200	2 399	2 467
Qld	129	144	564	632	252	255	945	1 031
SA	133	143	721	735	358	360	1 212	1 238
WA	73	74	836	846	215	223	1 124	1 143
Tas.	64	64	1 144	1 144	225	226	1 433	1 434
NT	80	86	97	102	53	52	230	240
ACT (a)	10	10	112	122	26	28	148	160
External Territories	0	0	15	15	16	16	31	31
Total	**793**	**830**	**8 252**	**8 433**	**1 728**	**1 768**	**10 773**	**11 031**

(a) Includes Jervis Bay.
Source: AHC 1995.

13.3.2 Examples of action by government bodies to reduce the direct restructuring of natural assets by the economy (Continued)

Sponsoring body	*Scheme*	*Aims and objectives*
Department of Tourism	Forest Ecotourism Program	To encourage and facilitate ecotourism in forests throughout Australia.
	National Ecotourism Program	To increase Australia's competitiveness as an ecotourism destination, enhance visitor appreciation of natural and cultural values, and contribute to the long-term conservation and management of ecotourism resources.
	Regional Tourism Development Program	To encourage sustainable tourism and economic growth in regional areas through the development of regional tourism strategic plans, infrastructure and information co-ordination within a region.
	Sites of National Tourism Significance Program	To encourage and facilitate the ecologically sustainable management and use of natural sites of national tourism significance.
Environmental Protection Agency (EPA)	Cleaner technologies and processes	To identify and implement opportunities for waste and pollution prevention, better use of resources and energy and increased productivity.
	Monitoring River Health	To investigate environmental flows, and scientifically monitor water quality.
	National Water Quality Management Strategy (NWQMS)	To develop national guidelines for water quality management including: fresh and marine waters, groundwater, sewage systems, reclaimed water, urban stormwater and water management in the rural environment.
Technical advice from Great Barrier Reef Marine Park Authority (GBRMPA) and ANCA	Ocean Rescue 2000 (OR2000)	The conservation and sustainable use of the marine environment of Australia and its Territories.
Great Barrier Reef Marine Park Authority (GBRMPA)	Twenty-Five Year Strategic Plan for the Great Barrier Reef World Heritage Area	To establish a vision for the GBRWHA and provide guidance for people involved in the area to enable them to contribute to the achievement of this vision.
Greening Australia	River Murray Corridor of Green Program (RMCOG)	To develop a network of vegetation corridors along the river Murray, helping communities extend existing vegetation corridors along the river, railway, roadsides and ridge lines, and begin the process of linking these and remnant vegetation together.
Murray-Darling Basin Commission (MDBC)	Murray-Darling Basin Initiative	To improve land management practices; maintain or improve water quality and ensure adequate supply; manage and conserve the Basin's natural environment; conserve, manage and protect the Basin's Aboriginal and historic Heritage; manage problems associated with salinity, waterlogging and land salinisation in the irrigation areas in the Basin; and construct and maintain works associated with the storage and regulation of the waters in the Murray-Darling river system.
	Murray-Darling Basin Natural Resources Management Strategy (NRMS)	To provide a framework for cooperative and coordinated Community and Government action to address the basin's natural and cultural resource management problems on a long-term, integrated basis.
	NRMS Integrated Catchment Management Program	To develop and implement district and regional scale integrated catchment plans or action plans in the Murray-Darling Basin; site specific projects in the basin to ensure resources are properly managed during development of integrated catchment management plans; and preserve cultural resource values in the Basin.
Standards Australia	Draft environmental standards — ISO 14000 — Environmental Management Systems: general guidelines ISO 14001 — Environmental Management Systems: specification with guidance for use ISO 14021 — Environmental labelling	To develop international standards for environmental management.

Source: CRES 1994; ANCA 1995; DEST 1995; NLP 1994.

13.3.2 Examples of action by government bodies to reduce the direct restructuring of natural assets by the economy *(Continued)*

Sponsoring body	*Scheme*	*Aims and objectives*
Department of Employment, Education and Training (DEET)	Landcare and Environment Action Program (LEAP)	To provide young unemployed Australians aged 15–20 years, who wish to participate in the development and implementation of conservation practices, with formal training and practical experience.
Department of Environment, Sports and Territories (DEST)	Environmental Resource Officers	To provide information, contacts and answers to environmentally related queries to assist Local Government officers, departments and associated professions.
	National Strategy for the Conservation of Biological Diversity	To protect Australia's biodiversity and maintain ecological processes and systems. The six key target areas are conservation of biodiversity across Australia, integrating biodiversity, conservation and natural resource management, managing threatening processes, improving our knowledge, involving the community, and Australia's international role.
	National Greenhouse Response Strategy	To contribute towards effective global action to limit greenhouse gas emissions and enhance greenhouse gas sinks, to improve knowledge and understanding of the enhanced greenhouse effect, and to prepare for potential impacts of climate change in Australia.
Department of Housing and Regional Development (DHRD)	Australian Urban and Regional Development Review (AURD)	To examine how urban development meets national economic, social and environmental objectives.
	Better Cities Program (BCP)	To encourage better urban planning and management by all levels of government to create: economic growth and micro-economic reform; improved social justice for the less advantaged; ecologically sustainable development; and more liveable cities.
	Local Government Development Program	To assist councils to respond to the natural priorities of micro-economic reform, urban reform, regional economic development, environmental management and social justice.
	National Housing Strategy	To expand the range and supply of affordable and appropriate housing, developing efficient, effective land and housing provision and developing urban forms that create safe, sustainable, quality environments.
	The TASQUE force	To investigate the role of Local Government in environmental management and to address how Local Government can effectively contribute to managing local environments.
Department of Industry, Science and Technology (DIST)	Best Practice environmental management program	To encourage small and medium sized enterprises to use raw materials more efficiently, reduce solid and liquid waste discharge and increase recycling.
Department of Primary Industry and Energy (DPIE)	National Landcare Program (NLP) — community component	To assist community groups and local government authorities to undertake activities for the sustainable management of land, water, vegetation resources, biological diversity and cultural heritage in their local area.
Funded directly through DPIE	National Landcare Program (NLP) — National Component	To provide catalysts and facilitate funding to review, pilot or demonstrate innovative natural resource management policies or practices of significant national interest. It will consider funding for project submissions from academic, research and non-governmental organisations, community groups and individuals.
DPIE, DEST	National Landcare Program (NLP) Commonwealth/State/Territory Component	To provide and stimulate change through partnerships that will result in improved natural resource management.
	Centre for Integrated Resource Management (CIRM)	To provide an integrated resource management aimed at sustaining the land itself as well as land use.
	Decade of Landcare Plan (DOLP)	To integrate action by government, individuals and the community to raise the long term productivity and ecologically sustainability of land resources.
	Farm Forestry Program (FFP)	To promote commercial wood production on cleared agricultural land as a resource base for industry, diversify farm incomes, and concurrently address land degradation and water quality problems.
	Rural Adjustment Scheme	To provide non-viable farmers with assistance to adopt viable farming techniques for long-term stability.

Table 13.3.2 sets out examples of policies and schemes that Government bodies have initiated, which create the vision and framework under which action can take place.

Government bodies also support grass roots schemes which, although initiated by community organisations, have benefited from the financial and educational resources provided by government. One such group is Landcare; as Figure 13.3.3 indicates, over 75% of all Landcare groups receive material Government assistance. Of the States surveyed, Queensland Landcare groups received the greatest amount of financial support, averaging, just under $15,000 each, while Western Australian Landcare groups received the least, averaging just over $ 6,000. Interestingly, only 66% of Landcare groups in Western Australia reported receiving valuable information from Government staff, while in Victoria 93% of Landcare groups reported receiving valuable information.

Data on the activities at the national level, or even by industry groups, are limited to a few specific activities, such as environmental impact assessments, and recycling of packaging.

Environmental impact assessments (EIAs) have been defined as "a detailed written assessment of the likely impact that a change in land use or a commercial or industrial operation would have on the environment" (Meagher, p. 108). Table 13.3.4 indicates the extent to which manufacturing groups were undertaking EIAs in 1991–92. The overall proportion of establishments which conducted environmental impact statements and audits was 5%. 14% of chemical, petroleum and coal product manufacturers undertook EIAs or audits: the greatest proportion of any manufacturing group (14%). Individual industries showing the highest proportion of establishments undertaking EIAs or audits included the tobacco products (40%), petroleum refining (37%) and margarine, oils and fats industries (36%). Glass and glass products, and rubber products industries contained the highest proportion of establishments which did not complete EIAs or audits, 93% and 92% respectively. These proportions are underestimated, because no assumptions have been made about those establishments that did not give an answer.

Table 13.3.4 also indicates the proportion of manufacturing groups encouraging the return of their own packaging. This reduces the industry's use of packaging, and reduces the amount going to landfill after use. Overall, 22% of manufacturing establishments encouraged the return of their packaging in 1991–92. The beverage and malt industry contained the greatest proportion of establishments which encouraged the return of their packaging (44%), while the tobacco products industry contained the greatest proportion of establishments which did not encourage the return of their own packaging (80%). .

13.3.3 Agency-community relationships, Landcare groups in selected States, 1993

	Vic.	*Qld*	*SA*	*WA*	*Tas.*
	$	*$*	*$*	*$*	*$*
Mean value of Government assistance per group	8 139	14 974	6 316	6 092	9 897
Relationship with government (a)	%	%	%	%	%
Material government assistance	80	77	84	88	82
Inadequate material Government assistance	46	42	na	72	44
Government staff in regular contact	67	79	63	na	46
Government staff respect skills and knowledge of most members	92	82	91	91	92
Government staff provided valuable information and advice	93	89	89	66	81
	No.	*No.*	*No.*	*No.*	*No.*
Groups in sample	145	72	68	110	76
Total groups in State, Jan 1994	**400**	**132**	**243**	**136**	**126**

(a) Perception of group.
Source: Curtis 1995.

13.3.4 Environmental activities by manufacturing establishments, 1991–92

	Impact assessments and audits				*Encourage return of own packaging*			
	Yes		*No*		*Yes*		*No*	
Industry group/industry	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Food, beverages and tobacco	**421**	**10**	**2 324**	**54**	**999**	**23**	**1 904**	**45**
Meat products	75	13	398	67	116	19	377	63
Milk products	57	27	116	54	72	34	109	51
Fruit and vegetable products	33	18	119	64	62	34	101	55
Margarine, oils and fats n.e.c	12	36	21	64	13	39	19	58
Flour mill and cereal food products	20	14	103	71	48	33	80	55
Bread, cakes, and biscuits	51	3	786	41	309	16	592	31
Other food products	115	15	524	69	207	27	458	60
Beverages and malt	56	14	255	65	171	44	164	42
Tobacco products	2	40	2	40	1	20	4	80
Textiles	**79**	**8**	**673**	**70**	**241**	**25**	**562**	**58**
Textile fibres, yarns, and woven fabrics	50	17	188	64	99	34	162	55
Other textile products	29	4	485	73	142	21	400	60
Clothing and footwear	**49**	**2**	**2 013**	**76**	**495**	**19**	**1 696**	**64**
Knitting mills	9	4	192	77	49	20	165	66
Clothing	33	2	1 665	76	404	18	1 405	64
Footwear	7	3	156	76	42	20	126	61
Wood, wood products and furniture	**203**	**3**	**5 268**	**79**	**957**	**14**	**4 539**	**68**
Wood and wood products	147	4	2 657	78	491	14	2 335	69
Furniture and mattresses	56	2	2 611	79	466	14	2 204	67
Paper products, printing and publishing	**198**	**4**	**4 080**	**82**	**1 504**	**30**	**2 889**	**58**
Paper and paper products	42	13	232	73	125	39	140	44
Printing and allied industries	156	3	3 848	82	1 379	29	2 749	59
Chemical, petroleum and coal products	**170**	**14**	**1 019**	**82**	**471**	**38**	**592**	**48**
Basic chemicals	56	16	287	80	155	43	153	43
Other chemical products	100	12	686	83	295	36	407	49
Petroleum refining	11	37	18	60	13	43	12	40
Petroleum and coal products	3	9	28	88	8	25	20	63
Non-metallic mineral products	**105**	**6**	**1 587**	**89**	**489**	**27**	**949**	**53**
Glass and glass products	5	2	199	93	63	29	123	57
Clay products and refractories	32	8	331	87	158	41	168	44
Cement and concrete products	51	6	724	88	172	21	450	55
Other non-metallic mineral products	17	5	333	91	96	26	208	57
Basic metal products	**79**	**9**	**757**	**84**	**205**	**23**	**549**	**61**
Basic iron and steel	35	6	552	90	117	19	393	64
Basic non-ferrous metals	22	19	91	78	36	31	60	52
Non-ferrous metal basic products	22	13	114	65	52	30	96	55
Fabricated metal products	**279**	**4**	**5 295**	**80**	**1 367**	**21**	**4 321**	**65**
Structural metal products	68	3	1 957	80	412	17	1 638	67
Sheet metal products	71	6	1 007	78	319	25	803	63
Other fabricated metal products	140	5	2 331	81	636	22	1 880	66
Transport equipment	**107**	**5**	**1 645**	**77**	**462**	**22**	**1 287**	**61**
Motor vehicles and parts	75	6	1 000	75	289	22	794	60
Other transport equipment	32	4	645	81	173	22	493	62
Other machinery and equipment	**258**	**4**	**4 321**	**73**	**1 227**	**21**	**3 462**	**58**
Photographic, professional and scientific	34	3	424	40	172	16	289	28
Appliances and electrical equipment	114	6	1 445	79	456	25	1 144	63
Industrial machinery and equipment	110	4	2 452	79	599	19	2 029	66
Miscellaneous manufacturing	**125**	**3**	**3 343**	**86**	**972**	**25**	**2 293**	**59**
Leather and leather products	17	7	181	77	36	15	145	61
Rubber products	6	2	235	92	70	27	132	52
Plastic and related products	52	4	1 257	91	470	34	679	49
Other manufacturing	50	2	1 670	83	396	20	1 337	67
Total manufacturing	**2 073**	**5**	**32 325**	**77**	**9 389**	**22**	**25 043**	**60**

Source: ABS 1995 (4603.0).

Case study — an automotive group

This group supplies automotive seating components and systems in Australia. Moving to best practice meant that the company had to find a way to decrease waste, improve working conditions, reduce the environmental impact of the factory output and reduce costs. An environmental review in 1992 provided the company with a strategy of installing a water re-treatment plant, providing for recycling of industrial components, water based lubricants, and error detection systems to reduce waste. Tables 13.3.5 and 13.3.6 indicate the costs and savings associated with this installation, showing that cleaner production techniques have basically paid for themselves only 18 months after implementation.

Reducing waste and leakage, and increasing recycling

The use and consumption of resources by the economy also creates wastes (see Section 12.1). In an effort to reduce waste and leakage, industry and government bodies have taken a two pronged approach; to more efficiently use resources, and to increase the recycling of waste once it has been generated.

13.3.5 Costs of cleaner production, automotive group case study

System	*$*
Seat slide pre-treatment system	235 000
Oil/water separation system	3 000
Waste bins	1 000
Error and waste detection system	70 000
Total	**309 000**

Source: National Cleaner Production Database 1996.

13.3.6 Annual savings from cleaner production, automotive group case study

Expense	*$*
Dumping costs	4 000
Electricity	35 000
Water based lubricants	14 000
Error detection systems	35 000
Waste bin usage	6 000
Recycling	20 000
Continuous improvement team savings	114 000
Total annual savings	**270 000**

Source: National Cleaner Production Database 1996.

The scale of recycling and waste reduction activities at an economy-wide level is fairly hard to measure. Although the availability of data covering household recycling rates is increasing (see Section 10.1), the extent of data on industries and government bodies across the economy is variable.

Manufacturing and wholesaling industries play a part in the reduction of waste, through various recycling schemes. Table 13.3.4 indicates the proportion of manufacturing establishments within each industry group which indicated that they actively encouraged the return of their packaging. Table 13.3.7 looks at the packaging flow through wholesale industries.

Wholesale industries containing the greatest proportion of establishments reusing any packaging that is sent to them include tobacco products (100%) and toys and sporting goods (74%). In some industries in the motor vehicle wholesaler group, no establishments re-use packaging.

Apart from recycling of packaging initially received, wholesale industries can also encourage the return of their own packaging. Table 13.3.7 indicates that those industries which may reuse a large proportion of packaging received may not necessarily encourage the return of their own packaging. In 1991–92 100% of tobacco products establishments reused packaging received, yet only 50% permitted the return of their own packaging. 74% of toy and sporting goods wholesalers reused packaging received, while only 27% permitted the return of their own packaging. The reason for this may be that the packaging in those industries is more difficult to re-use than, for example, packaging of chemical wholesalers, where 58% of establishments permitted the return of their own packaging. Those wholesale industry groups which contained the least proportion of establishments permitting the return of packaging included motor vehicle wholesalers (0–6%), books and magazines (13%), and meat (13%).

Mining industries create both noise and water pollution, and a relatively small amount of land clearance (see Section 12.2.1). However the mining sector, in a bid to lessen the impact of extraction of minerals on the surrounding environment, has established numerous control techniques and rehabilitation programs. Table 13.3.8 indicates the proportion of establishments within the mining sector undertaking selected pollution abatement and control techniques at end June 1994. The coal industry, for example, uses a relatively large amount of land in open-cut mines, and so creates a large amount of dust. It is

13.3.7 Return and re-use of packaging in wholesale industries in Australia, 1991–92

	Re-use packaging received		Permit return of packaging	
Description	No.	%	No.	%
Farm produce	**720**	**39.6**	**604**	**33.2**
Wool	93	34.4	66	24.4
Cereal grains	33	34.7	20	21.1
Farm produce and supplies	594	40.8	518	35.6
Minerals, metals and chemicals	**597**	**39.2**	**594**	**39.0**
Petroleum products	156	26.2	191	32.1
Metals and minerals	151	34.6	119	27.3
Chemicals	290	59.1	283	57.6
Builders supplies	**1 379**	**35.2**	**820**	**20.9**
Timber	156	34.2	69	15.1
Building supplies	1 223	35.3	751	21.7
Machinery and equipment	**5 154**	**62.9**	**2 295**	**28.0**
Farm and construction machinery	518	38.1	286	21.1
Professional equipment	570	71.1	232	28.9
Computers	798	63.5	432	34.4
Business machines	344	60.8	146	25.8
Elec and electronic equipment	1 188	65.3	487	26.8
Machinery and equipment n.e.c	1 736	72.7	712	29.8
Motor vehicles	**497**	**12.2**	**161**	**3.9**
Cars	0	0.0	0	0.0
Commercial vehicles	0	0.0	0	0.0
Motor vehicles new parts	497	20.0	161	6.5
Motor vehicles dismantling/ used parts	0	0.0	0	0.0
Food, drink and tobacco wholesaling	**1 534**	**44.0**	**1 172**	**33.6**
Meat	98	26.8	49	13.4
Poultry and small goods	113	43.8	79	30.6
Dairy produce	127	41.6	139	45.6
Fish	135	39.4	128	37.3
Fruit and vegetables	238	37.7	233	36.9
Confectionary and soft drinks	172	55.3	119	38.3
Liquor	83	51.9	51	31.9
Tobacco products	10	100.0	5	50.0
Groceries n.e.c	558	50.7	369	33.6
Textiles, clothing and footwear	**1 072**	**56.7**	**428**	**22.6**
Textile products	449	58.8	177	23.2
Clothing	567	57.2	204	20.6
Footwear	55	40.1	47	34.3
Household goods	**675**	**53.9**	**320**	**25.6**
Household appliances	158	62.9	72	28.7
Furniture	178	40.9	96	22.1
Floor coverings	65	47.8	22	16.2
Household goods n.e.c	274	63.7	129	30.0
Other wholesaling	**2 347**	**61.8**	**1 001**	**26.3**
Photographic equipment	49	45.4	17	15.7
Jewellery and watches	222	48.1	116	25.1
Toys and sporting goods	431	73.5	157	26.8
Books and magazines	243	61.8	52	13.2
Paper products	356	61.3	143	24.6
Pharmaceutical and toiletries	230	60.2	113	29.6
Wholesalers n.e.c	816	63.3	402	31.2
Wholesale trade total	**13 977**	**46.6**	**7 393**	**24.7**

Source: ABS 1995 (4603.0).

13.3.8 Establishments using pollution abatement and control techniques by industry, 30 June 1994

Techniques	*Coal* %	*Oil & gas* %	*Metal ore* %	*Other mining* %	*Services to mining* %	*Total mining* %
Control of dust and other substances emitted into the air						
Protective activity	73	18	58	47	26	46
Ventilation	56	18	68	28	26	40
Application of water	98	27	92	92	48	77
Application of chemicals	41	9	22	20	6	19
Cleaning of exhaust gases	40	36	44	16	14	25
Other	9	0	6	4	2	4
No method used	0	0	1	0	3	1
No dust/substances emitted into the air	1	55	3	6	35	15
Control of noise levels for employees and/or the environment						
Silencers	83	64	74	64	47	64
Protective equipment	95	82	94	90	59	85
Erection of noise barriers	48	27	54	48	17	38
Modification of buildings	41	27	24	35	9	25
Limitations on hours of operations	30	0	19	52	20	30
Other	10	18	5	4	3	5
No method used	0	0	1	1	1	1
No method required	4	18	2	2	25	10
Treatment of waste water						
Mechanical treatment technology	70	73	62	52	25	49
Biological treatment technology	38	36	22	4	5	14
Advanced treatment technology	12	18	12	2	2	6
Other	15	9	14	8	4	9
No method used	4	0	5	3	2	3
No waste water produced	14	18	19	36	66	38
Treatment of hazardous wastes						
Physical treatment	19	0	26	3	4	11
Chemical treatment	6	18	16	2	3	6
Thermal treatment	5	36	5	0	1	3
Biological treatment	1	0	2	0	1	1
Conditioning of radioactive wastes	0	0	2	0	1	1
Other	7	18	15	3	6	8
No method used	4	0	4	1	4	3
No hazardous waste produced	68	45	47	93	84	75

Note: Data for rehabilitation is available
Source : ABS 1996 (8413.0).

13.3.9 Examples of actions by Government Bodies to reduce waste flow and increase recycling

Sponsoring body	*Scheme*	*Aims and objectives*
Department of Administrative Services (DAS)	Creating an eco-office	To provide a framework for establishing an office waste minimisation and recycling system.
Department of Environment Sports and Territories (DEST)	Greenhouse Gas Inventory	To establish a methodology for estimating emission of greenhouse gases from sources and removals by sinks.
Environment Protection Agency (EPA)	High Grade Waste Paper program	To improve the collection of paper used for printing and writing and increase the market demand for recycled paper.
	National Waste Minimisation and Recycling Strategy	To encourage the ecologically sustainable non-wasteful use of resources; to reduce potential hazards to human health and the environment posed by pollution and wastes; and to maintain or improve environmental quality.
	National Hazardous Waste Management Guidelines	
EPA, ANZECC	National Pollutant Inventory	To provide an information system for Australia, including an annual report of major pollutants and wastes released to the environment.
	National Kerbside Recycling Scheme	
	National Land Based Marine Pollution Strategy	

Source: CRES 1994; ANCA 1995; DEST 1995; NLP 1994.

the coal industry which contains the greatest proportion of establishments which use application of water (98%), protective activity (73%), and application of chemicals (41%) to control dust and other substances emitted to air, and protective equipment (95%) to control noise levels. The metal ore industry largely concentrates on underground mining, and so contains the highest proportion of establishments using ventilation (68%), and cleaning of exhaust gases (44%), to control dust and other substances.

Data on initiatives by Government to encourage recycling and waste reduction are confined here to a presentation of various schemes and policies that the Federal Government has in place — see Table 13.3.9.

13.3.10 Clean up Australia Day

	Volunteers	*Cities & Towns*	*Clean up sites*	*Rubbish removed*
	'000	*No.*	*No.*	*tonnes*
1994	500	700	6 500	20 000
1995	500	750	7 000	10 000

Source: Clean Up Australia 1995.

Case study — Clean Up Australia Day

The objectives of this scheme are to:

- help rid Australia's waterways, parklands and roadsides of unsightly and potentially damaging pollutants;
- help raise community awareness of the need for positive and practical action to save Australia's environment;
- assist in the education of the community at large about sound environmental practices — for example, reducing consumption, reusing and recycling materials;
- create a community-driven activity in which Australians can participate; and
- demonstrate to the rest of the world that Australia as a nation is prepared to take positive action and do something to assist the preservation of the environment.

The scheme itself is a non-profit organisation using the efforts of around 500,000 volunteers in Australia each year "to carry out positive community activities to protect and improve the natural environment" (see Table 13.3.10) (Clean Up Australia 1995, p. 2).

Clean Up Australia also sponsors several ongoing projects throughout the year. One of these projects of particular use in providing a 'snap shot' look at Australia's waste problems is the

13.3.11 Resources devoted to Research and Development, 1992–93

	Government		*Non-government*		*Total*	
	$m	*Person years*	*$m*	*Person years*	*$m*	*Person years*
Defence	201.3	2 104	137.7	429	339.0	2 533
Economic development	1 005.7	10 853	2 911.2	29 920	3 916.9	40 773
Society	165.7	2 587	588.2	11 701	753.8	14 288
Advancement of knowledge	90.0	816	745.4	14 124	835.4	14 940
Environment						
Environmental knowledge	140.0	1 393	98.0	1 919	237.9	3 312
Environmental aspects of economic development	115.5	1 136	56.7	880	172.2	2 016
Environmental management and other aspects	25.6	299	27.9	376	53.6	675
Total environment	281.1	2 829	182.6	3 174	463.7	6 003
Total	**1 743.8**	**19 188**	**4 565.1**	**59 350**	**6 308.8**	**78 538**

Source: ABS 1995 (8112.0).

annual Rubbish Report, giving a breakdown of the composition of the rubbish collected each year. The Report is distributed to schools across Australia as an educational source.

Increasing education, research and development

Any attempt to change society's behaviour, and hence the economy's pressure on the environment, must include research and development, and education, so that Government and industry groups know what the problems are, and are well informed on how to solve them.

Table 13.3.11 indicates the resources that were channelled into research and development in 1993–94, by socio-economic objective. It is interesting to note that expenditure and human input into environmental research and development were greater than those spent on defence. Government expenditure on environmental research and development was greater than expenditure from non-government sources (which include business enterprises, higher education establishments and private non-profit organisations). This differs from the outcomes for all socio-economic objectives other than defence.

Government action to increase research and development has been initiated in various ways. They include the establishment and continuous funding of various projects in scientific organisations, such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Environmental Protection Agency (EPA), and also encouragement of industry to conduct research and development, such as through the industry Innovation Program administered under the Department of Industry, Science and Technology (DIST). Table 13.3.12 lists a broad range of schemes sponsored by the Government at various levels to encourage research, development and education about the impact of the economy on the environment.

13.3.12 Examples of action taken by government bodies to increase education, information, research and development

Sponsoring body	Scheme	Aim/ Objective
Australian Government Analytical Laboratories (AGAL)		To provide a comprehensive range of chemical and microbiological services , including determination of pesticide, organic residue, metal and other contaminants in soil, water, effluent and agricultural produce.
Australian Heritage Commission (AHC)	National Wilderness Inventory	To measure wilderness quality values across a region and store them in a database.
	Wild Rivers (formerly Near-Pristine Rivers)	To complete a national inventory of wild rivers; consult with important stockholders and provide public information on wild rivers and develop guidelines for protection of wild river values.
Australian Nature Conservation Agency (ANCA)	Australian Biological Resources Study (ABRS)	To document what plants and animals exist in Australia and where they occur.
	Australian Biological Resources Study Participatory Program	To provide support for research aimed at determining what plants and animals are found in Australia and their distribution.
	Marine and Estuarine Protected Areas Inventory	To provide a database of all Australian established marine parks and reserves.
	Grasslands Ecology Unit	To collect information that will assist the National Landcare Program in developing and assessing projects related to the conservation and sustainable management of native grassland ecosystems.
	National Water Watch Program	To improve community awareness through supporting and facilitating the development of community-based water quality monitoring programs.
	Research and Surveys Program (RSP)	To gather and maintain scientific, socio-economic and cultural information required to enable the Australian Nature Conservation Agency to meet its obligations under the various Acts.
Bureau of Resource Sciences	Natural Resource Information Centre (NRIC)	To underpin policy development and implementation and resource management through provision and analysis of databases.
Commonwealth Scientific and Industry Research Organisation (CSIRO)	Coastal Zone Program	To examine land and water quality, sediments, estuarine mixing models, Coastal and Marine Resources Information Systems.
	Coastal Zone Research Program	To understand the processes by which land use and changes affect the coastal zone and to use this understanding to produce appropriate management tools, including an information base for management.
	Division of Wildlife and Ecology	Collaborative research between other governmental and non-governmental organisations.
	Dryland Farming Systems for Catchment Care	To develop effective total catchment management that should lead to dryland farming systems that are sustainable in the long-term.
Cooperative Research Centre for Soil and Land Management (CRC)		To support urban, industrial and agricultural land managers by providing a world-class resource of technology and learning in contemporary and emerging issues in soil and land management.
Department of Administrative Services (DAS)	Australian Surveying and Land Information Group (AUSLIG)	To support Australia's economic and social development through the provision of geographic information, surveying and land information management services.
Department of Environment, Sports and Territories DEST), Land and Water Resource Research and Development Corporation (LWRRDC)	Environmental Flow Requirements of Australia's Waterways (EFR)	To enhance scientific understanding of the water flows necessary to maintain ecological processes in a variety of ecosystems, and to facilitate the use of that information in policy decision making.
DEST	Council Net	To facilitate better delivery by local governments on a range of national environmental strategies, and to enhance communication and information exchange.
Department of Health	HealthWiz	

13.3.12 Examples of action taken by government bodies to increase education, information, research and development (Continued)

Sponsoring Body	Scheme	Aim
Department of Industry, Science and Technology (DIST)	Industry Research and Development Board's Environmental Technology Committee	To fund collaborative research and development projects which have the potential to improve the Australian environment and the competitiveness of Australian manufacturing through the adoption of environmentally sensitive systems.
	Industry Innovation Program	To increase research, development projects and commercialisation of products, process and systems, so that Australian firms can improve their performance and win new markets.
Department of Primary Industry and Energy (DPIE)	Energy Research and Development Corporation	
	National Cleaner Production Database	
	National Environment Industries Database	To provide a network of information on Australia's environment management capability, acting as a link between those with environmental problems and those with the solutions to them.
Environmental Protection Agency (EPA)	Environmental Resources Information Network (ERIN)	To provide geographically related environmental information required for planning and decision making.
	Local Government Environment Information Exchange	
	Monitoring River Health Initiative (MRHI)	To provide funding for integrated biological, physical and chemical water quality monitoring by State agencies at key sites in major urban and rural catchments, and research and development projects in support of the State programs.
	National State of the Environment Reporting System	To describe the Australian environment; monitor and report on change in environmental quality over time; identify the agents responsible for change; monitor and report on the effectiveness of policies and programs responding to change; and report on implications of any identified trends.
EPA-ANZECC, DPIE-AWRC	National Water Quality Guidelines (part of the National Water Quality Strategy)	To identify environmental values, criteria and guidelines for: domestic water supplies, ecosystems protection (inland and marine), waters for recreation and aesthetics, agricultural water supplies, industrial water supplies.
Great Barrier Reef Marine Park Authority (GBRMPA)	State of the Marine Environment Report	To provide information about conservation and management of the marine environment.
	Research and monitoring	To initiate and fund research that will assist in the conservation and management of the Great Barrier Reef.
Land and Water Resources Research and Development Corporation (LWRRDC)		To improve the long-term productive capacity, sustainable use, management and conservation of Australia's land, water and vegetation resources through a directed, integrated and focused research and development effort.
Murray-Darling Basin Commission	NRMS Investigations and Education Program	To assist organisations such as State agencies, CSIRO, universities and private bodies to carry out knowledge-based activities such as applied research, investigations, monitoring and community education.
	NRMS Investigations and Education Program	
Rural Industries Research and Development Corporation		To help agricultural industries enhance their sustained economic contribution to the national economy by organising and funding research and development which will facilitate their growth.
Urban Water Research Association of Australia		To foster and promote a comprehensive , coordinated and cost-effective approach to urban water research within Australia, for both metropolitan and non-metropolitan areas.

Source: CRES 1994; ANCA 1995; DEST 1995.

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Abbreviations

AAP	Australian Associated Press
ABARE	Australian Bureau of Agricultural and Resource Economics
ABRS	Australian Biological Resources Study
ABS	Australian Bureau of Statistics
ACF	Australian Conservation Foundation
ACIUCN	Australian Committee for IUCN
ACT	Australian Capital Territory
ACTEW	ACT Electricity and Water
ACTU	Australian Council of Trade Unions
ADIs	Acceptable Daily Intakes
AEC	Australian Environment Council
AFS	Agricultural Finance Survey
AGA	Australian Gas Association
AGAL	Australian Government Analytical Laboratories
AGPS	Australian Government Publishing Service
AGS	Australian Geographic Society
AGSO	Australian Geological Survey Organisation
AHC	Australian Heritage Commission
AHR	Airway Hyperresponsiveness
AIP	Australian Institute of Petroleum
AMA	Australian Medical Association
AMIC	Australian Mining Industry Council now MCA
ANA	Australian National Accounts
ANCA	Australian Nature Conservation Agency
ANCOLD	Australian National Committee on Large Dams
ANOP	Australian National Opinion Polls
ANZEC	Australian and New Zealand Environment Council
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZSIC	Australia and New Zealand Standard Industry Classification
Apia	Convention on the conservation of Nature in the South Pacific, signed in Apia, Western Samoa (see p. 377)
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASEAN	Association South East Asian Nations
ASGC	Australian Standard Geographic Classification
ASIC	Australian Standard Industry Classification (See ANZSIC)
ATC	Australian Tourist Commission
ATSIC	Aboriginal and Torres Strait Islander Commission
AURD	Australian Urban and Regional Development Review
AUSLIG	Australian Surveying and Land Information Group
Aust.	Australia
AWRC	Australian Water Resources Council
BaU	Business-as-Usual
BCC	Brisbane City Council
BCP	Better Cities Program
BDL	Below Detectable Limits
BHC	Benzene-hexachloride
BHP	Broken Hill Pty Ltd
BP	British Petroleum
BRS	Bureau of Resource Sciences
BTR	Bureau of Tourism Research
C'wealth	Commonwealth
C/SCC	Commonwealth/State Consultative Committee
CALMR	Convention on the Conservation of Antarctic Marine Resources
CAMBA	China–Australia Migratory Bird Agreement
CBCS	Commonwealth Buireau of Census and Statistics (Now ABS)
CD	Collection District
CDK	Climatic Droplet Keratopathy
CEPA	Commonwealth Environmental Protection Agency (Now EPA)
CEPANCRM	Contract Employment Program for Aboriginals in Natural and Cultural Resource Management
CFCs	Chlorofluorocarbons
CIRM	Centre for Integrated Resource Management
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CMM	Cutaneous Malignant Melanoma
CPI	Consumer Price Index
CRAs	Comprehensive Regional Assessment
CRC	Co-operative Research Centre
CRES	Centre for Resource and Environmental Studies
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAS	Department of Administrative Services
DASETT	Department of the Arts, Sport, the Environment, Tourism and Territories
DEET	Commonwealth Department of Employment Education and Training
DELM	Department of Environment and Land Management
DENR SA	Department of Environment and Natural Resources South Australia
DEST	Department of Environment, Sport and Territories
DFAT	Department of Foreign Affairs and Trade
DHRD	Department of Housing and Regional Development
DIST	Department of Industry, Science and Technology now Department of Industry, Science and Tourism
DIST	Department of Industry Science and Tourism
DITC	Department of Industry Technology and Commerce
DLPE NT	Department of Lands Planning and Environment Northern Territory

DLWC, NSW	Department of Land and Water Conservation (NSW)
DOLP	Decade of Landcare Plan
DOWR	Department of Water Resources
DPI	Department of Primary Industries (Qld)
DPIE	Department of Primary Industries and Energy
EC	Electrical Conductivity
EC	European Community
EDO	Environmental Defenders Office
EDR	Economic Demonstrated Resource
EEZ	Exclusive Economic Zone
EFR	Environment Flow Requirements
EIAs	Environmental Impact Assessments
ELZ	Extensive Landuse Zone
EPA	Environment(al) Protection Agency/Authority. Title varies in different juristictions
ERIN	Environmental Resources Information Network
ERP	Estimated Resident Population
ESD	Ecologically Sustainable Development
ESDWG	Ecologically Sustainable Development Working Group
ESP	Endangered Species Program
EVAO	Estimated Value of Agricultural Output
EWS	Engineering and Water Supply (South Australia)
FAO	Food and Agriculture Organisation of the United Nations
FFP	Farm Forestry Program
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
GDB	Geographic Database (ABS data from 1981 Census of Population and Housing)
GDP	Gross Domestic Product
GDP(I)	Gross Domestic Product (Income)
GDP(P)	Gross Domestic Product (Production)
GPC	Government Purpose Classification
GPs	General Practitioners
GWP	Global Warming Potential
HCFCs	HydrocholorofluoroCarbons
HES	Household Expenditure Survey
HTI	High Temperature Incinerators
HWC	Hunter Water Corporation
IAEA	International Atomic Energy Agency
IBRA	Interim Biographic Regionalisation for Australia
IC	Industry Commission
IDNDR	International Decade for Natural Disaster Reduction
IGAE	Inter-Governmental Agreement on the Environment
ILAP	Integrated Local Area Planning Program
ILZ	Intensive Landuse Zone
IMCO	International Maritime Consultatitive Organisation
IMO	International Maritime Organisation
incl.	Including
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature (World Conservation Union)
IWC	International Whaling Commission
JAMBA	Japan-Australia Migratory Birds Agreement
KNP	Kosciusko National Park
LAC	Limits of acceptable change
LEAP	Landcare and Environment Action Program
LOSC	Law of the Sea Convention
LWRRDC	Land and Water Resources Research and Development Corporation
MCA	Minerals Council of Australia
MDBC	Murray-Darling Basin Commission
MDBMC	Murray-Darling Basin Ministerial Council
MENSA	Multiple Energy Systems of Australia
MPAs	Marine Protected Areas
MRHI	Monitoring River Health Initiative
MRL	Maximum Residue Limit
MSS	Multispectral scanner
MW	Melbourne Water
NATO	North Atlantic Treaty Organisation
NATSI	National Aboriginal and Torres Strait Islander
NBT	Nature Based Tourism
NEGP	National Estate Grants Program
NFPS	National Forest Policy Statement
NGGI	National Greenhouse Gas Inventory
NHMRC	National Health and Medical Research Council
NLP	National Landcare Program
NMSC	Non-melanocytic Skin Cancer
NPI	National Pollutant Inventory
NRIC	National Resource Information Centre
NRMS	National Resources Management Strategy
NRS	National Reserves System
NSW	New South Wales
NSW GFA	New South Wales Game Fishing Association
NSWPWS	New South Wales Parks and Wildlife Service
NT	Northern Territory
NWMRS	National Waste Minimisation and Recycling Strategy
NWQMS	National Water Quality Management Strategy
OBT	One Billion Trees Program
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
OR2000	Ocean Rescue 2000
ORF	Other Refinery Feedstocks
PACC	Pesticides and Agricultural Chemicals Committee
PAWA	Power and Water Authority (Northern Territory)
PCBs	Polychlorinated Biphenyls
PEP	Population – Environment Process
PFCE	Private Final Consumption Expenditure
Pop.	Population

PPP	Purchasing Power Parity
PWS	Parks and Wildlife Service
QDPI	Queensland Department of Primary Industries
QFMA	Queensland Fish Management Authority
Qld	Queensland
R&D	Research and Development
RAC	Resource Assessment Commission
RAMSAR	Convention on wetlands of International Importance, signed in Ramsar, Iran (see p. 376)
RCD	Rabbit Calicivirus Disease
REEP	Regional Environmental Employment Program
Rep	Republic
RFAs	Regional Forest Agreements
RMCOG	River Murray Corridor of Green Program
RSP	Research and Surveys Program
SA	South Australia
SCA	Standing Committee on Agriculture
SCARM	Standing Committee on Agriculture and Resource Management
SD	Statistical Division
SE	South-east
SECWA	State Energy Commission of Western Australia
SLAs	Statistical Local Areas
SNA	System of National Accounts
SNA(93)	1993 System of National Accounts
SO	Southern Oscillation
SoE 1996	1996 State of the Environment Report
SPM	Suspended Particulate Matter
SPNFZ	South Pacific Nuclear Free Zone
SPREP	South Pacific Regional Environment Programme
SSCERA	Senate Standing Committee on Environment, Recreation and the Arts
SSDs	Statistical Sub-divisions
STB	Save the Bush Program
STI	Shell Thickness Index
STW	Sewage Treatment Works
SW	Sydney Water
SW	South-west
TAC	Total Allowable Catch
Tas.	Tasmania
TBT	Tributyltin
TC	Tropical Cyclone
TEFs	Toxicity Equivalence Factors
TN	Total Nitrogen
TP	Total Phosphorus
TSP	Total Suspended Particulates
TV	Television
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Conference on the Law of the Sea
UNEP	United Nations Environment Program
UNESCO	United Nations Education, Scientific and Cultural Organisation
USA	United States of America
USSR	Union of Soviet Socialist Republics
UV	Ultraviolet
UVR	Ultraviolet Radiation
VFRI	Victoria Fisheries Research Institute
Vic.	Victoria
VOCs	Volatile Organic Compounds
WA	Western Australia
WAWA	Water Authority of Western Australia
WCED	World Commission on Environment and Development
WHA	World Heritage Area
WHO	World Health Organisation
WW	Waterwatch Program

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Produced by the Australian Government