# Biodiversity


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# Contents

# Acronyms and abbreviations

## Acronyms

| | |
|---|---|
| **AAS** | Australian Academy of Science |
| **AAT** | Australian Antarctic Territory (Commonwealth) |
| **ABRS** | Australian Biological Resources Study (Commonwealth) |
| **ABS** | Australian Bureau of Statistics (Commonwealth) |
| **ACF** | Australian Conservation Foundation |
| **ACT** | Australian Capital Territory |
| **AEI** | Australian Ethical Investments |
| **AGO** | Australian Greenhouse Office |
| **AHC** | Australian Heritage Commission |
| **AIMS** | Australian Institute of Marine Science |
| **ALGA** | Australian Local Government Association (Local Government) |
| **AMC** | Australian Minerals Council |
| **AMJ** | Australian Marine Jurisdiction |
| **ANZECC** | Australian and New Zealand Environment and Conservation Council |
| **ARC** | Australian Research Council |
| **ARCCD** | Australian Rivers and Catchment Condition Database |
| **ARMCANZ** | Agricultural and Resource Management Council of Australia and New Zealand (Commonwealth/State/International) |
| **AVHRR** | Advanced Very High Resolution Radiometer |
| **BAP** | Bycatch Action Plan |
| **BDAC** | Biological Diversity Advisory Committee (Commonwealth) |
| **BFC** | Bushfires Council (Northern Territory) |
| **BFMP** | Bushfire Fuel Management Plan |
| **BRD** | Bycatch Reduction Devices |
| **CALM** | Department of Conservation and Land Management (Western Australia) |
| **CAMBA** | China–Australian Migratory Birds Agreement |
| **CAP** | Community Assistance Program |
| **CAR** | Comprehensiveness, Adequacy and Representativeness |
| **CBD** | Convention on Biological Diversity (International) |
| **CBN** | Community Biodiversity Network |
| **CRC** | Cooperative Research Centre |
| **CITES** | Convention on the International Trade in Endangered Species of Wild Fauna and Flora, 1973, Washington (International) |
| **COAG** | Council of Australian Governments |
| **CSIRO** | Commonwealth Scientific and Industrial Research Organisation (Commonwealth) |
| **CYPLUS** | Cape York Peninsula Land Use Study (Commonwealth/State) |
| **DNRE** | Department of Natural Resources and Environment (Victoria) |
| **DPIWE** | Department of Primary Industries, Water and Environment (Tasmania) |
| **DRC** | Democratic Republic of the Congo |
| **EEZ** | Exclusive Economic Zone (Marine) |
| **ELZ** | Extensive Land-use Zone |
| **EMS** | Environmental Management System |
| **ENSO** | El Niño–Southern Oscillation |
| **EPA** | Environment Protection Agency (Queensland) |
| **EPBC Act** | Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) |
| **ERA** | Energy Resources Australia |
| **ERO** | Environment Resources Officer |
| **ESA** | Ecological Society of Australia |
| **ESD** | Ecologically Sustainable Development |
| **ESP** | Endangered Species Program |
| **FAA** | Fire Affected Areas |
| **FHS** | Fire Hot Spots |

| | |
|---|---|
| **FSC** | Forest Stewardship Council |
| **GIS** | Geographic Information System |
| **GM** | Genetically Modified |
| **GMAC** | Genetic Manipulation Advisory Committee |
| **GMO** | Genetically Modified Organism |
| **GNP** | Gross National Product |
| **IBC** | Institutional Biosafety Committee |
| **IBRA** | Interim Biogeographic Regionalisation for Australia |
| **ILZ** | Intensive Land-use Zone |
| **IMCRA** | Interim Marine and Coastal Regionalisation for Australia |
| **IMG** | Interim Management Guidelines |
| **IPA** | Indigenous Protected Areas |
| **IPAP** | Indigenous Protected Areas Program |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **ISP** | Independent Scientific Panel |
| **ITTO** | International Tropical Timber Agreement |
| **IUCN** | International Union for the Conservation of Nature |
| **JAMBA** | Japan–Australian Migratory Birds Agreement |
| **LCC** | Land Conservation Council |
| **LEAF** | Local Environmental Assistance Fund |
| **LWRRDC** | Land and Water Resources Research and Development Corporation |
| **MCFFA** | Ministerial Council on Forestry, Fisheries and Aquaculture |
| **NBP** | National Bycatch Policy |
| **NEAP** | Nature and Ecotourism Accreditation Program |
| **NEGCP** | Nature Ecotour Guide Certification Program |
| **NGO** | Non-government Organisation |
| **NHT** | Natural Heritage Trust (Commonwealth) |
| **NLWRA** | National Land and Water Resources Audit (Commonwealth) |
| **NLGBS** | National Local Government Biodiversity Strategy (Local Government) |
| **NOAA** | National Oceanic and Atmospheric Administration (USA) |
| **NPFB** | National Policy on Fisheries Bycatch |
| **NPI** | National Pollutant Inventory |
| **NPWS** | National Parks and Wildlife Service (New South Wales) |
| **NQCC** | North Queensland Conservation Council |
| **NRSP** | National Reserve System Program |
| **NSCABD** | National Strategy for the Conservation of Australia's Biological Diversity |
| **NVCA** | Native Vegetation Conservation Act 1997 (NSW) |
| **NVIS** | Native Vegetation Information System (Commonwealth/State) |
| **OBP** | Ord Bonapart Program (north-west Australia) |
| **PWC** | Parks and Wildlife Commission (of the Northern Territory) |
| **QPWS** | Queensland Parks and Wildlife Service |
| **RCD** | Rabbit calicivirus disease |
| **RFA** | Regional Forest Agreement |
| **ROTAP** | Rare or Threatened Australian Plants (database) |
| **RVMP** | Regional Vegetation Management Plans |
| **SoE** | State of the Environment |
| **SPP** | State Planning Policy |
| **SRI** | Socially Responsible Investment |
| **TAP** | Threat Abatement Plan |
| **TED** | Turtle Excluder Device |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **WBCSD** | World Business Council for Sustainable Development |
| **WONS** | Weeds of National Significance |
| **WTO** | World Trade Organization |
| **WWF** | World Wildlife Fund for Nature |

## Abbreviations

| | |
|---|---|
| µg | micrograms ($10^{-6}$ grams) |
| µm | micrometres ($10^{-6}$ metres) |
| m | metre |
| kg | kilogram |
| mm | millimetres |
| t | tonne |

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# Executive summary

## Introduction

Biodiversity or *the diversity of life* is essential for the continued existence of humanity. The wellbeing of humans is intimately linked to the wellbeing of the environment. Today, unfortunately, there are innumerable examples worldwide where biodiversity depletion and loss have led to environmental, social and economic collapse. A vital challenge for all Australians in the 21st century is to put human development on a sustainable trajectory and to avoid further biodiversity loss.

The 1996 Australian State of the Environment (SoE) Report (SoE 1996) identified several areas where tangible progress had been made to enhance conservation since Australia had signed the United Nations Convention on Biodiversity (CBD) in 1992. However, the Report also outlined many areas of concern including threats (e.g. land clearance) to biodiversity that required both immediate and strategic attention by governments and society to avoid further loss.

## Environmental indicators

The indicators used in the 2001 Report fall into three main categories: those that measure *pressures* on biodiversity, those that measure the *state* of biodiversity, and a third group that measures the *response* of a broad range of groups in society to both the pressures on, and status of, biodiversity. Importantly, this Report also addresses the *implications* of the trends in the different indicators for biodiversity conservation.

## Structure of the report

The 2001 report on biodiversity focuses on the national level. It comprises eight sections, a glossary and considerable supporting material. Key topics covered in the sections include: meanings, significance and implications; status and trends; indicators; issues and challenges; knowledge, roles and responsibilities; and safeguarding Australia's biodiversity heritage. The status of biodiversity is considered using quantitative and qualitative data to report on the 65 indicators. These indicators are covered systematically using six themes: disturbance regimes and biodiversity; exotic species and genetically modified organisms; protecting biodiversity; increase in the knowledge of biodiversity; roles and responsibilities; and the international dimension.

## Disturbance regimes and biodiversity

The clearance of native vegetation remains the single most significant threat to terrestrial biodiversity. Only four other countries exceed the rate of clearance of native vegetation in Australia. Since European settlement, most native vegetation has been removed or significantly modified by human activity. The rate of land clearance has accelerated over time, with as much cleared during the last 50 years as in the 150 years before 1945. During 1999, it is estimated that Australian governments granted permits for clearing a total area in excess of one million hectares of vegetation. The State governments of Queensland and New South Wales, alone, granted permits to clear 713 515 ha of vegetation. This pattern continued in 2000 when, for example, clearing permits for the first six months were granted for a total of 431 781 ha, of which 166 194 ha is old growth vegetation. Over 400 000 ha of native vegetation is estimated to have been cleared in 1999 and well over 500 000 ha was cleared in 2000.

Land clearance destroys biodiversity. The clearance of native vegetation results in the loss and depletion of plant species and destroys the habitat for thousands of other species. For example, it is estimated that 1000 to 2000 birds permanently lose their habitat for every 100 ha of woodland that is cleared, while the clearing of mallee for wheat farming kills, on average, more than 85% of the resident reptiles and more than 200 individual reptiles per hectare. As a legacy of this broad-scale clearance, in the next 50 years it is predicted that up to two million hectares of remnant native vegetation will be at risk from dryland salinity. Broad-scale land clearance can fundamentally change the functioning of ecosystems, including regional climate,

and in the medium to long term can undermine agricultural production and regional economies.

The pressures on biodiversity in old growth forests were identified as a major issue in the 1996 national State of the Environment Report (SoE 1996). Since 1996, regional forest agreements (RFAs) have been completed in a number of states and new guidelines for conservation reservation and intensive management of production forests have been put in place. Even so, community concerns about native forest biodiversity remain. The RFAs do not provide a comprehensive coverage of all native forest types. Within some target regions many biologically significant ecosystems and species have not been adequately protected and the efficacy of many forest management prescriptions remain to be determined.

Until recently, the focus on biodiversity conservation has been in the Intensive Land-use Zone in southern and eastern Australia where broad-scale clearing has been concentrated. There is now a growing appreciation among government and the community of the potentially significant effects of altered fire, grazing and hydrological regimes, pests and weeds and mining on biodiversity in the Extensive Land-use Zone in central, western and northern Australia. The pastoral industry covers about 70% of the continent, and grazing in arid and semi-arid regions is considered partly responsible for the extinction of many plant species and continues to threaten around one-quarter of the plant species listed as endangered.

Altered fire regimes were not listed as one of the key threatening process for biodiversity in the SoE (1996). Today, however, there is much greater awareness of the links between fire regimes (season, frequency, intensity and type) and the conservation of biodiversity. In particular, there is greater appreciation of the magnitude and importance of fires in northern Australia. The use of satellite monitoring in this region is building up a picture of changes in fire patterns over time which are being used to help inform management activities.

Threats affecting Australia's coral reefs include the effects of sediments, agricultural chemicals and nutrients, the effects of fishing and tourism, the threats of oil spills, and negative changes in habitats as a result of enhanced climate variability and climate change. Specific threats include elevated nutrients in the inner Great Barrier Reef and outbreaks of the Crown-of-thorns Starfish (*Acanthaster planci*). Tourism values of Australia's reefs are of growing importance and tourism must be actively managed to avoid the likelihood of habitat degradation and biodiversity loss.

The status of most marine species is a major concern, but limited data preclude a reliable evaluation of the true status of these resources at this time. A significant trend is that some marine species, like whales and seals, which were hunted in Australian waters until fairly recently, continue to show signs of recovery. However, the use of marine resources remains high and few fisheries have comprehensive management plans. For example, only 60 of the 144 managed marine and estuarine fisheries in Australia have management plans, and very few of these plans have indicators for monitoring non-target species.

A recent Commonwealth government report on Commonwealth fisheries demonstrates that fishing conducted by longline and dropline has increased in intensity during the1990s, while the level of bycatch for some significant fisheries is very high. The Northern Prawn Fishery, Southern Bluefin Fishery and South East Trawl Fishery have high levels of bycatch that result in a significant, detrimental effect on marine biodiversity. Bycatch figures of 95, 83 and 50 to 86% are reported for these fisheries, respectively. Some 30 000 to 60 000 t of marine life might be discarded to land around 10 000 t of northern prawns. This 'discard' may involve over 500 species including turtles, snakes, sawfish, sharks and seabirds. The effect of fisheries such as the Bass Strait Central Scallop fishery on the biodiversity of sea-bottom communities is also likely to be high, but cannot be quantified at this time. The effects of harvesting on marine invertebrates are also unable to be quantified, but are likely to be significant.

The continued degradation of freshwater aquatic ecosystems is also of major concern. Declines of several species of frog, aquatic tortoise and lizard continue and are primarily the result of continuing declines in wetlands, riverine systems and water quality.

Climate change remains a key issue confronting Australia. The response of the Australian government to the Kyoto Protocol has significantly changed the way climate change is viewed and the amount of resources directed to this issue. In terms of the climate change policy of the present Commonwealth government, emphasis has been placed on the mitigation of greenhouse gases emissions through processes such as the Greenhouse Challenge, with the direct and indirect effects of climate change on biodiversity receiving much less attention. This situation must change if the potential impacts of climate change on terrestrial (e.g. alpine

and arid zone) and marine (e.g. Great Barrier Reef) biodiversity are to be adequately researched, better understood and managed. The important role of native vegetation in carbon sequestration and the mitigation of climate change is well known. Despite this, some Australian jurisdictions continue to permit high rates of land clearance.

Several new initiatives since 1996 have helped to increase the representativeness of Australia's system of conservation reserves. These include the National Reserve System Program and related state and territory programs, the RFAs, the Indigenous Protected Area scheme, new multitenure management schemes, and the enormous growth in contributions from the non-government sector (e.g. the Victorian Trust for Nature and the Australian Bush Heritage Fund).

Even so, many anomalies exist. For example, some regions have relatively high levels of reservation (e.g. South-East Tasmania; Australian Alps; Cape York Peninsula), while other regions that have been subject to extensive modification and species loss have relatively low levels of reservation (e.g. where agriculture dominates in southern continental Australia and relatively productive regions of the Australian rangelands). The RFAs rarely tackled conservation and management needs outside of the public forest estate. Hence, many biologically significant forest ecosystems, including old growth forests, remain poorly conserved and are considered under threat.

Some recent initiatives, which fall into two groups, advance capacities for bioregional planning: those directly concerned with biodiversity; and a much larger array of other 'regional' arrangements which may or may not integrate biodiversity issues. Difficulties remain in matching existing, and often very useful, jurisdictional and planning boundaries with regionalisations such as the Interim Biogeographic Regionalisation for Australia (IBRA). Data matching is a particular issue, with many relevant data sets as yet unavailable at the scale of IBRA or the Interim Marine and Coastal Regionalisation for Australia (IMCRA). The efficacy of implementation of recent bioregional planning mechanisms will need to be closely monitored.

## Exotic species and genetically modified organisms

Exotic organisms were identified as a major threat to biodiversity in SoE (1996), and remain so. 'Sleeper' weeds (species that have established, but are yet to become a widespread problem) are now recognised to be of major concern, as are exotic organisms that might find their way through Australia's quarantine barriers as a result of trade, tourism and other human activities. Since 1996, a National Weeds Strategy has been released, 20 weeds of national significance identified and another 28 species listed that pose a potential threat to biodiversity. Threat abatement plans have also been developed for the fox, rabbit, cat and goat. At the national level, two Cooperative Research Centres (CRCs) fund most of the research into the ecology and management of exotic plants and animals that threaten biodiversity. Considering the magnitude of the issue, however, considerably more funding could be allocated to these areas. The effects of genetically modified organisms (GMOs) on biodiversity could also be significant. Comprehensive investigation of the potential effects of GMOs in Australia is a priority.

## Protecting biodiversity

Biodiversity encompasses the variety of life at the gene, species and ecosystem levels. Consequently, protection of biodiversity must consider all of these elements. Management strategies, for example, should aim to conserve species across a broad range of climatic regions and to conserve all races, variants and subspecies. This will ensure that any genotypes fixed because of local adaptation will be conserved and available to counter future climatic changes. Overall, the recommendations on genetic indicators by Brown et al. (1997) and Saunders et al. (1998) may generate some useful statistics for monitoring species but most current genetic studies of Australian species do not provide sufficient information for the relevant variables to be calculated.

The ABRS provided the most recent summary of our knowledge of species diversity in Australia (summarised in Table 46). The estimated total number of Australian flora (plants and fungi) species is 290 000. The estimated total number of Australian fauna species is 200 000, about 192 000 invertebrate species and 8 000 vertebrate species. For many groups,

particularly the invertebrates, it is estimated that more than 50% of species remain to be described.

The Australian continent is recognised as a centre of endemism of global significance (Major 1988). Because of its size, age and geological and evolutionary isolation, over 80% of mammal, reptile, flowering plant, fungi, mollusc and insect species in Australia are endemic (Table 46).

It appears that the number of nationally endangered and vulnerable species has increased in several groups over the last seven years (Table 50). In some instances, the numbers of species in these categories may change over time because there have been changes in the abundance or distribution of species. But in many cases, the changes are due to taxonomic revisions resulting in either the creation or loss of new species. There are 1451 species and 27 ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in February 2001, as either endangered or vulnerable at the national level. The categories 'critically endangered', 'conservation dependant' and 'extinct in the wild' have been added to the previous categories of endangered, vulnerable and extinct for threatened species and 'critically endangered' and 'vulnerable' have been added to the previous category of endangered for ecological communities.

As of May 2000, there were 37 adopted Recovery Plans in place under the EPBC Act (Table 51) covering 44 species, 18 of which are plants. This means that around 3% of nationally listed species and communities have recovery plans. In early 2001, another 100 recovery plans, covering in excess of 130 species were being considered for adoption by the Threatened Species Scientific Committee. State and territory governments also prepare recovery plans under their legislation, but documenting these plans was beyond the scope of this report. There are many more plans in preparation, many without any funding support from the ESP.

Bioprospecting (the chemical prospecting for pharmaceuticals in natural organisms) is a growing industry in Australia, with potential in both terrestrial and aquatic environments. If managed appropriately, bioprospecting has the potential to have minimal impact. The ability to capture new biotechnological benefits will rely on maintaining biodiversity in its natural environment because the exploitation of metabolites usually depends on observing the interactions between organisms where they normally live.

The 'ecosystem services' (indirect utilitarian values) provided by biodiversity have received increasing attention but the economic value of these services is often difficult to calculate. One estimate in 1997 valued terrestrial Australian ecosystems at US$245 billion per year and US$640 billion per year for marine ecosystems (Jones & Pittock 1997). While these figures are relatively coarse, they emphasise the major contribution that biodiversity makes to healthy and functioning landscapes.

## Increase in the knowledge of biodiversity

The diversity of life found in Australia is highly significant by world standards and contributes enormously to the Australian economy and way of life. Many plants and animals are found only in Australia and this is something the country is renowned for. Our understanding of the diversity of vascular plants, mammals and birds is reasonably good, but when it comes to groups such as the invertebrates, fungi and bacteria the situation is very different. There is a mismatch between effort and the amount of outstanding work needed to describe the hundreds of thousands of unnamed species in Australia and its territories. Fungi in particular are underresourced, relative to other taxa, when the total numbers of undescribed taxa are taken into account. Fungi are important in ecosystem services and biogeochemical cycles, making them just as important as vascular plants from a utilitarian perspective.

Whereas only a small proportion of the species in Australia has been described and named, it is still possible to identify areas of biological significance such as those with high species diversity or levels of endemism. The ability to report on genetic diversity, however, is extremely restricted and we are just starting to appreciate the role of biodiversity in the provision of ecosystem services and important products that support the economy.

The conservation status of many components of terrestrial biodiversity remains disturbing. For example, some 8% of Australia's higher plants, 14% of birds, 23% of marsupials, 8% of reptiles, 18% of amphibians and 9% of freshwater fish are extinct, endangered or vulnerable at the national level. Australia's record of mammal species extinctions is the worst of any country. In the 1800s and 1900s, Australia has lost ten species

of the original marsupial fauna of 144 species and eight of the 53 species of native rodents. Serious concern also exists for the conservation status of many invertebrate groups and non-vascular plants as a result of the alarming extent of habitat destruction and modification that has occurred since 1996. The condition of many ecosystems remains uncertain and of concern as a result of the lack of biological surveys and inadequate reservation.

Australia's territorial waters cover a large geographical area extending from the shores and wetlands along the coastline to the abyssal deeps, and from the coral reefs of Torres Strait in the north to the pack ice of Antarctica in the south. As a result of the diversity of marine environments, Australia's fish fauna is one of the richest in the world. While understanding of marine biodiversity has improved during the 1990s, knowledge of most ecosystems and their dynamics remains inadequate for proper understanding and management.

Australia has the largest area of coral reefs of any nation and the largest coral reef complex, the Great Barrier Reef. Major areas of coral reefs are also present in Torres Strait, the Coral Sea Territories, and central and northern Western Australia. Shallow water habitats around emerged reefs have received the most research attention in Australia. There is a major gap in scientific knowledge of deep reef habitats, inter-reef habitats and submerged reef habitats, while the nature of biotic communities of the continental slope, which drops from a depth of 150 to 4000 m and is at least two million square kilometres in area, is largely unknown to science.

## Roles and responsibilities

Perceptions of the role of all sections of Australian society in biodiversity conservation have developed since 1996. Today, there is much greater awareness of the important role of local governments in managing biodiversity, whereas previously the focus had been largely on state and Commonwealth governments. There is also now a much greater emphasis on the potential role that philanthropists, industry and the broader community can make to conservation.

As the attitudes of the Australian public to environmental issues change, so do those of industry. Several corporations and industry sectors have begun to adopt ethical and environmental codes of practice that can support biodiversity conservation. This is a positive change to that reported in 1996. For example, Visy Industries was recognised recently as Australia's most environmentally conscious corporation. Overall, however, 'corporate Australia' is yet to fully recognise and fulfil its environmental obligations.

Studies of the urban environment and biodiversity in urban settings are important if these components of biodiversity are to be sustained. Improved understanding of urban biodiversity can help improve the quality of life of many citizens and also provide a basis to enhance community education about biodiversity and its management. Because most Australians live in urban environments, increasing the awareness of biodiversity and the role of individuals in conserving it is essential.

Some important reforms supporting biodiversity conservation have been adopted in the agricultural sector. Farmers comprise the bulk of the membership of many community groups such as Landcare. Some parts of the sector now routinely incorporate nature conservation objectives into their resource and landscape management strategies, and commercial programs. Even so, much more can be done by the agricultural sector to improve its contribution to biodiversity conservation. Many cases exist where industries have failed to respond of their own accord to pressures on biodiversity and have only acted in response to government legislation and enforcement.

Today, the involvement of Indigenous peoples in land management has a much higher profile, with repeated calls for Indigenous issues to be fully integrated into policy and program management. This is essential to the future of biodiversity in Australia because by 1996 about 15% of the country was managed by Aboriginal and Torres Strait Islander people and this area continues to expand. Furthermore, the extensive body of Indigenous ecological knowledge that could be used to improve understanding of biodiversity and its management is yet to be adequately harnessed. Exchange of this knowledge and learning would be assisted by a more comprehensive and interactive involvement of Indigenous people in land management.

Most of the remaining land in Australia is either freehold or leasehold, managed for commercial use. It is encouraging, therefore, that increased attention is being paid to the integration of biodiversity conservation with production objectives across landscapes. This goes together with greater recognition of the vital contribution that areas outside of the formal reserve system make to biodiversity conservation. The significance of ecosystem services to

humans and the 'value' of biodiversity is also now more widely appreciated. This is reflected in the increasing use of native species for commercial purposes (e.g. bioprospecting and the bush food industry) and recent discussions on the potential role of biodiversity credits and other mechanisms aimed at incorporating environmental values into market decisions.

Many community groups regularly monitor the environment and undertake field activities to either protect or restore biodiversity. The Landcare movement and related groups have become a key mechanism for integrating conservation of biodiversity into agricultural and pastoral production. A challenge for Landcare and many similar developments is to put their activities on a stronger scientific footing to maximise the longer-term biodiversity benefits that might arise from their hard work.

There has been an increased emphasis on the need for active management of landscapes and aquatic and marine ecosystems, and that this be done at the regional level if effective natural resource management is to be achieved. This rationale has led to the development of numerous regional processes and plans. Nonetheless, there has been only limited success in achieving active and integrated management at the regional level whereby different people, groups and the full range of land tenures are involved.

The Natural Heritage Trust has provided a major focus for funding of environmental management and biodiversity conservation measures by the Commonwealth government since 1996. The EPBC Act came into operation in 2000 and covers a range of key areas of biodiversity conservation including Australia's obligations under the Convention for the Protection of World Cultural and Natural Heritage. A major concern expressed about the Act has been the absence of land clearance as a trigger for invoking Commonwealth action. In early 2001, however, land clearing was listed as a key threatening process. It is premature to comment on the effectiveness of the Act, with various amendments made or proposed.

In 2000, concurrent with the preparation of this Report, the Commonwealth government reviewed the implementation of the National Strategy for the Conservation of Australia's Biodiversity (NSCABD). The review identified some signs of significant progress as well as many areas where pressures on biodiversity continue and responses remain inadequate.

## The international dimension

At the international level, biodiversity conservation policy and legislation have become more complex since 1996. Australia is active in many international forums including the United Nations Convention on Biodiversity (CBD). Australia is well regarded for its support of sustainable natural resource management in partner countries, although overseas development aid funding for biodiversity-related projects has fallen.

Two international instruments can be expected to assume greater significance for biodiversity conservation. The United Nations Framework Convention on Climate Change (UNFCCC) is likely to be a significant international instrument since the effects of climate change on Australia's biodiversity are likely to be highly significant, and strategies for carbon sequestration have major significance for land management and thus for biodiversity conservation. The World Trade Organization (WTO) and related processes governing international trade are becoming more important to environment and biodiversity management.

Australia traditionally has been one of the most active participants in the Antarctic Treaty System. Australia's domestic policy and scientific research presence continue to exceed that of most other nations. Australia has been active internationally in the promotion and development of the Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol), which provides for comprehensive protection of the Antarctic environment. Australia is pursuing with other Treaty Parties further measures such as rules relating to liability for environmental damage, and the entry into force of Annex V which provides for area protection and management.

## Conclusions

The destruction of habitat by human activities remains the major cause of biodiversity loss. Land management issues such as the clearance of native vegetation, control of exotic weeds and pests, provision of environmental flows in rivers, geographical expansion of dryland salinity, changed fire regimes and intensification of resource use in sectors such as forestry,

fisheries and agriculture are well known and widely reported. Many attempts to address these issues have been inadequate or have stalled. This situation must change if the future of Australia's biodiversity is to be safeguarded. Failure to reverse these trends will not only guarantee further loss of biodiversity, but also will diminish the quality of life enjoyed by Australians and ultimately undermine the Australian economy.

Governments are fundamental and critical to biodiversity conservation in Australia. However, policies relating to biodiversity conservation have not been commonly matched by effective policy implementation and good biodiversity outcomes. During the 1990s, Australia's biodiversity has experienced continued degradation and decline. Clearly, the sustainable management of Australia's resource base will not be possible unless many more financial and human resources are directed to support improved understanding and management of the nation's terrestrial and marine ecosystems. The recently released *Coordinating Catchment Management* report, from the bipartisan House of Representatives Standing Committee on Environment and Heritage, recommended that a National Environment Levy be put in place for the next 25 years to help fund programs to address this need. Additional mechanisms may be required to ensure that the funding is adequate, and comprehensive in its coverage of ecosystems and biota.

# Introduction

The diversity of living organisms we observe today is the product of billions of years of evolution. This biodiversity is, however, now threatened by humanity. Global trends show that human activities are destroying and degrading a diverse range of ecosystems and result in the extinction of thousands of species annually. Wilson (1992), among other leading commentators, calls this a great spasm of extinction—caused entirely by humans.

Australia has a diverse and often unique environment that represents a priceless heritage that should be a source of pride to all Australians. The Australian government is a signatory to the United Nations CBD, and Australia has a national strategy for safeguarding its biodiversity heritage. Some aspects of the Australian environment were in relatively good condition by international standards (SoE 1996) and the approach to environmental management had international recognition in some areas. The 1996 Report also demonstrated that Australia has some very serious environmental problems, the cumulative consequences of human population growth and distribution, lifestyles, technologies and demands on natural resources over the last 200 years and more. The Report suggested that changes were needed in government policies and programs, corporate practices and personal behaviour.

The estimated population of Australia when Europeans arrived varies greatly, from 300 000 to 1.5 million. Seventy years later, the European population had reached one million. By 2001, the total population approaches 20 million. These citizens and their governments, industry and community organisations have responsibility for Australia's biodiversity.

## State of the Environment reporting and the 2001 national report

Progress towards sustainability is difficult, if not impossible, without adequate and accessible information about the environment. State of the Environment (SoE) reporting can be a powerful tool for providing this information—to the public, industry, non-government organisations (NGOs) and all levels of government. As such, SoE reporting is being embraced at the local, regional, state and national levels. It allows regular reports on agreed sets of indicators of changes and trends in environmental conditions, in much the same way as well-accepted economic indicators are used to report on the state of the economy. It describes the effects of human activities on the environment, and their implications for human health and economic wellbeing. It also provides an opportunity to monitor the performance of government policies against actual outcomes. Thus, SoE reporting can act as a report card on the condition of the environment and natural resource stocks.

For the 2001 national SoE Report, a suite of agreed biodiversity indicators have been developed (Saunders et al. 1998) and these are used to describe and evaluate conditions and trends in biodiversity (see *Biodiversity status, trends and indicators*, page 19).

# The meaning, significance and implications of biodiversity

## What is biodiversity?

After billions of years of evolution, earth is home to a large array of life forms and ecosystems. The Australian continent supports a significant proportion of this global diversity, and Australians increasingly accept a share of the responsibility for it. Concern for non-human life forms goes back in history and across many cultures. However, the level and nature of concern for these life forms changes over time, reflecting our understanding of the nature and importance of this legacy, the values we ascribe to it, the threats it is under and what might be done to conserve it (see Wilson (1992) and Burgman & Lindenmayer (1998)).

### Defining biodiversity

The evolutionary legacy of life on earth is now described by the term 'biodiversity', or biodiversity, but this term has come into wide use only recently. It refers to the variety of life of earth—plants, animals and microorganisms, as well as the variety of genetic material they contain and of the ecological systems in which they occur. It is a simple concept, but one which also has great complexity and significance. In Article 2 of the 1992 United Nations CBD (United Nations CBD 1992a), biodiversity was defined as:

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

This definition was repeated in Australia's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the NSCABD (Commonwealth of Australia 1996) expands on the three levels at which biodiversity occurs. These levels of biodiversity are:

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

These three levels of diversity are interrelated and interdependent (e.g. a population of a species is thoroughly dependent on its habitat for survival, and a functioning ecosystem is dependent on the complex of species that comprises it).

### Attitudes towards biodiversity

In the human history of Australia, changing values, scientific knowledge and cultural understanding have altered the way we perceive and interact with the natural environment generally and with biodiversity in particular. The following six phases offer a simplified summary of this process, characterising six different sets of attitudes (extended from Frawley 1994; see also Griffiths 1996; Bowman 1998). While the emphasis has changed over time, these phases reflect attitudes toward the Australian environment and biodiversity that are, to some extent, current.

*Indigenous*

The Indigenous peoples of Australia have valued and utilised components of biodiversity for at least 60 000 years (Thorne et al. 1999). Indigenous culture and practices have developed in a dynamic relationship with the environment. For example, the use of fire and hunting of animals helped shape the terrestrial environment. Today, Australians live in a cultural landscape that incorporates a diversity of manifestations of the interactions between humans and the natural environment over the last 60 000 years.

While 'western science' is still dominant in terms of the way non-Indigenous people view, describe and classify our flora and fauna, there are an increasing numbers of examples where Indigenous ecological knowledge is being accepted on an equal basis (Kakadu Board of Management and Parks Australia 1998).

*Exploration and contact*
Australia's flora and fauna were often a focus, but mostly in terms of their possible value for colonial trade or of their scientific interest and peculiarity.

*Exploitative pioneering*
The environment was viewed as feedstock for colonial economic and trade development. There was little in the way of specific law or management aimed at the protection of native species. Acclimatisation Societies were set up so the early settlers could make the environment more like 'home' and brought in some plants and animals that ended up becoming pests.

*Wise use for national development*
New resource management arrangements were established that were informed by science and aimed at management of natural resources (especially forests, water and soils) to best answer human needs in both the present and future.

**Yam Daisy (*Microseris lanceolata*).**

The edible tubers and bulbs of the Yam Daisy or Murnong were once a staple diet of the Indigenous peoples of south-east Australia.

**Source:** JJ Bruhl, University of New England.

*Modern environmentalism*
The modern conservation movement, prominent from the 1960s onward, expressed new issues and values in environmental management debates. In this era, the intrinsic value of biodiversity was more widely recognised, and when laws and policies for biodiversity conservation became the norm rather than the exception.

*Ecologically sustainable development*
Since the early 1990s, the central organising concept used by governments to describe human interaction with the environment has been 'sustainable development', termed 'ecologically sustainable development' (ESD) in Australia. The main aims of ESD are to: integrate environmental, social and economic concerns over a long time; adopt a precautionary approach; and recognise the importance of biodiversity and ecosystem processes.

Current debates and practices still feature these different attitudes. One constant is the character of Australia's biota. The biota, special to Indigenous people for millennia, appeared fantastic and fascinating to early European observers. Beneath the superficial strangeness of kangaroos, black swans, platypus and endless eucalypts, a special quality has been increasingly realised.

## Domestic law and biodiversity

One indication of change is the expression of biodiversity in domestic law. Integrated nature conservation legislation, which caters for harvesting control, conservation reserves and species protection, and specific legislation, which deals with threatened species, only date back a few decades in Australia (most states enacted such laws in the 1970s). By 1999, over 120 state, territory and Commonwealth statutes expressly referred to ESD as an objective and set of guiding principles (Stein 2000). There has also been a growth in the number and scope of international instruments concerning biodiversity (see *Roles and responsibilities* on page 160).

## Values associated with biodiversity

The following categories summarise the different values people and society place on biodiversity:

*Direct utilitarian value*
Biodiversity is consumed by humans as food and is used to feed stock. It provides materials such as timber and fibre, medicines, chemicals and genetic material.

*Indirect utilitarian values*
Indirect utilitarian values include the maintenance of 'ecosystem services' or important ecological processes. Examples include maintaining water quality in catchments, moderating atmospheric processes or weather, conserving the structure or fertility of soil, maintaining coastal function, assimilating or removing wastes from water or soil, maintaining evolutionary

potential in ecosystems, sequestering carbon emissions, cycling of nutrients, pest control, and pollination of crops.

*Aesthetic and recreational values*

Biodiversity has aesthetic and recreational uses for humans, both in the form of specific taxa such as flowers, birds, trees or whales, and as components of natural or semi-natural landscapes such as the Great Barrier Reef and the wetlands of Kakadu National Park.

*Scientific and educational values*

Scientific discovery can lead to the development of utilitarian values. It will often be through scientific research, other forms of investigation and learning about community or Indigenous knowledge that such uses will be recognised. Also, the variety of life is of educational value across a wide variety of subjects and disciplines (e.g. biology, biochemistry, ecology, genetics and agronomy).

*Intrinsic, spiritual and ethical values*

Various cultural and religious systems (e.g. Aboriginal and Torres Strait Islander people) place value on components of biodiversity. Also, there is the ethical position that non-human forms of life have intrinsic value and a right to exist independent of any use to humans.

*Future or 'option' values*

For all of the above values, there is the added dimension of keeping options open for the future. We are uncertain as to what species and populations are crucial to ecosystem services, or the actual significance of some of these services. Similarly, there may be uses for species or genetic diversity yet to be discovered, such as for food or medicine. And, if the values held in society change as they have in the past, then what is viewed as unimportant now may be more highly valued in the future.

All the values identified above are evident in Australian society, and many individuals will value biodiversity for more than one of these reasons. Perhaps the most important change in understanding in the long term has been the recognition of the reliance of biodiversity on functioning ecosystems, and its role in maintaining ecological processes. This recasts biodiversity science, policy and management in important ways. Managing just a few species and protecting a small selection of natural areas is not sufficient to protect Australia's biodiversity.

Another major and continuing change is the attention being paid to *indirect* (or underlying) as well as *direct* (or proximate) causes of biodiversity loss. For example, land clearing by farmers is a direct cause of biodiversity loss in Australia. The indirect causes lie in the social, institutional and economic settings that influence farmer behaviour and farm profitability. This includes the information available to landholders, economic conditions affecting rural industries and perverse incentives encouraging clearance.

This shift in emphasis deepens our understanding of the processes of biodiversity loss and allows more sophisticated policy responses. In the land clearance example, strict regulation is invited by the direct cause, whereas understanding the indirect cause invites the use of incentive mechanisms, forward planning, information provision and other approaches.

## Concern for biodiversity

An indication of society's concern for biodiversity can be gleaned from opinion surveys, even though these have only been undertaken recently. An analysis of national surveys from 1975 to 1994 identified high levels of concern over environmental issues, and biodiversity was consistently important within the broader environmental field (Lothian 1994). During the 1990s, the ABS undertook more regular surveys (ABS 1999a). In 1999, the environment was nominated as the most important social issue by 9% of the Bureau's sample, above issues such as crime and health. Of those who did not rank the environment as their top issue, 69% stated that they were concerned about environmental issues. This represents a slight decrease on recent years although in 1986 the corresponding figure was 49% (SOE 1996, p. 10–11). The issues of concern most directly relevant to biodiversity, destruction of trees/ecosystems and of animals/wildlife, were identified by 29% of people, and 43% believed that the quality of the environment had decreased in the 1990s.

## Australia's biodiversity: A unique heritage

Australia's biodiversity has been especially shaped by the features of the Australian landscape, and long periods of evolutionary isolation. Compared with other parts of the world and because of the age and deep weathering of the landscape, Australia has low relief, low and variable rainfall and low nutrient soils. Long periods of isolation from other landmasses have resulted in the evolutionary radiation of groups of terrestrial plants and animals such as eucalypts, wattle, hummock grasses and marsupials (Strahan 1983; Flora of Australia 1999). The aquatic environment also hosts a great diversity of plant and animal species, although this element of the Australian flora and fauna often receives less attention despite its ecological significance (Flora of Australia 1999).

### Geological history

All the present continents coalesced into a single supercontinent, Pangaea, about 230 million years ago. Within Pangaea, the land masses of Australia, New Guinea, South America, Africa, Madagascar, Antarctica, India, New Zealand, Arabia and parts of South-East Asia were close together and formed the continent of Gondwana. Pangaea began to break up about 160 million years ago. Australia and Antarctica parted only 35 million years ago. At that time, the climate of Gondwana was humid and temperate and rainforest covered much of the landscape. Australia drifted north and collided with the islands in the Pacific about 15 million years ago. During this period of isolation, the continent was exposed to dramatic climatic changes. The circum-Antarctic current formed when Australia and Antarctica separated, resulting in substantially reduced temperatures at the southern pole and the formation of the Antarctic ice cap over the next 20 million years. Most of the Australian landscape was stable during the isolation of the last 30 million years, resulting in today's ancient, weathered surfaces (Archer et al. 1998).

These geological events and the associated landscape and climate changes have created a unique legacy of flora, fauna and landforms on the Australian continent. In general, Australia's flora and fauna are a mixture of the original Gondwanan stock, modified over millions of years of separation, and the more recent arrivals from Asia. For example, in northern Australia, several plant and animal groups are shared with the islands of New Guinea and Indonesia. Many taxa (families and genera) are also shared between southern Africa, South America and Australia because of their common origins. For example, marsupials are common in Australia, South America and New Guinea, but not in Asia. The rainforest trees *Nothofagus* and *Araucaria* occur in South America and Australia. The flora of south-west Australia shares many relatives with the flora of southern Africa.

### Droughts and flooding rains

The major components of the Australian terrestrial flora and fauna have diversified into a rich spectrum of species adapted to the vagaries of the Australian environment. The droughts, fires and floods that are a part of the Australian environment are closely tied to regional climate patterns, especially the El Niño–Southern Oscillation (ENSO) phenomenon. Rainfall, especially for eastern Australia, has a very high interannual variability. Extensive and often prolonged droughts, sometimes with severe fires in forested regions, occur during El Niño years, whereas flooding is common in La Niña years. The widespread rainfall associated with La Niña events affects the abundance of plants and animals through the filling of water bodies such as Lake Eyre and indirectly through its effect on fire regimes and pest outbreaks.

Disturbance and climatic cycles are also important for biodiversity in marine systems. Natural agents of change in

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

**Source:** AM Gill, CSIRO Plant Industry.

marine communities include tropical cyclones and temperate severe storms, outbreaks of predators and ENSO effects on currents and coastal ocean productivity.

## Megadiverse countries

Australia is identified as a megadiverse country. The concept of megadiversity is based on the total number of species in a country and the degree of endemism at the species level and at higher taxonomic levels. The World Conservation Monitoring Centre recognised 17 megadiverse countries in July 2000 including Australia, Brazil, China, Colombia, Democratic Republic of the Congo (DRC) (formerly Zaire), Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, the Philippines, South Africa, the United States of America (USA) and Venezuela. Together, these 17 countries harbour more than 70% of the earth's species (Figures 1 and 2).

Of countries containing large endowments of biodiversity, Australia is unique in another, very significant way. Of all the countries classified as megadiverse, Australia is one of only two countries in the high income category (Table 1). Australia as a richer, healthier, better educated country with a more developed economy is better positioned to deal with problems of environment and development than all but one other megadiverse nation—the USA. This position carries a special responsibility and implies that a high standard of biodiversity protection can be expected in Australia. It also carries with it an opportunity for world leadership.

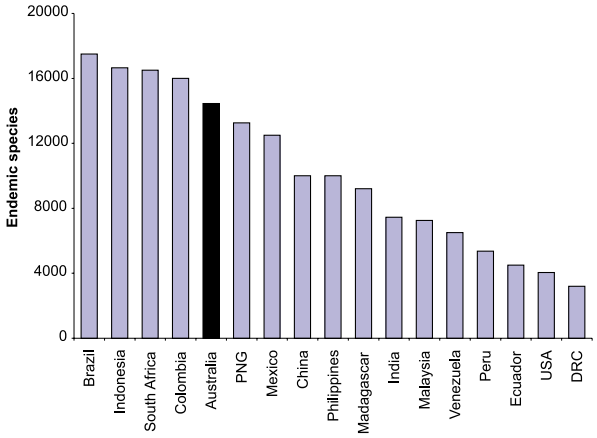



**Figure 1: Number of endemic vascular plant species in 17 megadiverse countries illustrating that Australia has the fifth highest number of species in this group.**

PNG, Papua New Guinea; DRC, Democratic Republic of the Congo.

**Source**: Conservation International (2000).

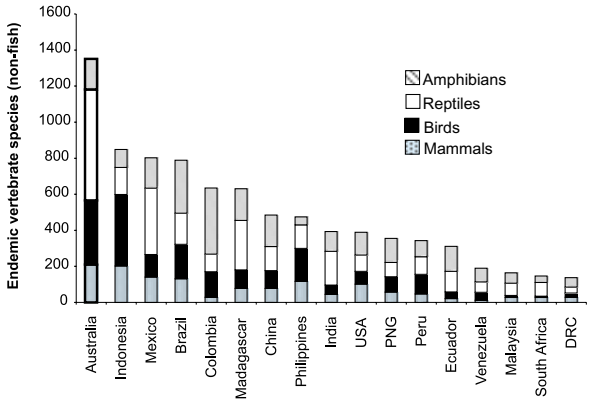



**Figure 2: Number of endemic non-fish vertebrate species in 17 mega-diverse countries illustrating that Australia has the highest level of endemism for this group of species.**

PNG, Papua New Guinea; DRC, Democratic Republic of the Congo.

**Source:** Conservation International (2000).

## Key features of Australia's biodiversity

### Vegetation types

The terrestrial ecosystems found in Australia are very varied owing to the range of climates—including subalpine, cool temperate, arid and tropical biomes. This diversity leads to a range of vegetation types whose distribution at a broad scale is limited mainly by rainfall. These include the spinifex-dominated arid interior, semi-arid shrublands, tropical and temperate grasslands, rainforests and woodlands (including savannas), eucalypt-dominated forests and shrublands, chenopod shrublands, heathlands, alpine and subalpine vegetation (Groves 1994; Flora of Australia 1999). The only available Australia-wide map of Australia's natural vegetation (Figure 3) was compiled by JA Carnahan (Commonwealth of Australia 1990). During 2001, a new continental-scale vegetation map is to be produced by the National Land and Water Resources Audit (NLWRA) (see http://www.nlwra.gov.au). This is part of a major initiative, the National Vegetation Information System, which is a collaborative project between the state, territory and Commonwealth governments.

Australian terrestrial vegetation contains very few deciduous species, relatively few conifers and no cactuses or other large succulents in the arid zone. In particular, the appearance of the unique Australian landscape is largely as a result of the predominance of species-rich genera such as *Eucalyptus* and *Acacia*.

Mangrove forests and saltmarshes occur in intertidal areas and are thus influenced by the characteristics of both the land and the sea. Intertidal mudflats are another significant, yet often forgotten, habitat.

Aquatic vegetation types, especially in the marine environment, are much less diverse than their terrestrial counterparts. For example, vegetation communities in marine areas are largely dominated by seagrasses and macroalgae (Zann 1995). A broader range of vegetation

**Table 1: Comparative socioeconomic data for the 17 megadiverse nations**

Updated from Common and Norton (1992). All figures are from 1998 except life expectancy (1997), protected areas (1996) and the income figures for the DRC (Congo) and Malaysia that are based on regression. Figures for the land area of China, Brazil and Australia have increased since 1989.

| Country | Population (millions) | Area (thousands km$^2$) | Population density (persons km$^2$) | Life expectancy (y) | Income (per capita US$) | Agriculture (% of output) | Nationally protected areas (% land area) | Adult literacy rate (%) |
|---|---|---|---|---|---|---|---|---|
| Australia | 19 | 7 741 | 2 | 78.2 | 20 130 | 3 | 7.3 | 99.0 |
| Brazil | 166 | 8 547 | 20 | 66.8 | 6 160 | 8 | 4.2 | 84.0 |
| China | 1 239 | 9 597 | 133 | 69.8 | 3 220 | 18 | 6.4 | 82.9 |
| Colombia | 41 | 1 139 | 39 | 70.4 | 7 500 | 13 | 9.0 | 90.9 |
| DRC | 48 | 2 345 | 21 | 50.8 | 750 | 58 | 4.5 | 79.5 |
| Ecuador | 12 | 284 | 44 | 69.5 | 4 630 | 12 | 43.1 | 90.7 |
| India | 980 | 3 288 | 330 | 62.6 | 1 700 | 25 | 4.8 | 55.0 |
| Indonesia | 204 | 1 905 | 112 | 65.1 | 2 790 | 16 | 10.6 | 85.5 |
| Madagascar | 15 | 587 | 25 | 57.5 | 900 | 31 | 1.9 | 65.0 |
| Malaysia | 22 | 330 | 68 | 72.0 | 6 990 | 12 | 4.5 | 86.5 |
| Mexico | 96 | 1 958 | 50 | 72.2 | 8 190 | 5 | 3.7 | 90.1 |
| Papua New Guinea | 5 | 463 | 10 | 58.0 | 2 700 | NA | 0.0 | NA |
| Peru | 25 | 1 285 | 19 | 68.3 | NA | 7 | 2.7 | 88.7 |
| Philippines | 75 | 300 | 252 | 68.5 | 3 540 | NA | 4.9 | 94.5 |
| South Africa | 41 | 1 221 | 34 | 65.0 | 6 990 | NA | 5.4 | 84.0 |
| USA | 270 | 9 363 | 29 | 76.0 | 29 340 | NA | 13.4 | NA |
| Venezuela | 23 | 912 | 26 | 73.0 | 8190 | NA | 36.3 | 92.5 |

**Source:** World Bank (1999a, 1999b).

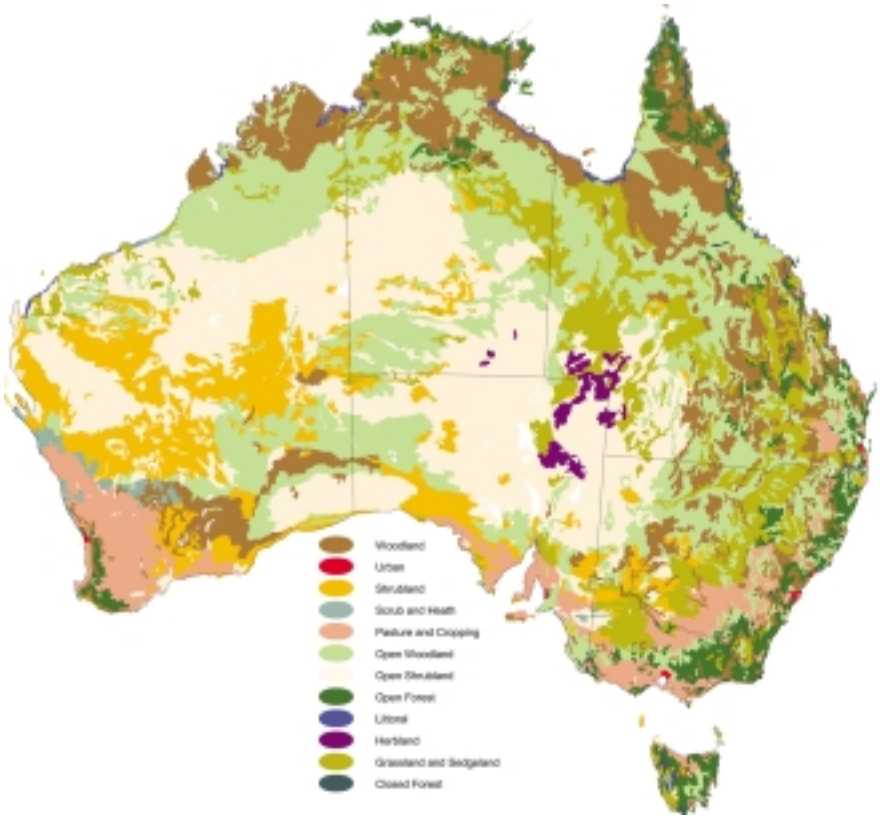



**Figure 3: Major vegetation types in Australia in 1988.**

The National Vegetation Information System is developing an interactive database that will allow mapping of native vegetation at several scales.

**Source:** Commonwealth of Australia (1990). Compiled by Environmental Resources Information Network.

types are associated with the lakes, rivers, wetlands and areas dependent on ground water that help make up the freshwater systems of Australia (Boulton & Brock 1999).

The photographs (pp. 15–17) illustrate an indicative range of diversity of vegetation types. Some of these vegetation types such as tropical rainforests and alpine vegetation are restricted in occurrence. This contrasts with tropical savannas (dominated by eucalypt species) and spinifex-dominated grasslands which cover large areas of tropical and arid Australia, respectively. Another widespread community is the Mulga (*Acacia aneura*)-dominated shrublands. Together with hummock grasslands wooded with Mulga, these communities are estimated to occupy 1.5 million square kilometres or about 20% of the Australian continent (Hodgkinson 2001). Although most of the continent is dominated by semi-arid and arid ecosystems, ecosystem diversity is greatest in the higher rainfall regions on the eastern and southern edges of the continent.

## Marine habitats

Australia has one of the world's longest national coastlines and one of the largest marine jurisdictions, about twice the size of the Australian mainland ranging from the sub-Antarctic to the tropics. These measurements refer only to surface area—marine organisms live in all available habitats extending throughout the water column to the floor of deep ocean trenches. Some of these trenches reach 11 000 m in depth but even in these extreme habitats, marine invertebrates still occur. In addition to well-known habitats such as shorelines, estuaries, rocky shores and rock pools, coral reefs and seagrass beds, marine invertebrates can be found in other habitats such as the interstitial spaces between grains of sand, around hydrothermal vents, on floating debris (e.g. algal mats and driftwood attached to other animals), the peaks and slopes of seamounts and swimming or floating in the water itself.

## Classifying vegetation or habitat types

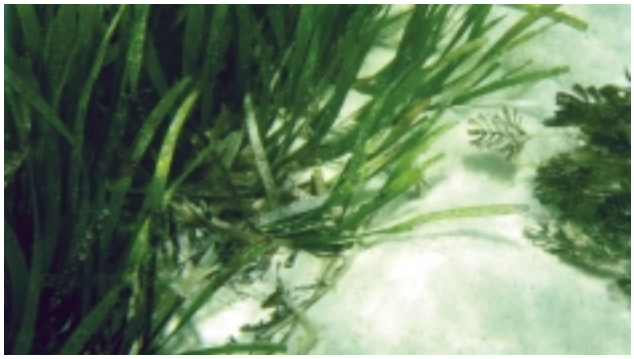
Indigenous people have developed classifications for vegetation or habitat types that can bear marked similarities to the broad associations defined by western science (Table 2). While western science is based on evolutionary theory and Linnaean taxonomy, all aspects of Indigenous life is governed by the genesis of life and classification based on their religious and social laws (Baker & Mutitjulu Community 1992).

**Cushion plant community Tasmania.**

**Source:** JJ Bruhl, University of New England.

**Complex mesophyll vineforest south of Cape Tribulation, Qld.**

Source: VJ Neldner, Environment Protection Agency, Queensland.



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

**Source:** M Waycott, James Cook University.

**Table 2: Indigenous words for arid zone systems and taxa**

| Habitat type | Anangu name |
|---|---|
| Rocky range and outcrops | puli |
| Mulga shrublands | puti |
| Riverbed and riverbanks | karu |
| Sand plain | pila |
| Dunefields | tali |
| Saltlakes or claypans | Pantu or tjintjira |

## The biodiversity challenge: Responsibilities roles and partnerships

In seeking to reconcile economic political and legal systems with the natural systems on which they depend, several core 'attributes' are encountered and these very much shape the way in which policy management and scientific responses might be framed.

First, ESD issues need to be considered over different space and time scales from those of many other policy issues. Ecosystems and ecological processes rarely concur with political boundaries, national borders, election cycles or the timing of government budgets. Second, there are significant knowledge gaps concerning biodiversity: its component parts, the role of taxa in ecosystems, and both the actual and possible future values of biodiversity. Third, ESD problems often involve cumulative effects (e.g. diffuse pollution sources affecting an ecosystem over time, and dryland salinity) and irreversible effects (e.g. species extinction). Fourth, many environmental issues cut across industry and government portfolio sectors, which means that responses must be integrated and coordinated. Finally, there is the sheer novelty of many ESD issues—their relatively recent arrival on the policy agenda means that there is a lack of defined policy and property rights and responsibilities and a lack of agreed management approaches and policy instruments. These attributes characterise the challenge of biodiversity conservation.

## Improving information and knowledge

Several elements are involved in trying to improve the information and knowledge base on the state of Australia's biodiversity. These include the tasks of improving taxonomic knowledge of Australia's biodiversity; improving our ecological knowledge across populations, species and ecosystems; describing the abundance, status, life histories of these and the threats to them; and the more recently defined area of increasing our understanding of genetic diversity within species and populations. All these require collaboration between scientific and government institutions as well as the important role of the private sector in research and development.

If our understanding of biodiversity is to inform policy and management, then an historical dimension is needed to provide the baselines against which judgments can be made which brings in a wider range of research disciplines (i.e. history) as well as members of the community and Indigenous groups who have strong links with specific places.

Information regarding the success or otherwise of past and present policy interventions and management practices is important if we are to know whether and how well these are working. Although governments are central in monitoring policy and management, the community, science, relevant professions and industry also need to be involved.

## Communication and education strategies

Gathering and storing information on the protection and sustainable use of Australia's biodiversity is pointless without its communication to those who need to use it. This includes the spread of research findings to decision makers, other researchers and the broader community. The media, schools, university and various training curriculums are also important.

**Shrubby eucalypt woodland remnant on sandstone in the Glenorie area of the Hills District, north-western Sydney.**

This woodland has a very diverse shrub layer including *Boronia*, *Dillwynia*, heath species and the rare and restricted *Acacia gordonii*.

**Source:** JJ Bruhl, University of New England.

**Spinifex (*Triodia* spp.)-dominated grassland burnt most recently in 1991, north of Uluṟu-Kata Tjuṯa National Park, NT.**

**Source:** JE Williams.

**Dropseed (*Sporobolus virginicu*)-dominated grassland with termite mounds near Kowanyama, Qld.**

**Source:** VJ Neldner, Environment Protection Agency, Queensland.

## Managing biodiversity

Managing biodiversity across the Australian landscape requires:

- management of protected areas such as national parks and nature reserves
- management of biodiversity outside the reserve system
- control of harvesting and use of biota.

**Mulga (*Acacia aneura*)-dominated community in foreground with scattered individuals of the endangered Undoolyana Wattle (*Acacia undoolyana*) which can be identified by its bright green foliage.**

**Spinifex (*Triodia brizoides*)-dominated hillside in the background on a different substrate. Undoolyana Station east of Alice Springs, NT.**

**Source:** JE Williams.

Although reservation of land is a government responsibility, many reserves are established following community pressure. Community involvement in the management of reserves has increased through boards and committees that include community representatives, as in the case of those co-managed by Indigenous land owners and park services (e.g. Kakadu Board of Management and Parks Australia 1998; Uluṟu-Kata Tjuṯa Board of Management and Parks Australia 2000). The off-reserve task involves a mix of legislation, regulation, incentive measures and voluntary efforts across farmland, in production forests, in industries such as tourism and mining, on Indigenous lands and in the marine realm. The control of harvesting and other uses of native plants and animals applies to both public and private land and waters within a regulatory framework that involves close interaction with individuals, communities, firms, governments and industry.

## Restoration and recovery

An important aspect of managing biodiversity is the increasing attempts to restore habitats to some previous or more desirable condition and to encourage the recovery of diminished or threatened species or populations. As well as government agency staff and scientists, community groups, private landholders and firms have an important role in many such attempts. While *in situ* conservation is the preferred option, in some instances it is not always feasible.

## Policy and management settings

Protection of biodiversity is primarily the responsibility of governments. The broader community, however, has input in various ways into policy formulation, the design or reform of laws and on-the-ground implementation of policies.

In the case of biodiversity and most other environmental issues, legislation (i.e. statute law) rather than common law has overwhelmingly been the predominant source of power and responsibility. Legislation does or can serve many purposes, such as: setting out government objectives and the structure of agencies; establishing opportunities for public participation; enabling financial incentives; defining procedures for development approval; impact assessment; strategic planning processes; and ensuring transparency of decision making.

Australia's federal system of government is important to understanding how biodiversity is or can be managed. Under Australia's constitutional arrangements, the great bulk of responsibility for environmental management, including biodiversity, resides with the states. The Commonwealth, however, has considerable potential and actual power via the trade, external affairs, corporations, finance and taxation and race powers in s51 of the Australian Constitution (Bates 1995). These powers were confirmed in court cases over the 1970s and 1980s. Over the past decade, however, there has been a trend toward less confrontational and more cooperative approaches to the environment. The Intergovernmental Agreement on the Environment, the National Environment Protection Council and the development of national policies such as the NSCABD reflect this.

A major role of the Commonwealth, recognised in the Intergovernmental Agreement on the Environment, is in the implementation of international agreements (e.g. the Convention on Biodiversity, CBD). Some international obligations have become triggers in the EPBC Act,

## Law in biodiversity conservation

The following examples demonstrate the increasing relevance and role of law in biodiversity conservation:

- very different approaches taken in the different States to biodiversity management and the tensions which this causes (e.g. Queensland's vegetation clearance legislation proposes to offer compensation for land use restrictions but this has been strenuously resisted in New South Wales)
- movement away from ad hoc regulation of individual project proposals towards strategic planning (e.g. bioregional planning)
- law's role in setting up decision-making procedures relating to biodiversity management rather than setting out absolute standards (which would guarantee the protection of threatened species)
- lack of integration between older law focusing on the management of particular resources (e.g. water) and more recent law based on a holistic view of the environment
- lack of integration between the functions of elected local councils and appointed community resource management committees (e.g. catchment committees)
- perceived failure of command and control regulation specifically in the private land context and an attempt to develop economic instruments and community driven mechanisms (e.g. catchment committees)
- increased recognition that biodiversity conservation is as much about active management as land use restriction
- difficulties posed by planning law's traditional respect for existing land uses.

which can lead to environmental assessment and regulation of project proposals by the Commonwealth. The triggers of relevance to biodiversity are significant effects on Ramsar wetlands, World Heritage areas, migratory species, nationally threatened species and ecological communities and Commonwealth marine areas. In early 2001, the Environment Minister, following advice from the Threatened Species Scientific Committee, listed land clearing as a key threatening process to biodiversity.

The role and relevance of law in biodiversity conservation is becoming increasingly important (see *Law in biodiversity conservation* box above).

# Biodiversity status, trends and indicators

## The 1996 State of the Environment Report

The 1996 Report (SoE 1996) was motivated by a commitment to ecological sustainability and a concern for Australia's biodiversity. It outlined over 50 major issues of concern for biodiversity and its conservation including 11 key issues that were identified as threats to biodiversity (Table 3).

**Table 3: The 11 key issues identified in SoE (1996) as threats to biodiversity**
The detail and comments are also from the 1996 report and mostly still apply in 2001.

| Issue | Detail | Comment |
|---|---|---|
| Effects of human population and consumption | The overwhelming causes of the decline in Australia's biodiversity result from the human population, their lifestyles, technologies and demands on natural resources | The situation continues to deteriorate as population and demands on natural resources increase |
| Condition of ecosystems | Most terrestrial freshwater and marine ecosystems are altered in structure and function to some extent | Few ecosystems remain in a largely natural condition. The situation is deteriorating |
| Distribution and abundance of species | Many species are undescribed or poorly studied; of those that are described, many are lost or threatened | The loss of and decline in species continues and is cause for national concern |
| Changes in genetic diversity | Little is known for most species, although there is strong evidence of loss of genetic diversity for some | While the degree of genetic diversity is unclear, it is almost certainly declining |
| Land clearance and related activities | Land clearing destroys and modifies ecosystems thus threatening biodiversity. The past extent and continuing rate vary greatly between states and territories | This is the single largest threat to biodiversity. The situation is deteriorating as threatening activities continue |
| Effects of introduced species | Most terrestrial freshwater and marine ecosystems are affected or threatened, as are many native species | Effects have often been severe and the situation continues to deteriorate |
| Harvesting native species | Some species have been and are being overexploited. There are detrimental effects on habitat and non-target species | Harvesting of native species is an important pressure on biodiversity in some areas. The situation is deteriorating |
| Lack of knowledge of biodiversity | This affects ability to develop strategies for achieving sustainable production without further detrimental effects on biodiversity | The knowledge base, while still inadequate, is slowly improving |
| Effectiveness of conservation measures outside reserves | Most biodiversity will continue to rely on areas outside the system of conservation parks and reserves | Better integration of management approaches in the local regional and national spheres is required |
| Adequacy of protected areas | The number and extent of protected areas is increasing but nature conservation is generally a residual land use in agricultural districts | Some ecosystems and species are represented well, others poorly |
| Adoption of integrated ecosystem-based management of natural resources | This is necessary for achieving sustainable production without further detrimental changes in biodiversity | Bioregional management requirements are partially recognised but enormous efforts are still required to fully develop and implement them |

An explicit purpose of environmental reporting is to allow tracking of changes over time, particularly from one report to the next. This section compares some of the findings of the 2001 Report with those of SoE (1996).

The threats to biodiversity identified in SoE (1996) (Table 3) are presented here in further detail (Table 4). Many ecosystems and species are threatened by human activities such as habitat clearance and modification and the invasion of systems by exotic organisms. Genetic diversity is also threatened although the nature and detail of genetic diversity loss is most poorly documented. At the general level, SoE (1996) stated that 'to balance conservation of biodiversity, human population growth and economic development' would require 'substantial changes in the way that land and oceans are managed'. Clearly between 1996 and 2001, an expectation of 'substantial' change would be likely to be disappointed. Mostly we do not yet fully understand what such changes entail. This Report shows that there have been both encouraging signs of improvement and evidence of both lack of progress or emerging and as yet poorly addressed issues.

## Indicators of biodiversity

### Environmental indicators

This Report pioneers the use of environmental indicators on a continental scale. Environmental indicators are physical, chemical, biological or socioeconomic measures that

**Table 4: Qualitative comparison of status and trends for biodiversity between SoE (1996) and the 2001 Report**
Eucalypt-dominated savanna woodlands and marine systems such as seagrasses were not addressed in the 1996 report. Climate change is seen as a pervasive threat to both terrestrial and marine ecosystems.

| Key issue: (ecosystem or taxa) | Condition 1996 | Condition 2001 | Pressure 1996 | Pressure 2001 | Key response 1996 | Key response 2001 | Effectiveness of key response |
|---|---|---|---|---|---|---|---|
| | | | | **Ecosystem diversity** | | | |
| Northern rainforests | Highly fragmented many areas degraded | No change to 1996 | Habitat destruction | Habitat destruction | Listing as protected areas including World Heritage Register; improved land management | | Limited; some unique areas not protected; clearing grazing fire management and weeds still problematic |
| Southern rainforests | Highly fragmented | No change to 1996 | Habitat destruction | Habitat destruction | Listing in protected areas | | Increase in reserve estate (NSW) |
| Tall open forests | Extensive losses in area and altered species composition | No change to 1996 | Altered fire regimes, land clearance logging | Altered fire regimes, land clearance logging | Improved management reservation | Fire management | Reserve system expanded via RFA process; initial definition of Ecological Sustainable Forest Management (effectiveness not yet assessable) |
| Acacia forests, woodlands and shrublands | Habitat loss and degradation; species diversity reduced | Habitat loss and degradation; species diversity reduced | Clearance, grazing | Clearance, grazing, altered fire regimes. Land clearance is the single largest threat to biodiversity. The situation is deteriorating as threatening activities continue | Improved land management | Vegetation clearance controls | Locally effective. Vegetation clearance not yet controlled |
| Eucalypt-dominated temperate woodlands | Widespread habitat loss; fragmentation | Widespread habitat loss; fragmentation | Clearance, grazing, salinity | Clearance, grazing, salinity | | Vegetation clearance controls | Vegetation, clearance not yet controlled |
| Savanna woodlands | Habitat degradation and modification | Habitat degradation and modification | | Altered fire and grazing regimes, weeds, feral animals | | Improved land management | Locally effective |
| Eucalypt scrubs and shrublands | Extreme fragmentation, possible inability to regenerate | No change to 1996 | Clearance, grazing | Clearance, grazing, salinity. Land clearance is the single largest threat to biodiversity. The situation is deteriorating as threatening activities continue | Reservation; restoration | Vegetation clearance controls | Very limited; reserves inadequate. Vegetation clearance not yet controlled |
| Heathlands | Widespread habitat loss; fragmentation | No change to 1996 | Clearance, altered fire regimes, urbanisation, agriculture and sand mining | Clearance, altered fire regimes, urbanisation, agriculture and sand mining | Reserves | Fire management | Limited and only locally effective |
| Chenopod shrublands | Widespread habitat degradation; many plant species endangered | No change to 1996 | Grazing | Grazing, woody weeds | Improved land management; reserves | Weed control strategies | Locally effective only. Very limited |
| Native grasslands | Many areas highly degraded or altered by introduction of exotic species | No change to 1996 | Grazing | Grazing, weeds, urban development. Altered fire regimes | Improved land management and legislation; reservation | | Locally effective; reserves inadequate. Inclusion in regional vegetation planning in some jurisdictions (effectiveness unclear) |

**Table 4: Qualitative comparison of status and trends for biodiversity between SoE (1996) and the 2001 Report *(continued)***
Eucalypt-dominated savanna woodlands and marine systems such as seagrasses were not addressed in the 1996 report. Climate change is seen as a pervasive threat to both terrestrial and marine ecosystems.

| Key issue: (ecosystem or taxa) | Condition 1996 | Condition 2001 | Pressure 1996 | Pressure 2001 | Key response 1996 | Key response 2001 | Effectiveness of key response |
|---|---|---|---|---|---|---|---|
| Alpine and subalpine vegetation | Some areas highly degraded | No change to 1996 | Grazing, tourism, climate change (predicted) | Grazing, tourism, climate change (likely) | Reservation; improved land management | | Many areas now in national parks; others remain degraded and vulnerable |
| Salt marshes and mangroves | Extensive loss near urban areas | No change to 1996 | Habitat destruction and degradation | Habitat destruction and degradation, sediments and nutrients from land, climate change (sea level rise) | Protected areas, development control, community awareness | ICM pollution control. Greenhouse policy | Unknown. Greenhouse policy not clear on biodiversity aspects |
| | | | | **Species diversity** | | | |
| Microorganisms | Unknown but population composition and size likely to be affected | No change to 1996 | Habitat modification and loss | Habitat modification and loss, unknown | Little direct response | | Not known. Insufficient research or policy development |
| Marine invertebrates | Reduction in population size of exploited species | Unknown | Habitat modification and loss, harvesting; competition pests | Habitat modification and loss, harvesting, competition pests, sediments/ pollution from land | Management plans for exploited species; controls on illegal harvesting | Pollution control; ballast water management | Pressures are continuing; very few successes. Effect of pollution control unknown; ballast water strategies taking effect |
| Freshwater invertebrates | Insufficient information to assess | No change to 1996 | Habitat modification and loss | Habitat modification and loss, salinity; climate change; pollution; water allocation | ICM; waste-water treatment; restoration of wetlands; control of introduced pests | Various policy responses. Research and monitoring | Little known. Uncertain as yet. Increasing from low base |
| Land invertebrates | Massive reduction in population size of effected species | No change to 1996 | Habitat modification and loss | Habitat modification and loss | Little direct response; protected areas | | Little known |
| Marine fish | Many important species overexploited majority in good condition | Some species overexploited; majority sustainably harvested; some status unclear | Harvesting of edible species | Harvesting of edible species, effect on non-target species | Management plans for most major species | Management plans in place for few stocks—few properly address ecological effects. Individual transferable quota systems | Management plans required in most jurisdictions; bycatch planning commencing. Unclear |
| Freshwater fish | Generally in poor condition, many species threatened | Situation worsened? | Habitat modification and loss; introduced species | Habitat modification and loss, introduced species, salinity, pollution, sediments/ nutrients from land, reduce/altered flows from storages and diversion | ICM; wetland restoration; control of introduced pests | Various policy responses. Provision of environmental flows | ICM more widespread; NPI in place; control of exotics difficult. Efficacy of policies for protecting biodiversity unknown. Unclear; environmental flow provision beginning under COAG water reforms |
| Amphibians | Several species have disappeared or are declining | No change to 1996 | Sustained habitat loss but often pressures not identified, pollution, sediments and nutrients, climate change | Sustained habitat loss but often pressures not identified, pollution, sediments and nutrients, climate change | Protected areas; community-initiated protection | | Lack of knowledge of causes of declines prevents effective actions |

**Table 4: Qualitative comparison of status and trends for biodiversity between SoE (1996) and the 2001 Report *(continued)***
Eucalypt-dominated savanna woodlands and marine systems such as seagrasses were not addressed in the 1996 report. Climate change is seen as a pervasive threat to both terrestrial and marine ecosystems.

| Key issue: (ecosystem or taxa) | Condition 1996 | Condition 2001 | Pressure 1996 | Pressure 2001 | Key response 1996 | Key response 2001 | Effectiveness of key response |
|---|---|---|---|---|---|---|---|
| Reptiles | Massive reduction in numbers in urban and agricultural areas | No change to 1996 | Habitat loss | Habitat loss | Protection areas; protection of marine and freshwater turtles | Bycatch policy | Partially effective |
| Birds | Some species disappearing; others threatened; a few increasing their range | No change to 1996 | Habitat modification and loss, predation from feral animals | Habitat modification and loss, predation from feral animals | General protection; protected areas | Threat abatement plans. Revegetation (limited direct response). Increase in protected areas in some jurisdictions | Unclear as yet. Partially effective |
| Mammals | Several species lost; others threatened; a few increasing their range | No change to 1996 | Habitat modification and loss, competition with and predation by feral animals | Habitat modification and loss, competition with and predation by feral animals, forest management; land clearance | General protection; protected areas | Threat abatement plans; species action plans. Protected areas | Pressure from feral cats and foxes continues; unclear as yet. Partially effective |
| Marine plants | Extensive loss of seagrasses; localised loss of mangroves | No change to 1996 | Habitat modification and loss, pollution, natural events (floods cyclones) | Habitat modification and loss, pollution, natural events (floods cyclones), nutrients/ sediments from land, climate change (sea level rise) | Protection for seagrasses and mangroves but destruction still allowed in some areas by permit | ICM; pollution control; greenhouse policy; reservation | Unclear as yet; reserves increased in some jurisdictions |
| Freshwater plants | Species threatened | No change to 1996 | Habitat modification and loss | Habitat modification and loss, weeds, water extraction | Limitation on water licences; protected areas | Wetland restoration; environmental flows; ICM; weed strategies | Some localised advances—unclear as yet |
| Land plants | Many species endangered or vulnerable | No change to 1996 | Clearance, habitat modification and loss | Clearance, habitat modification and loss, environmental weeds altered fire regimes, grazing, harvesting | Protected areas | Weeds strategies; fire management; harvesting controls pastoral management strategies. Protected areas increased in some regions and jurisdictions | Unclear. Effective in some areas |
| | | | | **Genetic diversity** | | | |
| | Some species show reduced genetic diversity | While the degree of genetic diversity is unclear, it is almost certainly declining | Habitat fragmentation and loss | Habitat fragmentation and loss, GMOs | Protected areas; captive breeding; reintroduction; regulation of exploitation | | Little known; research in progress |

are considered to best represent the key elements of a complex ecosystem or environmental issue. When fully developed they should help define the nature and size of environmental issues, set goals for their solution and track progress towards these goals (Heinemann et al. 1998). In order to track these changes, a monitoring program is essential where repeated sets of measurements are compared with a benchmark set or condition. For SoE reporting, these benchmarks must enable the effects of current programs and policies and of land/resource management activities to be assessed in relation to their biodiversity outcomes.

## The 2001 State of the Environment Report

The national level biodiversity indicators that form the basis of the report were developed by Saunders et al. (1998). A total of 65 indicators were recommended (Table 5), 14 of which related to pressures on biodiversity, 17 to the condition of biodiversity and 34 to responses to the loss of or perceived threats to biodiversity. Throughout this Report the indicators will be referred to by the numbering system used in Table 5.

**Table 5: Biodiversity indicators for national State of Environment reporting**
Each Indicator is referred to in the Report according to its number.

| No. | Title |
|---|---|
| BD 1.1 | Human population distribution and density |
| BD 1.2 | Change in human population density |
| BD 2.1 | Extent and rate of clearing or major modification of natural vegetation or marine habitat |
| BD 2.2 | Location and configuration or fragmentation of remnant vegetation and marine habitat |
| BD 3.1 | Rate of extension of exotic species into IBRA |
| BD 3.2 | Pest numbers |
| BD 4.1 | Distribution and abundance of GMOs |
| BD 5 | Pollution |
| BD 6 | Areal extent of altered fire regimes |
| BD 7 | Human-induced climate change |
| BD 8.1 | Lists and numbers of organisms being trafficked and legally exported |
| BD 8.2 | Number of permits requested and issued for legal collecting or harvesting by venture |
| BD 8.3 | Proportion of numbers collected over size of reproducing population |
| BD 8.4 | Ratio of bycatch to target species |
| BD 9.1 | Number of subspecific taxa |
| BD 9.2 | Population size, numbers and physical isolation |
| BD 9.3 | Environmental amplitude of populations |
| BD 9.4 | Genetic diversity at marker loci |
| BD 10.1 | Number of species |
| BD 10.2 | Estimated number of species |
| BD 10.3 | Number of species formally described |
| BD 10.4 | Percentage of number of species described |
| BD 10.5 | Number of subspecies as a percentage of species |
| BD 10.6 | Number of endemic species |
| BD 10.7 | Conservation status of species |
| BD 10.8 | Economic importance of species |
| BD 10.9 | Percentage of species changing in distribution |
| BD 10.10 | Number distribution and abundance of migratory species |
| BD 10.11 | Demographic characteristics of target taxa |
| BD 11.1 | Ecosystem diversity |
| BD 11.2 | Number and extent of ecological communities of high conservation potential |
| BD 12 | Integrated bioregional planning |
| BD 13.1 | Extent of each vegetation type and marine habitat type in protected areas |
| BD 13.2 | Number of protected areas with management plans |
| BD 13.3 | Number of interest groups involved in protected area planning |
| BD 13.4 | Resources committed to protected areas |
| BD 14 | Proportion of bioregions covered by biological surveys |
| BD 15.1 | Number of recovery plans |
| BD 15.2 | Amount of funding for recovery plans |

**Table 5: Biodiversity indicators for national State of Environment reporting *(continued)***
Each Indicator is referred to in the Report according to its number.

| No. | Title |
|---|---|
| BD 16.1 | Number of *ex situ* research programs |
| BD 16.2 | Number of releases to the wild from *ex situ* breeding |
| BD 17.1 | Number of management plans for ecologically sustainable harvesting |
| BD 17.2 | Effectiveness of bycatch controls |
| BD 18.1 | Area of clearing officially permitted |
| BD 18.2 | Area cleared to area revegetated |
| BD 18.3 | Number of lending institutions considering biodiversity |
| BD 19.1 | Number of management plans for exotic/alien/GMOs |
| BD 19.2 | Number of research programs for exotic/alien/GMOs |
| BD 19.3 | Funding for research and control of exotic/alien/GMOs |
| BD 20 | Control over the impacts of pollution |
| BD 21 | Reducing the impacts of altered fire regimes |
| BD 22 | Minimising the potential impacts of human-induced climate change on biodiversity |
| BD 23.1 | Number of local governments with management plans for biodiversity |
| BD 23.2 | Number of companies with management plans for biodiversity |
| BD 24.1 | Number of species described per reporting cycle |
| BD 24.2 | Number of taxonomists involved per reporting cycle |
| BD 24.3 | Amount of funding for taxonomy |
| BD 24.4 | Number of research programs into surrogates |
| BD 24.5 | Number of research programs into the role of biodiversity in ecological processes |
| BD 24.6 | Number of long-term ecological monitoring sites |
| BD 24.7 | Percentage of budgets spent on conservation |
| BD 24.8 | Amount of Indigenous ethnobiological knowledge |
| BD 25.1 | Local government management of biodiversity |
| BD 25.2 | Involvement of community groups in conservation |
| BD 26 | Australia's international role in conservation |

**Source:** Saunders et al. (1998).

When Saunders et al. (1998) were developing the national level indicators, each one was assessed to see if it would:

1 serve as a robust indicator of environmental change
2 reflect a fundamental or highly valued aspect of the environment
3 be either national in scope or applicable to regional environmental issues of national significance
4 provide an early warning of potential problems
5 be capable of being monitored to provide statistically verifiable and reproducible data that show trends over time and preferably apply to a broad range of environmental regions
6 be scientifically credible
7 be easy to understand
8 be monitored regularly with relative ease
9 be cost-effective
10 have relevance to policy and management needs
11 contribute to monitoring of progress towards implementing commitments in nationally significant environmental policies
12 where possible and appropriate facilitate community involvement
13 contribute to the fulfilment of reporting obligations under international agreements
14 where possible and appropriate use existing commercial and managerial indicators
15 where possible and appropriate be consistent and comparable with other countries and state and territory indicators.

**Figure 4: Australian terrestrial and marine regions derived from IBRA (version 5) and IMCRA, respectively.**

These regionalisations are used as a framework for reporting on several of the biodiversity indicators used in this Report and are being increasingly used as the basis for biodiversity planning in Australia (see list of regions on pages 26–28).

**Source:** Environmental Information Resources Network.

## Reporting scale

The bioregional scale provides a national framework for the conservation and the protection of biodiversity and is used as the basis for reporting for many of the indicators developed by Saunders et al. (1998). The two major regionalisations used in Australia are the: IBRA (Thackway & Cresswell 1995) and IMCRA (IMCRA Technical Group 1998). In Australia, 85 IBRA and 60 IMCRA regions have been identified (Figure 4).

The National Reserve System Program (NRSP) has funded additional studies for the refinement of IBRA regions and in October 2000 a set of revised boundaries was agreed by the

**IBRA (version 5)**

| Name | Region No. |
|---|---|
| Australian Alps | 1 |
| Arnhem Coast | 2 |
| Arnhem Plateau | 3 |
| Avon wheat belt | 4 |
| Brigalow Belt North | 5 |
| Brigalow Belt South | 6 |
| Ben Lomond | 7 |
| Broken Hill Complex | 8 |
| Burt Plain | 9 |
| Central Arnhem | 10 |
| Carnarvon | 11 |
| Channel Country | 12 |
| Central Kimberley | 13 |
| Central Mackay Coast | 14 |
| Coolgardie | 15 |
| Cobar Peneplain | 16 |
| Central Ranges | 17 |
| Cape York Peninsula | 18 |
| Daly Basin | 19 |
| Darwin Coastal | 20 |
| Desert Uplands | 21 |
| Dampierland | 22 |
| Davenport Murchison Ranges | 23 |
| Darling Riverine Plains | 24 |
| Einasleigh Uplands | 25 |
| Esperance Plains | 26 |
| Eyre Yorke Block | 27 |
| Finke | 28 |
| Flinders Lofty Block | 29 |
| Flinders | 30 |
| Gascoyne | 31 |
| Gawler | 32 |
| Gibson Desert | 33 |
| Gulf Fall and Uplands | 34 |
| Geraldton Sandplains | 35 |
| Great Sandy Desert | 36 |
| Gulf Coastal | 37 |
| Gulf Plains | 38 |
| Great Victoria Desert | 39 |
| Hampton | 40 |
| Jarrah Forest | 41 |
| Kanmantoo | 42 |
| King | 43 |
| Little Sandy Desert | 44 |
| MacDonnell Ranges | 45 |
| Mallee | 46 |
| Murray–Darling Depression | 47 |
| Mitchell Grass Downs | 48 |
| Mount Isa Inlier | 49 |
| Mulga Lands | 50 |
| Murchison | 51 |
| Nandewar | 52 |
| Naracoorte Coastal Plain | 53 |
| New England Tableland | 54 |
| Northern Kimberley | 55 |
| NSW North Coast | 56 |
| NSW South Western Slopes | 57 |
| Nullarbor | 58 |
| Ord Victoria Plain | 59 |
| Pine Creek | 60 |
| Pilbara | 61 |
| Riverina | 62 |
| Sydney Basin | 63 |

**IBRA (version 5)**

| Name | Region No. |
|---|---|
| South East Coastal Plain | 64 |
| South East Corner | 65 |
| South Eastern Highlands | 66 |
| South Eastern Queensland | 67 |
| Simpson Strzelecki Dunefields | 68 |
| Stony Plains | 69 |
| Sturt Plateau | 70 |
| Swan Coastal Plain | 71 |
| Tanami | 72 |
| Tasmanian Central Highlands | 73 |
| Tiwi Cobourg | 74 |
| Tasmanian Northern Midlands | 75 |
| Tasmanian Northern Slopes | 76 |
| Tasmanian South East | 77 |
| Tasmanian Southern Ranges | 78 |
| Tasmanian West | 79 |
| Victoria Bonaparte | 80 |
| Victorian Midlands | 81 |
| Victorian Volcanic Plain | 82 |
| Warren | 83 |
| Wet Tropics | 84 |
| Yalgoo | 85 |

**IMCRA**

| Name | Region No. |
|---|---|
| Abrolhos Islands | 1 |
| Anson Beagle | 2 |
| Arafura | 3 |
| Arnhem Wessel | 4 |
| Batemans Shelf | 5 |
| Boags | 6 |
| Bonaparte Gulf | 7 |
| Bruny | 8 |
| Cambridge-Bonaparte | 9 |
| Canning | 10 |
| Carpentaria | 11 |
| Central Bass Strait | 12 |
| Central Reef | 13 |
| Central Victoria | 14 |
| Central West Coast | 15 |
| Cobourg | 16 |
| Coorong | 17 |
| Davey | 18 |
| Eyre | 19 |
| East Cape York | 20 |
| Eighty Mile Beach | 21 |
| Eucla | 22 |
| Flinders | 23 |
| Franklin | 24 |
| Freycinet | 25 |
| Groote | 26 |
| Hawkesbury Shelf | 27 |
| Karumba–Nassau | 28 |
| Kimberley | 29 |
| King Sound | 30 |
| Leeuwin–Naturaliste | 31 |
| Lucinda-Mackay Coast | 32 |
| Mackay-Capricorn | 33 |
| Manning Shelf | 34 |
| Murat | 35 |
| Ningaloo | 36 |
| North Spencer Gulf | 37 |

**IMCRA *(continued)***

| Name | Region No. |
|---|---|
| North West Shelf | 38 |
| Oceanic Shoals | 39 |
| Otway | 40 |
| Pellew | 41 |
| Pilbara (nearshore) | 42 |
| Pilbara (offshore) | 43 |
| Pompey–Swains | 44 |
| Ribbons | 45 |
| Spencer Gulf | 46 |
| St Vincent Gulf | 47 |
| Shark Bay | 48 |
| Shoalwater Coast | 49 |
| Tiwi | 50 |
| Torres Strait | 51 |
| Tweed-Moreton | 52 |
| Twofold Shelf | 53 |
| Victorian Embayments | 54 |
| Van Diemens Gulf | 55 |
| WA South Coast | 56 |
| Wellesley | 57 |
| West Cape York | 58 |
| Wet Tropic Coast | 59 |
| Zuytdorp | 60 |

Commonwealth, state and territory governments. As a result, IBRA version 5 is being developed and where indicated, is used in this Report.

## Other national scale indicators

Two other sets of national scale indicators have or are being developed in Australia. First, ANZECC (2000a) has chosen 13 core biodiversity indicators on the basis that they can be used to report on the state of the environment across jurisdictions within Australia. Many of these indicators have strong links to those recommended by Saunders et al. (1998) as illustrated in Table 6.

The second set of national scale indicators is being developed by the ABS. These represent a small set of headline indicators based on the core objectives of the National Strategy for Ecological Sustainable Development. Six indicators have been identified under the heading in the ABS document *Protecting biodiversity and maintaining ecological processes and life support systems*. Those most directly relevant to biodiversity conservation focus on the extent and condition of representative ecosystems, the health of land and water systems and the number of extinct endangered and vulnerable species and ecological communities.

**Table 6: The ANZECC core biodiversity indicators and their links to National State of Environment indicators**

| Issue | ANZECC indicator | Title | Description | Links to SoE biodiversity indicators (see *Table 5*) |
|---|---|---|---|---|
| Threatening processes | BD 1 | Native vegetation clearing | Rate of clearing in hectares per year of terrestrial native vegetation types by clearing activity | BD 2.1 |
| | BD 2 | Aquatic habitat destruction | Rate of destruction in hectares per year of freshwater and marine habitats by the types of disturbing activities | BD 2.1 |
| | BD 3 | Fire regimes | Area of vegetation burnt by frequency and intensity of burning and type of vegetation | BD 6 |
| | BD 4 | Introduced species | The distribution (and abundance) of non-Indigenous terrestrial, marine and freshwater species (plants, vertebrates, invertebrates and pathogens) identified as pests. This indicator also includes displaced or translocated native species. The identified species will vary with place and time | BD 3.1, BD 3.2, BD 4.1 |
| | BD 5 | Species outbreaks | The number (and identity) of native species outbreaks and the location and area affected | BD 3.2 |
| Loss of biodiversity | BD 6 | Extinct endangered and vulnerable species and ecological communities | Number of species and ecological communities presumed extinct endangered or vulnerable. This indicator should be reported by major group together with the estimated number of endemic species per major group. Applies to animals and plants both terrestrial and aquatic | BD 10.7, BD 11.2 |
| | BD 7 | Extent and condition of native vegetation | The area and condition of native vegetation by type. In the absence of other measures, vegetation assemblages are used as surrogates for ecological communities and ecosystem diversity | BD 11.1, BD 11.2 |
| | BD 8 | Extent and condition of aquatic habitats | The area and condition of marine coastal estuarine and freshwater habitats by type. Marine and estuarine habitat types include algal beds, beaches and dunes, coral reefs, intertidal reefs, intertidal sand/mudflats, mangroves, saltmarshes, seagrass and seamounts. Freshwater habitats include riverine areas and wetlands | BD 11.1, BD 11.2, BD 13.1 |
| | BD 9 | Populations of selected species | Estimated populations of selected species including declining species are an important measure for assessing the conservation status of species. They are also potential surrogates for assessing changes in genetic diversity | BD 10.9, BD 10.1, BD 10.7 |
| Biodiversity, conservation and management | BD 10 | Terrestrial protected areas | Area by vegetation type in protected area categories as defined by the International Union for the Conservation of Nature (IUCN) in hectares as a percentage of the pre-1750 area by IBRA region | BD 13.1 |
| | BD 11 | Marine and estuarine protected areas | The number extent and classification of marine and estuarine protected areas (classification based on IUCN World Conservation Union criteria). Also area as a percentage of each IMCRA region) | BD 13.1 |
| | BD 12 | Recovery plans | Recovery plans for threatened species and ecological communities as required under legislation | BD 15.1, BD 6, BD 9, BD 10 |
| | BD 13 | Area revegetated | The area revegetated by species or genus. In hectares per year, disaggregated into areas revegetated using local vegetation or other vegetation and the purpose of the revegetation | BD 18.2 |
| Marine habitat and biological resources | BD 3 | Total seafood catch | The total catch of fish (excluding aquaculture) disaggregated into: commercial fish catch (by species where possible), discarded catch, landed bycatch and estimated recreational and subsistence catch | BD 8.3, BD 8.4 |

**Source:** after ANZECC (2000a).

# Institutions and policies

## Changing roles and responsibilities

In line with changing understanding of biodiversity and the ways in which it needs to be protected, roles and responsibilities in biodiversity management have changed significantly in Australia in recent years, and continue to evolve. Consideration of all classes of biodiversity indicators—pressure, state, response and implications—are influenced by these changes in terms of who has policy and law-making power, who gathers information and who is involved in management in the field.

The changing roles and responsibilities of the Commonwealth, state and territory governments were outlined earlier (see *The biodiversity challenge: Responsibilities, roles and partnerships* on page 15). Change has occurred within jurisdictions as well. Traditionally a statutory authority (a parks and wildlife authority or service) was responsible in each jurisdiction for almost all practical wildlife protection and nature conservation activities perhaps with a related policy-making branch in a government department. Some jurisdictions have moved away from this with reserve management becoming an activity carried out by a government department (e.g. the Commonwealth after the EPBC Act, although the statutory office of Director of Parks is maintained).

Another model is where the parks service is incorporated into a broader arrangement. This approach is being used in Queensland where the reserve management agency is part of a larger Environmental Protection Authority (EPA). The responsibility for biodiversity has changed often as well, ranging from an environment department to various combinations of agriculture, forestry, water pollution control, cultural heritage planning and land administration. Increasingly, other portfolios (e.g. water, agriculture) have to some extent incorporated biodiversity into their decisions (whether adequately or not).

These changes in the organisation of the public sector are reflected and in many ways are products of broader changes outside of government. The expansion of focus to include off-reserve conservation matches the move away from single government agencies managing reserves. The increasing inclusion of private landholders and community groups in policy formulation management and program delivery has been a feature of the 1990s, as well as the emphasis on self-regulatory approaches by firms and industry sectors and greater focus on the role of local government.

## Partnerships

Not only have the statutory sources of responsibility and the number of organisations protecting biodiversity changed, but also the relationships between these bodies has changed. Few of the initiatives covered in this Report are undertaken by one interest alone. Partnership arrangements are becoming normal rather than the exception and they exist in all combinations between the following:

- governments: state or territory, Commonwealth, local
- community groups representing conservation, development, public health and other interests
- private sector individuals and organisations: landholders, firms, industry associations
- research and scientific practitioners and institutions.

## Statutory policy and organisational settings

Biodiversity conservation in Australia is influenced by an immense array of statutory and policy settings. As it is a deeply cross-sectoral issue, it is doubtful that biodiversity can ever be effectively managed through a small and narrowly focused set of laws and policies.

Only a small proportion of relevant policy and law is subject to the type of monitoring that can provide an accurate evaluation of the effectiveness of biodiversity law and policy. The difficulties of reporting against many ‘Response’ indicators indicate this (e.g. the number of management plans and research programs and the amount of funding spent on control of exotic species).

## Major biodiversity policy, law and programs

There is a range of policy and law of direct relevance to biodiversity. Originally regulation of use and trade of wildlife and declaration and management of a reserve estate was the predominant area of activity. While such regulation remains important in recent years, there has been an expansion of legislative and policy activity especially covering threatened species and ecosystems, and management of biodiversity occurring outside of the conservation reserve estate. This broadening reflects changing understanding of biodiversity issues and the increasing range of recognised social values ascribed to biodiversity.

Key legislation, statutory or other bodies that include representatives from outside government and a selection of major policy initiatives relevant to biodiversity across Australian jurisdictions is shown in Table 7 (see *Local government and biodiversity* on page 164 for the role of local government in managing biodiversity both of its own volition and under state policy and law). Table 7 is incomplete since biodiversity is a cross-sectoral issue and will be influenced by other laws and policies in areas such as taxation, trade and regional development.

**Table 7: Key biodiversity laws, policy initiatives and statutes for Australian jurisdictions**

Acts are listed in chronological order starting from the earliest enactments. The information in this table is not comprehensive and has been assembled from readily available government sources and information made available by a limited number of jurisdictions supplemented by sources such as ANZECC (2001) and Stirling (2000). Absence from this table of a policy or statute on a specific issue does not necessarily mean that such a policy or statute is missing in that jurisdiction. Regarding stakeholder involvement, see also *Involving the community in conservation* (page 172). Inclusion of a statutory organisation or policy in this table in no way implies any judgment as to the efficacy, appropriateness or otherwise of such to biodiversity conservation or any other matter.

| Laws, policy initiatives and statutes | Notes |
|---|---|
| **Commonwealth** | |
| **Key legislation** | |
| *Environment Protection (Impact of Proposals) Act 1974* | Replaced by EPBC Act |
| *Australian Heritage Commission Act 1975* | |
| [A]*Great Barrier Reef Marine Park Act 1975* | |
| [A]*National Parks and Wildlife Conservation Act 1975* | Replaced by EPBC Act |
| *Antarctic Treaty (Environment Protection) Act 1980* | |
| *Whale Protection Act 1980* | Replaced by EPBC Act |
| *Antarctic Living Marine Resources Conservation Act 1981* | |
| *Environment Protection (Impact of Sea Dumping) Act 1981* | |
| [A]*Wildlife Protection (Regulation of Exports and Imports) Act 1982* | |
| *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* | |
| *World Heritage Properties Conservation Act 1983* | |
| *Biological Control Act 1984* | |
| [A]*Endangered Species Protection Act 1992* | Replaced by EPBC Act |
| *National Environment Protection Council Act 1994* | |
| *Wet Tropics of Queensland World Heritage Area Conservation Act 1994* | |
| *Natural Heritage Trust of Australia Act 1997* | |
| [A]*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) | See *The Environment Protection and Biodiversity Conservation Act 1999* box (page 38) |
| *Environmental Reform (Consequential Provisions) Act 1999* | |
| **Selected major policy initiatives** | Includes Commonwealth and collaborative national policies |
| National Strategy for Ecologically Sustainable Development | |
| NSCABD | See text and the *National strategy for the conservation of Australia's biodiversity* box |
| National Principles and Guidelines for Rangeland Management | |
| National Strategy for the Conservation of Australian Species and Communities Threatened with Extinction 1992 | |
| National Framework for the Management and Monitoring of Australia's Native Vegetation | |

**Table 7:** **Key biodiversity laws, policy initiatives and statutes for Australian jurisdictions** ***(continued)***

| Laws, policy initiatives and statutes | Notes |
|---|---|
| National Weeds Strategy | |
| Strategic Plan of Action for the National Representative System of Marine Reserves | |
| National Forest Policy Statement/ RFA process | |
| Australia's Ocean Policy | |
| Coasts and Cleans Seas Program | |
| National Greenhouse Strategy | Includes land cover issues |
| Wetlands Policy of the Commonwealth Government | |
| National Reserves System Program | |
| Action Plan for Australian Birds | Revised 2000 |
| Endangered Species Program (ESP) | |
| Bushcare | |
| Australian Biological Resources Study (ABRS) | |
| National Feral Animal Control Program | |
| National Policy on Fisheries Bycatch (NPFB) | |
| National Strategy for the Management of Acid and Sulfate Soils | |
| Biodiversity Convention and Strategy Program | |
| **Selected statutory and other bodies including non-government stakeholders** | |
| Biodiversity Advisory Committee (BDAC) | Under the EPBC Act |
| Threatened Species Scientific Committee | Under the EPBC Act |
| Indigenous Advisory Committee | Under the EPBC Act |
| Council for Sustainable Vegetation Management | |
| Australian Landcare Council | |
| National Oceans Advisory Group | |
| **Key intergovernmental institutional arrangements involving the Commonwealth** | |
| Australian and New Zealand Environment and Conservation Council (ANZECC) | |
| Intergovernmental Agreement on the Environment | |
| Great Barrier Reef Marine Park Authority | Commonwealth–Queensland |
| Council of Australian Governments (COAG) water reform framework | Includes environmental flows |
| Murray–Darling Basin Initiative | Includes nature conservation |
| **Australian Capital Territory** | |
| **Key legislation** | |
| [A]*Nature Conservation Act 1980* | |
| *Land (Planning and Environment) Act 1991* | |
| *Commissioner for the Environment Act 1993* | |
| *Environment Protection Act 1997* | |
| **Selected, major policy initiatives** | |
| Nature Conservation Strategy | |
| ACT and Subregion Planning Strategy | |
| Greenhouse Strategy | |
| **Selected statutory and other bodies including non-government stakeholders** | |
| Commissioner for the Environment | |
| Environment Advisory Committee | |
| ACT Flora and Fauna Committee | |

**Table 7:** **Key biodiversity laws, policy initiatives and statutes for Australian jurisdictions *(continued)***

| Laws, policy initiatives and statutes | Notes |
|---|---|
| **New South Wales** | |
| **Key legislation** | |
| *Clean Waters Act 1970* | |
| [A]*National Parks and Wildlife Act 1974* | |
| *Heritage Act 1977* | |
| *Coastal Protection Act 1979* | |
| *Environmental Planning and Assessment Act 1979* | As amended |
| *Biological Control Act 1985* | |
| [A]*Wilderness Act 1987* | |
| *Catchment Management Act 1989* | |
| *Rural Land Protection Act 1989* | |
| *Protection of the Environment Administration Act 1991* | |
| [A]*Threatened Species Conservation Act 1995* | |
| [A]*Native Vegetation Conservation Act 1997* | |
| [A]*Marine Parks Act 1997* | |
| *Protection of the Environment Operations Act 1997* | |
| *Environmental Trusts Act 1998* | |
| **Selected major policy initiatives** | |
| NSW Biodiversity Strategy | |
| Native Vegetation Management Strategy | Draft |
| Weeds Strategy | |
| New Weed Incursions Strategy | |
| Vertebrate Pest Strategy | Linked to National Feral Animal Control Program |
| Rivercare | |
| Streamwatch | |
| Coastal Policy | |
| Policy for Sustainable Agriculture | Includes nature conservation |
| NSW Wetlands Management Policy | |
| **Selected statutory and other bodies including non-government stakeholders** | |
| Native Vegetation Advisory Council | |
| National Parks and Wildlife Advisory Council | |
| Healthy Rivers Commission | |
| Council on Environmental Education | |
| State Wetlands Action Group | |
| Forestry Advisory Council | |
| Coastal Council of NSW | |
| Resource and Conservation Assessment Council | |
| Sydney Catchment Authority | |
| Environment Protection Agency | |
| NSW Scientific Committee | *Threatened Species Conservation Act 1995* |
| **Queensland** | |
| **Key legislation** | |
| *Beach Protection Act 1968* | |
| [A]*Marine Parks Act 1982* | |

**Table 7:** **Key biodiversity laws, policy initiatives and statutes for Australian jurisdictions** ***(continued)***

| Laws, policy initiatives and statutes | Notes |
|---|---|
| *Rural Lands Protection Act 1985* | |
| *Local Government (Planning and Environment) Act 1990* | |
| [A]*Nature Conservation Act 1992* | |
| *Queensland Heritage Act 1992* | |
| *Wet Tropics World Heritage Protection and Management Act 1993* | |
| *Land Act 1994* | |
| *Environmental Protection Act 1994* | |
| *Fisheries Act 1994* | |
| *Coastal Protection and Management Act 1995* | |
| *Integrated Planning Act 1997* | |
| [A]*Vegetation Management Act 1999* | |
| **Selected major policy initiatives** | |
| Establishment of Qld Environmental Protection Agency: 1998–1999 incorporating Parks and Wildlife Service | Consolidation of environmental protection and nature conservation administrative arrangements |
| Statewide Landcover and Trees Study | |
| State Policy for Vegetation Management on Freehold Land | |
| Regional Vegetation Management Plans (RVMP) | In process |
| Coastal Management Plan | Draft |
| Coastal Contingency Action Plan | |
| Biodiversity strategy | Proposed |
| **Selected statutory and other bodies including non-government stakeholders** | |
| Wet Tropics Management Authority | |
| Wet Tropics Scientific Advisory Committee | |
| Natural Resource Management Policy Council | |
| Beach Protection Authority | |
| Brisbane River Management Group | |
| Landcare and Catchment Management Council | |
| Queensland Scientific Committee | |
| **South Australia** | |
| **Key legislation** | |
| [A]*National Parks and Wildlife Act 1972* | |
| *Coast Protection Act 1972* | |
| *Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986* | |
| *Soil Conservation and Landcare Act 1989* | |
| *Environment Protection Act 1993* | |
| [A]*Native Vegetation Act 1991* | |
| [A]*Wilderness Protection Act 1992* | |
| *Environment Resource and Development Court Act 1993* | |
| *Water Resources Act 1997* | |
| **Selected major policy initiatives** | |
| Vegetation Cover | |
| Wildlife Conservation Grants | |
| Revegetation Strategy for SA | Including regional plans |
| Biodiversity Plan for the South East | |

**Table 7:** **Key biodiversity laws, policy initiatives and statutes for Australian jurisdictions** ***(continued)***

| Laws, policy initiatives and statutes | Notes |
|---|---|
| Weeds Strategy | |
| Biological Survey of SA | |
| Parks Agenda Program | |
| Marine and Estuarine Strategy | |
| Urban Forest Biodiversity Program | |
| **Selected statutory and other bodies including non-government stakeholders** | |
| Native Vegetation Council | |
| Coast Protection Board | |
| Wilderness Advisory Committee | |
| National Parks and Wildlife Council | |
| Water Resources Council | |
| **Victoria** | |
| **Key legislation** | |
| *Victorian Conservation Trust Act 1972* | |
| [A]*Wildlife Act 1975* | |
| [A]*National Parks Act 1975* | |
| *Planning and Environment Act 1987* | |
| [A]*Flora and Fauna Guarantee Act 1988* | |
| *National Parks (Alpine National Park) Act 1989* | |
| [A]*National Parks (Wilderness) Act 1992* | |
| *Heritage Rivers Act 1992* | |
| *Catchment and Land Protection Act 1994* | |
| *Coastal Management Act 1995* | |
| *Fisheries Act 1995* | |
| *Environment Conservation Council Act 1997* | |
| **Selected major policy initiatives** | |
| Biodiversity Strategy | |
| Coastal Strategy | |
| Native Vegetation Management Framework | Draft |
| Greenhouse Action Statement | Includes Replanting Victoria 2020 |
| Weed Strategy | |
| Commissioner for Ecologically Sustainable Development | Proposed |
| **Selected statutory and other bodies including non-government stakeholders** | |
| National Parks Advisory Council | |
| Scientific Advisory Committee | Under *Flora and Fauna Guarantee Act 1988* |
| Trust for Nature Victoria | |
| Catchment Management Council | |
| Coastal Management Council | |
| Environment Protection Board | |
| Environment Conservation Council | Replaces Land Conservation Council (LCC) |
| Fisheries Co-Management Council | |
| **Western Australia** | |
| **Key legislation** | |
| *Town Planning and Development Act 1928* | |

**Table 7:** **Key biodiversity laws, policy initiatives and statutes for Australian jurisdictions** ***(continued)***

| Laws, policy initiatives and statutes | Notes |
|---|---|
| *Soil and Land Conservation Act 1945* | |
| [A]*Wildlife Conservation Act 1950* | |
| [A]*Conservation and Land Management Act 1984* | |
| *Environment Protection Act 1986–1993* | |
| *Water and Rivers Commission Act 1995* | |
| *Botanic Gardens and Parks Authority Act 1998* | |
| **Selected major policy initiatives** | |
| Western Shield Baiting Program and Return to Dryandra Recovery Program | Feral animal control and native species reintroduction |
| Remnant Vegetation Protection Scheme | |
| Ecoplan | Urban bushland |
| Perth Bush Forever | |
| FishPlan | |
| Wetlands Conservation Policy | |
| Salinity Strategy | |
| Environmental Weeds Strategy | |
| Marine Conservation Strategy | |
| Biodiversity Strategy | Under development |
| **Selected statutory and other bodies including non-government stakeholders** | |
| FarmBush Advisory Committee | |
| Marine Parks and Reserves Authority | |
| Conservation Commission of WA | |
| Threatened Species Scientific Committee | |
| Wetlands Coordinating Committee | |
| Roadside Conservation Committee | |
| Coastal Zone Council | |
| Botanic Gardens and Parks Authority | |
| Waterways Management Authorities | |
| Environmental Protection Authority | |
| **Northern Territory** | |
| **Key legislation** | |
| [A]*Territory Parks and Wildlife Conservation Act 1976* | |
| *Bushfires Act 1980* | |
| *Cobourg Peninsula Aboriginal Land Sanctuary and Marine Park Act 1981* | |
| *Environmental Assessment Act 1982* | |
| *Biological Control Act 1986* | |
| *Fisheries Act 1988* | |
| *Nitmiluk (Katherine Gorge) National Park Act 1989* | |
| *Pastoral Lands Act 1993* | |
| [A]*Parks and Wildlife Commission Act 1995* | |
| **Selected major policy initiatives** | |
| Enhancement of tourism usage and management of reserves | |
| Strategy for Conservation through the Sustainable Use of Wildlife | |
| Regional natural resource management plans | Process established |
| Regional biodiversity surveys | Five completed |

**Table 7:** **Key biodiversity laws, policy initiatives and statutes for Australian jurisdictions *(continued)***

| Laws, policy initiatives and statutes | Notes |
|---|---|
| **Selected statutory and other bodies including non-government stakeholders** | |
| Bushfires Council (BFC) | |
| Pastoral Land Board | |
| Landcare Council | |
| Central Land Council | |
| Northern Land Council | |
| **Tasmania** | |
| **Key legislation** | |
| *National Parks and Florentine Valley Act 1950* | |
| [A]*National Parks and Wildlife Act 1970* | |
| *Whales Protection Act 1988* | |
| *State Policies and Projects Act 1993* | |
| *Environmental Management and Pollution Control Act 1994* | |
| [A]*Threatened Species Protection Act 1995* | |
| [A]*Living Marine Resources Management Act 1995* | |
| *Inland Fisheries Act 1995* | |
| *Resource Planning and Development Commission Act 1997* | |
| *Weed Management Act 1999* | |
| **Selected major policy initiatives** | |
| Threatened Species Strategy | . |
| Action Plan For Whale Rescues: Tasmania | |
| Protected Environmental Values for Tasmanian Surface Waters | |
| State Coastal Policy | |
| Weed Management Strategy | |
| Nature Conservation Strategy | In preparation |
| **Selected statutory and other bodies including non-government stakeholders** | |
| State Biodiversity Committee | |
| National Parks and Wildlife Advisory Council | |
| Environment Protection Advisory Council | |
| Wildlife Advisory Committee | |
| World Heritage Area Consultative Committee | |
| Resource Planning and Development Commission | |
| Board of Environmental Management and Pollution Control | |

[A] Denotes principal nature conservation and biodiversity Acts.

Most policies included in Table 7 have been developed since 1996. The inclusion of statutory and other bodies which in some way include non-government stakeholders also reflects recent change—again most of these arrangements are recent.

## The *Environment Protection and Biodiversity Conservation Act 1999*

At the Commonwealth level, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which came into force in mid-2000, represents a major consolidation of legislation dealing with biodiversity. The *Environment Protection and Biodiversity Conservation Act 1999* box summarises the major features of the EPBC Act that concern biodiversity. With any law of this kind, and especially in this case, the proof of legislative effectiveness lies in the implementation and this cannot be assessed so early in the life of the EPBC Act. Overall, the EPBC Act is considered by many to be a welcome consolidation of biodiversity law. Critical

## The *Environment Protection and Biodiversity Conservation Act 1999*

The new Commonwealth legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), came into effect in July 2000. It aims to define, consolidate and streamline the role of the Commonwealth in environmental protection, assessment of environmental effects on nationally significant places and issues, and in biodiversity conservation. The EPBC Act replaces the following existing legislation: *Environment Protection (Impact of Proposals) Act 1974*, *National Parks and Wildlife Conservation Act 1975*, *Whale Protection Act 1980*, *World Heritage Properties Conservation Act 1983* and the *Endangered Species Protection Act 1992*.

The Objects of the EPBC Act defined at s3 are to:

- provide for the protection of the environment especially those aspects of the environment that are matters of national significance
- promote ESD through the conservation and ecologically sustainable use of natural resources
- promote the conservation of biodiversity
- promote a cooperative approach to the protection and management of the environment involving governments, the community, landholders and Indigenous peoples
- assist in the cooperative implementation of Australia's international environmental responsibilities
- recognise the role of Indigenous peoples in the conservation and ecologically sustainable use of Australia's biodiversity
- promote the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of that knowledge.

The EPBC Act primarily deals with actions of the Commonwealth, Commonwealth areas and matters of national environmental significance. Matters of national significance have been initially defined as: World Heritage areas, Ramsar wetlands, nationally listed threatened species and communities, nationally listed migratory species, nuclear actions and the marine environment.

The principal provisions and procedures under the EPBC Act concerning biodiversity conservation are as follows:

- lists threatened species and ecological communities, migratory species and threatening processes, and the preparation of recovery plans, wildlife conservation plans and threat abatement plans (TAPs)
- creates offences and penalties for activities such as killing, injuring and trading of listed species or communities in a Commonwealth area
- establishes the Australian Whale Sanctuary
- allows for regulations to be developed dealing with access to biological resources in Commonwealth areas
- allows for regulations to be developed to list non-native species that do, or may, threaten biodiversity, control trade in those species and make plans for their management or elimination
- provides for conservation agreements between the Commonwealth and landholders relating to biodiversity, including possible assistance for management; these agreements are binding to successor landholders
- establishes procedures regarding the nomination and management of World Heritage areas, Ramsar wetlands and biosphere reserves
- allows for the declaration and management of Commonwealth reserves, including regulation of activities, management plans and public consultation; 'conservation zones' may be declared as an interim measure prior to declaration of a Commonwealth reserve
- establishes the Indigenous Advisory Committee, Threatened Species Scientific Committee and BDAC.

Any project that will have, or is likely to have, a significant effect on a matter of national environmental significance needs to be approved and assessed under the EPBC Act. To end the duplication of assessing projects under both state and Commonwealth laws, bilateral agreements are being negotiated so that projects that trigger the EPBC Act will be assessed under the laws of the relevant jurisdiction. The accreditation process is meant to ensure that national benchmarks are met. The first bilateral agreement under the EPBC Act was signed by the Commonwealth and Tasmania on 15 December 2000 and negotiations with other states are well advanced.

Several amendments have been proposed to the EPBC Act, including adding a greenhouse trigger (the seventh trigger in the Act) as well as amending the world heritage provisions. In early 2001, the Minister for the Environment, following advice from the Threatened Species Scientific Committee, listed land clearing as a key threatening process to biodiversity. Several further amendments have been proposed but it is yet to be seen if these are incorporated into the EPBC Act.

**Table 8: Commentary on the strengths and weaknesses of the *Environment and Biodiversity Conservation Act 1999* from the Industry and Environmental Defenders Office (EDO)**

| Industry (Cochrane 1999) | | Conservation (NSW EDO; Wells 1999) | |
|---|---|---|---|
| **Criticisms** | **Questions as to the effectiveness of:** | **Criticisms** | **Questions as to the effectiveness of:** |
| Possible duplication and delay involving bilateral arrangements and accreditation of assessment processes | Bioregional planning | Inadequate third party standing provisions | Bilateral agreements |
| Vagueness and wide breadth of triggers for 'national environmental significance' such as World Heritage properties, Ramsar wetlands and threatened species and communities | Conservation agreements | Climate change, vegetation clearance, land degradation, water allocation and forestry operations not identified as issues of 'national environmental significance' | |
| Potential for legal challenges through third party injunctions | Conservation zones | No ability for the public to trigger an impact assessment process | |
| Constraints on prior usage rights on reserves | | Innovative provisions such as those relating to bioregional plans, critical habitat, invasive species and TAPs not made mandatory | |
| | | Independent Commonwealth reserve management authority abolished (functions remain under the office of Director) | |

commentaries on the EPBC Act by industry and conservation interests (Table 8) illustrate some key issues concerning the legislation that may determine the effectiveness of the Act.

Any particular provision of the EPBC Act will be viewed quite differently by different interest groups (Table 8). Other matters under the Act of relevance to future evaluation and reporting are: the functioning of the key advisory bodies (BDAC, Threatened Species Scientific Committee, Indigenous Advisory Committee), the treatment of biodiversity issues under impact assessment procedures (IAP) whether they are Commonwealth or accredited state or territory ones, and the listing and production of plans for threatened species communities and threatening processes.

## The National Strategy for the Conservation of Australia's Biodiversity

The major overarching policy at the national level is the NSCABD, finalised in 1996 by the Commonwealth and the states and territories after consultative development. The Strategy fulfils an obligation to develop a national strategy under the 1992 United Nations CBD. ANZECC (2001) reviewed the implementation of the Strategy. Such detailed reviews of major policies are crucially important to informing future policy and management but are not always carried out. The review of the Strategy forms an important basis for future monitoring of indicators that examines the response of government and society to the pressures on biodiversity. The *Implementation of the 1996 National Strategy for the Conservation of Australia's Biodiversity* box (page 40) presents the summary of progress against the Strategy's objectives in the review.

Although the review of the NSCABD (ANZECC 2001) indicates considerable progress in implementing the Strategy, several issues were identified that, while the subject of existing efforts, need to be advanced over the next few years:

- managing key threatening processes—vegetation clearance, invasive species and dryland salinity
- avoiding future threats—identification of components of biodiversity and key threatening processes, identification and inclusion in management of ethnobiological knowledge, improving integrated management approaches and bioregional planning, and raising public awareness of biodiversity.

## Implementation of the 1996 National Strategy for the Conservation of Australia's Biodiversity

The table summarises the findings of the ANZECC (2001) review of the implementation of the 1996 National Strategy. Opinions will differ among interest groups and stakeholders particularly regarding the degree to which an objective is 'partially achieved' (see also discussions of specific issues and indicators).

**Summary of the ANZECC (2001) review of the implementation of the 1996 National Strategy**

| | | |
|---|---|---|
| **1 Conservation of biodiversity across Australia** | | |
| 1.1 | **Identification**<br>(a) Identify important biological components<br>(b) Identify threatening processes | <br>Partially achieved<br>Partially achieved |
| 1.2 | **Bioregional planning**<br>Manage biodiversity on a regional basis using natural boundaries to facilitate the integration of conservation and production-oriented management | Partially achieved |
| 1.3 | **Management for conservation**<br>Improve the standards of management and protection of Australia's biodiversity by encouraging the implementation of integrated management techniques | Partially achieved |
| 1.4 | **Protected areas**<br>Establish and manage a CAR[A] system of protected areas | Partially achieved |
| 1.5 | **Conservation outside protected areas**<br>Strengthen off-reserve conservation of biodiversity | Partially achieved |
| 1.6 | **Wildlife conservation**<br>Ensure the maintenance of and where necessary strengthen existing arrangements to conserve Australia's native wildlife | Achieved but ongoing effort required |
| 1.7 | **Threatened biodiversity**<br>Enable Australia's species and ecological communities threatened with extinction to survive and thrive in their natural habitats and to retain their genetic diversity and potential for evolutionary development and prevent additional species and ecological communities from becoming threatened | Partially achieved |
| 1.8 | **Biodiversity and Aboriginal and Torres Strait Islander peoples**<br>Recognise and ensure the continuity of the contribution of the ethnobiological knowledge of Australia's Indigenous peoples to the conservation of Australia's biodiversity | Not achieved |
| 1.9 | ***Ex situ* conservation**<br>To complement *in situ* measures establish and maintain facilities for *ex situ* research into and conservation of plants animals and microorganisms particularly those identified by action taken in accordance with Objective 1.1 | Achieved[B] |
| **2 Integrating biodiversity conservation and natural resource management** | | |
| 2.1 | **National integrated policies**<br>Develop and implement national integrated policies for the ecologically sustainable use of biological resources | Partially achieved |
| 2.2 | **Agriculture and pastoralism**<br>Achieve the conservation of biodiversity through the adoption of ecologically sustainable agricultural and pastoral management | Not achieved |
| 2.3 | **Fisheries**<br>Achieve the conservation of biodiversity through the adoption of ecologically sustainable fisheries management practices | Not achieved |
| 2.4 | **Forestry**<br>Achieve the conservation of biodiversity through the adoption of ecologically sustainable forestry management practices | Achieved[B] |
| 2.5 | **Water**<br>Manage water resources in accordance with biodiversity conservation objectives and to satisfy economic, social and community needs | Partially achieved |
| 2.6 | **Tourism and recreation**<br>Achieve the conservation of biodiversity through the adoption of ecologically sustainable practices for tourism and recreation | Partially achieved |
| 2.7 | **Utilisation of wildlife**<br>Achieve the conservation of biodiversity through the adoption of ecologically sustainable wildlife management practices | Achieved |

## Implementation of the 1996 National Strategy for the Conservation of Australia's Biodiversity (*continued*)

**Summary of the ANZECC (2001) review of the implementation of the 1996 National Strategy *(continued)***

| | | |
|---|---|---|
| 2.8 | **Access to genetic resources**<br>Ensure that the social and economic benefits of the use of genetic material and products derived from Australia's biodiversity accrue to Australia | Partially achieved |
| **3 Managing threatening processes** | | |
| 3.1 | **Threatening processes and activities**<br>Monitor, regulate and minimise processes and categories of activities that have, or are likely to have, significant adverse effects on the conservation of biodiversity and be able to respond appropriately to emergency situations | Not achieved |
| 3.2 | **Clearing of native vegetation**<br>Ensure effective measures are in place to retain and manage native vegetation including controls on clearing | Not achieved |
| 3.3 | **Alien species and GMOs**<br>Control the introduction and spread of alien species and GMOs and manage the deliberate spread of native species outside their historically natural range | Partially achieved |
| 3.4 | **Pollution control**<br>Minimise and control the effects of pollution on biodiversity | Partially achieved |
| 3.5 | **Fire**<br>Reduce the adverse effects of altered fire regimes on biodiversity | Partially achieved |
| 3.6 | **Effects of climate change on biodiversity**<br>Plan to minimise the potential effects of human-induced climate change on biodiversity | Not achieved |
| 3.7 | **Rehabilitation**<br>Repair and rehabilitate areas to restore their biodiversity | Partially achieved |
| 3.8 | **Environmental assessment**<br>Ensure that the potential effects of any projects programs and policies on biodiversity are assessed and reflected in planning processes with a view to minimising or avoiding such effects | Achieved[B] |
| **4 Improving our knowledge** | | |
| 4.1 | **Knowledge and understanding**<br>Provide the knowledge and understanding of Australia's biodiversity essential for its effective conservation and management | Partially achieved |
| **5 Involving the community** | | |
| 5.1 | **Awareness and involvement**<br>Increase public awareness of and involvement in conservation of biodiversity | Achieved[B] |
| 5.2 | **Formal education**<br>Expand biodiversity studies in educational curricula | Achieved |
| **6 Australia's international role** | | |
| 6.1 | **International agreements**<br>Support and encourage the development of, and Australia's participation in, international agreements for the conservation of biodiversity | Achieved |
| 6.2 | **Overseas activities**<br>Seek to ensure that the activities of Australians outside Australia are consistent with the conservation of biodiversity | Partially achieved |
| 6.3 | **International cooperation**<br>Ensure continued and effective international cooperation in the conservation of biodiversity between governments or through relevant international governmental and NGOs | Achieved |

[A] Comprehensiveness, adequacy and representativeness.
[B] Denotes significant issues dealt with in this Report where, in the judgment of the authors and on the basis of discussion in the Review, substantive debate is both likely and justified concerning the categorisation as 'achieved'.

**Source:** ANZECC (2001).

## Land clearing approval rates in New South Wales: 1998–2000

The clearing and removal of native vegetation in New South Wales is governed by the *Native Vegetation Conservation Act 1998* (NVC Act) in combination with the *Threatened Species Conservation Act 1995* and the environmental planning law, the *Environmental Planning and Assessment Act 1979*. The NVC Act has objects including the protection of 'native vegetation of high conservation value' and the prevention of 'inappropriate clearing of native vegetation'. These objects are to be achieved 'in accordance with the principles of ecologically sustainable development'.

The NVC Act provides a range of mechanisms for the preservation of native vegetation and for the approval of clearing. The general rule is that in order to clear native vegetation, the development consent must be sought and obtained from the Minister administering the NVC Act. 'Clearing' of native vegetation is defined extremely broadly. The likely effect of clearing on threatened species is assessed as part of the development consent process against a statutory eight-part test.

The NVC Act contains a mechanism for the making of regional vegetation management plans (RVMPs). These plans are intended to be the primary instruments for conservation and management of native vegetation. The rationale for regional planning is to take account of regional variations in vegetation and the specific issues that arise (e.g. clearance of 'woody weeds' in western New South Wales). As of October 2000, no RVMPs have been formally made, although some are at an advanced stage of preparation.

The total area of native vegetation for which approval to clear was granted between January 1998 and August 2000 was 208 360 ha with the largest total amount of clearing approved in the North Coast Central West and Far West regions of the State. To date, most applications to clear vegetation under the NVC Act have received approval. Of the 1525 applications conclusively determined as at October 2000, 91.6% of applications were granted consent with conditions. Only 2.16% of these applications were refused, 1.57% were rejected prior to formal assessment and 4.65% were withdrawn by the applicants.

However, some clearing may not proceed despite successful applications for consent. Further, the total area approved for clearing may be less than the area that landholders originally sought to clear. Departmental documents indicate that in practice all clearing approvals are granted conditionally (DLWC 2001a). These conditions generally require the retention and replanting of trees within the approved area to ensure, among other things, preservation of habitat, and protection against land degradation (DLWC 1999; DLWC 2001a, 2001b).

Although approvals to clear are made subject to conditions, the recent (2000) decision of the Land and Environment Court in *Carr v. Minister for Land and Water Conservation* (2000, p. 175) has thrown some doubt on the Department's approach. The decision overturned a particular development consent on the grounds that specific conditions imposed on the consent to mitigate environmental effects of vegetation clearance had no valid basis in law.

The requirement of the NVC Act to seek consent to clear vegetation is subject to a range of exemptions. These exemptions include purposes ranging from 'private native forestry', 'minimal clearing' (i.e. clearing up to 2 ha per year) and clearing of regrowth less than ten years old. They also cover clearing in the Western Division of New South Wales, clearing on exempt land tenures (e.g. national parks, state forests and listed wetlands), clearing in exempt local government areas and forms of clearing authorised under other legislation (e.g. *Rural Fires Act 1997*). In total, there are at least 37 situations in which clearing may be exempt from the operation of the NVC Act. As the Act contains no notification mechanism for clearing under exemptions, the extent of such clearing is not known or included in statistics showing total vegetation cleared.

According to the Minister for Agriculture (2000):

> Some of the exemptions are poorly defined and open to interpretation. There are also concerns about the cumulative impacts of the exemptions and how they are being monitored and complied with.

The ambiguity surrounding some of the exemptions is causing difficulties in relation to enforcement of the NVC Act (DLWC 2000). In response, a formal review of exemptions was announced in late August 2000. An internal document (DLWC 2000) reviewing the exemptions states:

The exemptions which were meant to act as short term transitional arrangements have become the most problematical part of the Act in terms of achieving compliance.

Further, it says: 'The exemptions appear to be the most significant cause of inappropriate clearing' (DLWC 2000).

It appears there has been little activity regarding formal enforcement of the Act. There have been no prosecutions formally commenced and only nine stop work orders issued since January 1998. By October 2000, 112 warning letters had been sent in response to a total of 471 alleged (but not proven) breaches of the Act. Some observers may conclude that this approach to enforcement may be undermining the effectiveness of the Act in deterring inappropriate and unauthorised vegetation clearance.

In conclusion, the effectiveness of the New South Wales regime for control of native vegetation clearance has been affected by problems of ambiguous exemptions, a willingness to approve most clearing applications and an apparent reluctance to prosecute serious breaches of the NVC Act.

**Source:** James Prest, Centre for Natural Resources Law and Policy, University of

## Albatross and bycatch policy

In 1995, data revealing an estimated take of 44 000 albatross annually through ensnarement on Japanese longlines set for tuna fisheries in the Southern Ocean gained considerable scientific political and public attention. Although applying to all seabirds, it was the threat in particular to vulnerable and endangered species such as the wandering, Amsterdam and northern royal albatross that led to the listing of longline fishing as a key threatening process under the Commonwealth government's [then] environmental legislation, the *Endangered Species Protection Act 1992*. The provisions of this Act have been retained under the new Commonwealth legislation, the EPBC Act. The original Schedule 3 listing triggered a requirement that a Threat Abatement Plan (TAP) for the incidental catch or bycatch of seabirds during oceanic longline fishing be created by Environment Australia. The TAP was to be a nationally coordinated action to alleviate the effect on seabirds of longline fishing in Australian waters.

Although statutorily required within a maximum of three years, the plan took slightly longer to complete. When released, its stated objective was to reduce seabird bycatch to below 0.05 seabirds per thousand hooks: a 90% reduction in bycatch. The TAP also maintained zero bycatch of seabirds in longline fisheries as an ultimate goal, especially endangered albatross and petrel species. The plan adopted two years ago is to be reviewed at the end of five years of operation.

Under the recommended TAP, a series of bycatch mitigation gear and method modifications have been required. These include the use of tori poles or bird scaring devices, the thawing of bait or weighting of lines to increase the sink rate, a prohibition on the discharge of offal from vessels (in particular during setting and hauling), and the practice of night setting when the birds are, in general, less active. There has not been any dedicated measure of bycatch reduction levels since adoption of the TAP, which makes it difficult to evaluate the efficacy of the policy intervention.

Although anecdotal evidence suggests that these modifications have been broadly successful, unnecessary delay and interagency disagreements have hampered the process. Given the limited five-year life of the plan, these delays may prove to be a significant impediment to the successful reduction of longline seabird bycatch. One area where disagreement has proved problematic is that of the level of observer coverage necessary, and the source of funding, to support such a program. Initial studies suggested between 10 and 15% on-board observer coverage, which was costed at more than $3.5 million over three years. Prolonged discussions in this regard have resulted in an interim agreement to trial ten underwater setting devices, gear technology which has been successful in reducing seabird bycatch in longline fisheries in other countries. The approximate $560 000 cost of these trials will be apportioned at 40:60 between industry and government, respectively. In addition, Australia has also taken the lead in negotiating a regional albatross conservation agreement under the auspice of the United Nations Convention on the Conservation of Migratory Species of Wild Animals, which was signed in June, 2001.

**Source:** Dr Sali Bache, Centre for Maritime Policy, University of Wollongong.

Managing such key threatening processes and future threats will be critical if substantive improvements are to be made in biodiversity conservation in Australia.

## Monitoring and evaluating policy and law

Evaluating biodiversity policy is a challenging task with the vast array of biodiversity and biodiversity-related laws, policies and programs (Table 7). Evaluation can take several forms and operate at different resolutions. In this Report, the summary assessments of the application of vegetation clearance controls in New South Wales (see the *Land clearing approval rates in New South Wales: 1998–2000* box on page 42) and implementation of albatross and bycatch policy (see the *Albatross and bycatch policy* box) are evaluations at a finer level. However, such evaluations are time consuming, and unless they have been carried out independently, or the required data are kept in a suitable manner and are easily accessible, it is not possible to conduct evaluations specifically for SoE reporting.

It is unlikely that detailed policy evaluation can ever be part of a broad scale national SoE Report, but the need certainly exists. More difficult again is the evaluation of how well biodiversity issues are incorporated into other policy areas (e.g. transport, trade, regional development and taxation). Such evaluation is certainly outside the scope of SoE reporting and moreover is rarely undertaken in a detailed manner. Yet it is an important issue that governments should consider to ensure that indirect causes of biodiversity loss are attended to.

# Biodiversity issues and challenges

This section considers each of the 65 biodiversity indicators outlined by Saunders et al. (1998) (Table 5). Where available, major supporting data, tables and figures are provided for these indicators, and details given for the key biodiversity issues and challenges facing Australia. The section is grouped into major areas: disturbance regimes and biodiversity, exotic species and GMOs and protecting biodiversity. Several key issues are examined in each major area and the relevant indicators explored.

## Disturbance regimes and biodiversity

This section reports on the following environmental indicators, which are defined in Saunders et al. (1998).

| Environmental Indicator | |
|---|---|
| BD 1.1 | Human population distribution and density |
| BD 1.2 | Change in human population density |
| BD 2.1 | Extent and rate of clearing or major modification of natural vegetation or marine habitat |
| BD 2.2 | Location and configuration or fragmentation of remnant vegetation and marine habitat |
| BD 5 | Pollution |
| BD 6 | Areal extent of altered fire regimes |
| BD 7 | Human-induced climate change |
| BD 8.1 | Lists and numbers of organisms being trafficked and legally exported |
| BD 8.2 | Number of permits requested and issued for legal collecting or harvesting by venture |
| BD 8.3 | Proportion of numbers collected over size of reproducing population |
| BD 8.4 | Ratio of bycatch to target species |
| BD 12 | Integrated bioregional planning |
| BD 13.1 | Extent of each vegetation type and marine habitat type in protected areas |
| BD 13.2 | Number of protected areas with management plans |
| BD 17.1 | Number of management plans for ecologically sustainable harvesting |
| BD 17.2 | Effectiveness of bycatch controls |
| BD 18.1 | Area of clearing officially permitted |
| BD 18.2 | Area cleared to area revegetated |
| BD 20 | Control over the impacts of pollution |
| BD 21 | Reducing the impacts of altered fire regimes |
| BD 22 | Minimising the potential impacts of human-induced climate change on biodiversity |

### Human population growth and density

#### Changes in human population [BD Indicators 1.1 and 1.2]

The relationship between human population and the environment, including biodiversity, is complex. The total environmental effect of a human population is a function of the nature of the environment or resource in question, which is highly variable, and a range of factors that determine the *per capita* environmental effect of each person (Dovers 1997b). These factors include resource consumption, waste production, recreational activities and other direct interactions (e.g. spread of weeds), management or regulatory regimes for land use and the remedial strategies in place.

Human populations in 1997 by IBRA region (Figure 5) and projections for change in population density through to 2006 (Figure 6) show that the pattern of human settlement in Australia is characterised by high rates of urbanisation, low-density cities and the concentration of the population within 50 km of the coast, mainly between Melbourne and Brisbane in south-east Australia and in south-west Australia. In Antarctica, the total Australian population is around 300 people in summer and 75 in winter. The *Human Settlements* Report

describes human population patterns in considerable detail. The focus here is on the potential effects of settlements on biodiversity.

Regions where population growth might increase pressure on biodiversity will depend on the resilience of regional environments and the management (or lack thereof) of the activities of the human population. Considering other indicators reported on in this report, pressures on biodiversity may be exacerbated by growth in human population in several coastal bioregions, especially in southern and eastern Australia. Population decline, such as is occurring in many Australian localities, may also influence biodiversity through a lessened ability to monitor or manage the environment.

Although the generation of population projections by IBRA is useful, population effects are not contained within such boundaries. Flows of people and the associated effects occur across bioregional (and other) boundaries, such as through both domestic and international tourism, the extraction or use of natural resource for consumers elsewhere (e.g. transport corridors or air or waterborne wastes). Such interregional flows of people and their effects on biodiversity point to the need for integrated approaches between different levels of government and other stakeholders, and of the need to incorporate biodiversity considerations into, for example, land use planning and transport policy.

Some people believe, on environmental grounds, that Australia's current human population (estimated as 19.4 million in August 2001) is too high. Others believe that the environmental effect of population growth can be managed. However, population is a complex, cross-sectoral issue and it is likely that the situation varies across different parts of Australia. Although population and settlement issues are managed to an extent through state, territory and local government planning, there is a strong case for national-scale coordination and development in order to consider the possible effects of population change for issues such as biodiversity.

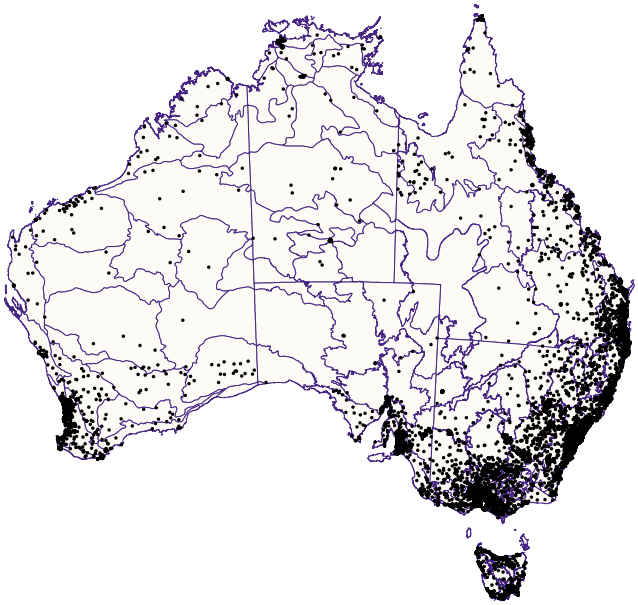


**Figure 5: Human population density in Australia in 1997 showing the concentration of Australians in coastal, urban areas.**

Figures derived from ABS projections. Each dot equals 1000 people.

**Source:** ABS, Statistical Local Area-based projections. Compiled by the Environmental Information Resources Network.

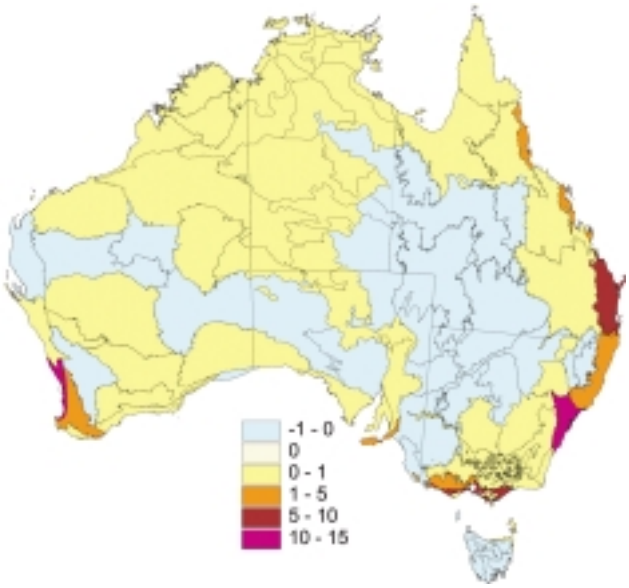



**Figure 6: Projected change in human population density by IBRA region, between 1997 and 2006. The main increases are expected in the coastal regions of southern and eastern Australia.**

Units are persons per square kilometre.

**Source:** derived from the ABS, Statistical Local Area-based projections for 1997. Compiled by the Environmental Information Resources Network.

## Clearing, fragmentation, degradation of native vegetation or marine habitat

The conservation of native vegetation is vital to biodiversity conservation. Vegetation is a key element of biodiversity in Australia since it comprises tens of thousands of plant species, thousands of vegetation communities and assemblages, and provides habitat to myriads of microorganisms and animal species. Native vegetation is also integral to the functioning of landscapes and ecosystems. As a consequence, the clearance and modification of native vegetation has several effects far beyond losing trees, shrubs, grasses and seagrasses.

### Terrestrial vegetation [BD Indicators 2.1 and 2.2]

European occupation of the Australian continent has resulted in significant changes in the extent and condition of native terrestrial vegetation. Clearance of vegetation for agriculture in the higher-rainfall regions, as well as those with more fertile soils and close to settlements, was promoted by governments. In all coastal regions of eastern Australia, this activity resulted in the removal and major modification of many vegetation communities including grassland, mallee and closed forest ecosystems. In some instances, the clearance of regional vegetation

communities approaches 100%. Continental studies of landscape features such as biophysical naturalness (estimate of the extent to which regional plant and animal communities have been disturbed by modern technology), level of disturbance (Figure 7) and wild rivers (Figure 8) indicate that much of continental Australia has been highly modified by human activities, including areas that until recently have remained relatively inaccessible to Europeans.

The broad land use types in Australia have been categorised simply as two regions: the Intensive Land-use Zone (ILZ), and the Extensive Land-use Zone (ELZ). Typically, the nature and extent of vegetation clearance differs significantly between these two zones. Most Australians would be more familiar with the former that includes the intensive agriculture zone of the Murray-Darling Basin where the ecological and biological effects of clearance are increasingly self evident and irreversible. In contrast, the effects of vegetation modification on biodiversity in the ELZ is generally much less obvious to the human eye. Even today, some well-informed scientists and many members of the public think of northern Australia as 'pristine'. This is far from the truth (see *Vegetation modification and fragmentation* on page 51).

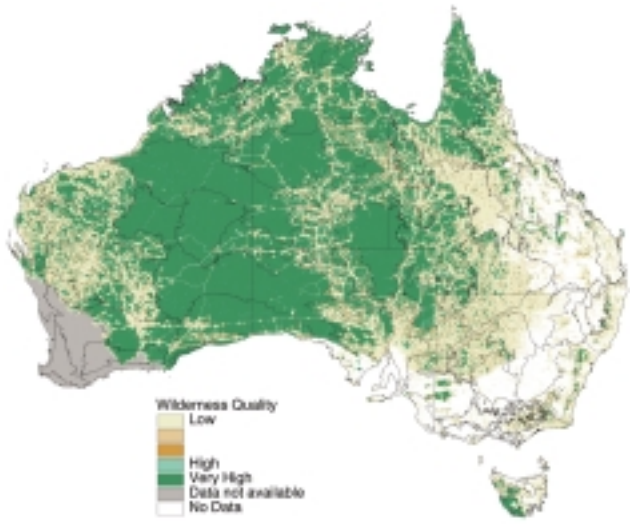



**Figure 7: Extent of land disturbance in Australia.**

Criteria for assessment include remoteness from access, remoteness from settlement, apparent naturalness and biophysical naturalness. (Refer to Lesslie et al. (1995) for methodology).

**Source:** Environmental Information Resources Network.

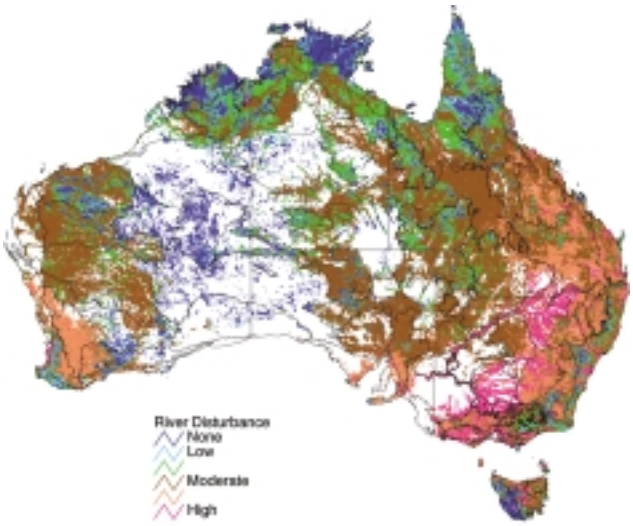



**Figure 8: The River Disturbance Index.**

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

**Source:** Environmental Information Resources Network.

*The effects of vegetation clearance*

The impact of broad-scale vegetation clearance on natural heritage and biodiversity is profound and has been of concern for several decades in Australia. The immediate effect of clearance of terrestrial native vegetation on plant and animal species can be significant. For vertebrate animals, comparative estimates of the population density of woodland birds indicate that between 1000 and 2000 birds permanently lose their habitat for every 100 ha of woodland cleared (Glanznig & Kennedy 2000), while it has been estimated that the clearing of mallee for wheat kills more than 85% of the resident reptiles (Glanznig & Kennedy 2000), on average, more than 200 individual reptiles per hectare. Longer-term effects of native vegetation clearance on species result from habitat loss and fragmentation combined with other threats.

The links between clearance of native vegetation and changes in hydrological cycles are relatively well understood and have serious implications for land management and biodiversity. Vegetation clearance changes the water balance of an area and this may lead to fundamental changes in the local soils and climate, as well as the local water table and its chemical composition (Stirzaker et al. 2000). Extensive clearance of vegetation across a catchment or region may generate 'cascading effects' (e.g. Mac Nally 1999) on the biophysical systems of the area and these changes may be irreversible or difficult to deal with other than through long-term (decade or century) mitigation and restoration strategies (Blackmore et al. 1999).

One recently publicised example of the physical changes that can occur to the hydrological cycle and environment as a result of vegetation clearance is dryland salinity. This has led to the recent development of several state and regional salinity strategies or audits. Western Australia developed their Salinity Action Plan in 1996, and Victoria, New South Wales and the Murray–Darling Basin Commission followed in 1999 to 2000. The most recent assessment of dryland salinity at the national scale was released in early 2001 by the NLWRA (2001). This assessment estimated that 630 000 ha of remnant native vegetation and associated ecosystems were within regions with areas mapped to be 'at risk'. These areas were projected to increase by up to 2 000 000 ha over the next 50 years. Dryland salinity poses a major threat to biodiversity in Australia.

## Salinity, biodiversity conservation and a new National Action Plan

Australia has critical salinity and water quality problems that require urgent attention. At least 2.5 million hectares (5% of cultivated land) are affected by dryland salinity (Commonwealth of Australia 2000) and this could rise to 17 million hectares at the current rate of increase in this type of land degradation (NLWRA 2001). In addition, one-third of Australian rivers are in extremely poor condition (e.g. within 20 years, Adelaide's drinking water is predicted to fail World Health Organization salinity standards in two days out of five). Infrastructure (e.g. buildings and roads) is being severely damaged in many rural urban centres.

Most salinity problems in Australia result from broad-scale land clearing, such as the type of land clearance occurring in Queensland. The clearance of vegetation can fundamentally change the hydrology of an area, and lead to a significant increase in the volume of water draining beneath the normal root zone of the local vegetation. If stored salt is present in the soil or ground water, then hydrological changes may result in salt concentrations dramatically increasing in near-surface soils and/or at ground level.

Dryland salinity can have a serious effect on biodiversity. For example, preliminary findings from a four-year biological survey of the Western Australian agricultural zone indicate that 450 endemic plant species are under threat of extinction from salinity (CALM 2000a). Further, the death of trees and shrubs in many wetlands in the wheat belt as a result of salinity has caused a 50% decrease in the number of waterbirds using them, and without intervention, about 75% of the waterbird species in the region will severely decline. If all wetlands in the wheat belt become saline, well over 200 aquatic invertebrate species will become regionally extinct (CALM 2000a).

In October 2000, 'A National Action Plan for Salinity and Water Quality in Australia' was released by the Commonwealth government. This plan proposes that concentrated action by governments and communities needs to lead to land use change supported by the application of scientific advances in mapping salinity, targeted tree planting and new cropping systems to manage salinity and water quality. The plan identifies high priority, immediate actions to address salinity, particularly dryland salinity, and deteriorating water quality in key catchments and regions across Australia.

The goal of the plan is to:

- prevent, stabilise and reverse trends in dryland salinity affecting the sustainability of production, the conservation of biodiversity and the viability of our infrastructure
- improve water quality and secure reliable allocations for human uses, industry and the environment.

The Action Plan builds on the work established under the NHT, the Murray Darling Basin Commission, state and territory strategies and the COAG Water Agreement. The plan will be implemented through targets and standards for natural resource management, particularly for water quality and salinity, including salinity, water quality and associated water flows, and stream and terrestrial biodiversity based on good science and economics.

To ensure that integrated catchment or region management plans contribute to the achievement of nationally agreed outcomes, catchment or region-specific targets for salt, nutrients, water flow regimes, water quality, stream and terrestrial biodiversity will be required. This capability will need to be able to:

- map salinity hazard using 'ultrasound' technology and assess catchment and region conditions and issues
- maintain and improve the condition of existing native vegetation
- establish multiple purpose perennial vegetation (focused on agriculture, forests, biodiversity and carbon credits) in targeted areas, identified through salinity, vegetation and hydrology mapping, and ground water modelling
- protect and rehabilitate priority waterways, floodplains and wetlands
- improve environmental flows, where this is beneficial
- improve stream water quality using engineering works in critical areas (e.g. salt interception devices and ground water pumping, removal of weirs and redundant structures, fish ladders (to assist fish migrate upstream past structures such as dams) and artificial wetlands)
- install drainage in catchments or regions where agreed by affected land managers, the downstream effects are positive, and the overall benefits of the scheme provide substantial long-term results over other approaches
- address the harder adjustment and property amalgamation issues
- address the problems of degradation of rural urban infrastructure (e.g. buildings and roads).

There are some 20 high priority catchments and regions that need attention, including: the Burdekin–Fitzroy (Qld), Lockyer–Burnett–Mary (Qld), Namoi–Gwydir (NSW), Macquarie–Castlereagh (NSW), Murray (NSW), Goulburn–Broken (Vic.); Glenelg–Corangamite (Vic.), Midlands (Tas.), South-East (SA), Avon (WA), Northern Agricultural Region (WA), South West (WA) and Ord (WA–NT).

The plan acknowledges that land clearing in salinity risk areas is a primary cause of dryland salinity. It indicates

## Salinity, biodiversity conservation and a new National Action Plan (*continued*)

that effective controls on land clearing are required in each jurisdiction, and states that:

- any Commonwealth investment in catchment or region plans will be contingent upon land clearing being prohibited in areas where it would lead to unacceptable land or water degradation
- the Commonwealth will require agreement from relevant states and territories (particularly Queensland, New South Wales and Tasmania) that their vegetation management regulations are effectively used or, where necessary, amended to combat salinity and water quality.

The National Action Plan is intended to promote major systemic improvements in land and water management. The Plan suggests that attention will need to be given to other high priority natural resource management issues such as the broader conservation of biodiversity and preventing productivity decline in other catchments and regions.

In October 2000, the Commonwealth government released a National Action Plan for Salinity and Water Quality (Commonwealth of Australia 2000) to help manage dryland salinity and deteriorating water quality more systematically in key catchments and regions (Figure 9; *A new National Action Plan* box). The National Action Plan explicitly includes the conservation of biodiversity as one of its goals, to help ensure that the policy responses introduced to tackle land degradation are also consistent with the requirements for biodiversity conservation at the landscape level.

Vegetation clearance also results in changes to the physical and chemical composition of soils and may significantly increase the likelihood of soil erosion and nutrient loss (AAS 2000), whereas clearance itself may lead to soil compaction and other physical modifications of the landscape. These changes may affect biodiversity deleteriously, both directly and indirectly (MDBC 1999; Stirzaker et al. 2000).


**Figure 9: Salinity and water quality in Australia showing the major areas of concern.**

The areas shown were identified in the National Action Plan for Salinity and Water Quality (2000).

**Source:** Areas identified in the Prime Minister's launch of the National Action Plan for Salinity and Water Quality (2000).

*Vegetation clearance*

Concern about the fate of the nation's native vegetation and its associated biodiversity led to the adoption of two key targets in *National Strategy for the Conservation of Australia's Biodiversity* (1996) so that by the year 2000:

- Australia will have avoided or limited any further broad-scale clearance of native vegetation, consistent with ecologically sustainable management and bioregional planning, to those instances in which regional biodiversity objectives are not compromised
- Australia will have arrested and reversed the decline of native remnant vegetation.

As will become clear in the following sections, these targets are not close to being met.

*National figures on vegetation clearance:* The most widespread quantitative study of land cover change occurred in the ILZ that covers 38% of the continent (Barson et al. 2000). This study estimated that from 1990 to 1995, about 1 212 000 ha of woody vegetation were cleared for agriculture (cropping), grazing and other activities such as urban development. Although not all of this clearance may result in the permanent loss of woody vegetation, and does not include grasslands or sparse woodlands, these data are a compelling reminder of the spatial extent and intensity of vegetation clearance. These data also indicate that the

**Gully erosion along a creek in Bathurst, NSW.**

**Source:** JE Williams.

relatively high rates of vegetation clearance recorded during the 1980s have continued into the 1990s. Recent data for 1997 to 1999 indicate that the rate and area of native vegetation cleared remains very high, especially in Queensland (Figure 10), and in some cases the rate of clearance has increased over the past three years.

Information about types of vegetation cleared and the nature of landscape modification and biodiversity depletion resulting from vegetation clearance is vital. The effects of native vegetation clearance on the extent of particular ecosystems and ecological communities are well known. For example, the estimated original extent of the Big Scrub (subtropical rainforest between Lismore and Bangalow in northern NSW) was over 75 000 ha. However, by 1900, it had been reduced to about 300 ha scattered over 10 remnant patches. An assessment of areas in Queensland where the dominant vegetation type is Brigalow (*Acacia harpophylla*) shows that of the original estimated extent of more than six million hectares, only about 5% remains, and only about 30 260 ha, or 0.5%, were reserved. Most clearance occurred in the 1960s, and by the 1970s a large portion of the brigalow had disappeared (Nix 1994).

Glanznig and Kennedy (2000) reported that nominations for several biodiversity 'hotspots' that are threatened by vegetation clearance for sugar cane were being prepared by conservation organisations to inform governments of high priority areas for conservation protection. These hotspots include lowland forests, freshwater wetlands, grasslands, littoral rainforest and other ecosystems along the eastern seaboard bioregions of Queensland.

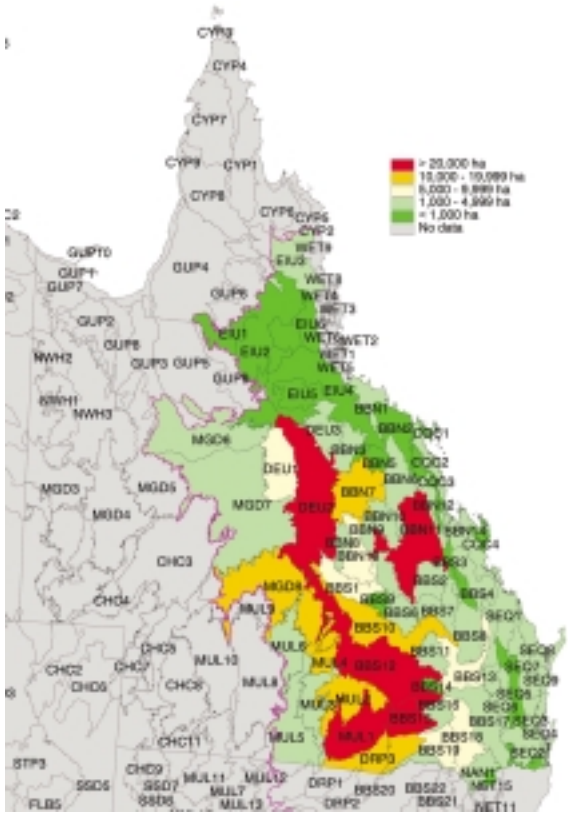


**Figure 10: Area of native vegetation cleared within the ILZ of Queensland between 1997 and 1999 by subregion.**

Indicative map only.

**Source:** EPA, Queensland; AGO. Compiled by: NLWRA, Landscape Health Project, Canberra.

Barson et al. (2000) provided another indication of the changes in particular vegetation types in their review of land cover change in the Intensive Land-use Zone for 1990 to 1995. Using the J. Carnahan broad vegetation mapping as a baseline (Commonwealth of Australia 1990), these authors reported that open forest and woodland ecosystems represented much of the cleared area. For example, 147 650 ha and 515 990 ha of these ecosystems, respectively, were cleared in Queensland between 1990 and 1995. About 350 000 ha of low woodland was also cleared across Australia during the same period, with some 90% occurring in Queensland (Barson et al. 2000). On a more positive note, this and related studies (e.g. Graetz et al. 1995) suggested that the extent of clearance of closed forests such as rainforest is lower than estimated previously.

At the end of the 1990s, the total area of native vegetation that has government sanction for clearing remains high, in excess of one million hectares per year. Rates of clearance varied across Australia, with Queensland estimated to have the highest rate of clearance: about 425 000 ha of vegetation removed per year between 1997 and 1999 (Department of Natural Resources 2000) (see also *Figure 10*).

Various estimates of clearing rates for New South Wales are 14 028 ha per year for 1997 to 2000 (Department of Land and Water Conservation 2001), 30 000 ha in 1999 (AGO 2001) and 100 000 ha in 2000 (ACF 2001). Based on estimates compiled by the ACF (2001), the total area of native vegetation that was cleared in Australia during 2000 was over 564 800 ha; the Australian Greenhouse Office (AGO) estimate for 1999 is 468 844 ha. On available figures, the former area is exceeded by only four other countries in the world: Brazil, Indonesia, DRC (Congo) and Bolivia (Figure 11).

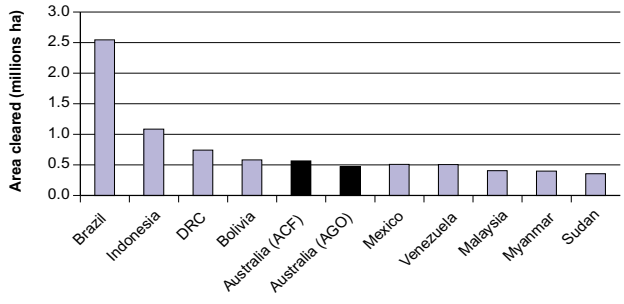



**Figure 11: Countries with highest estimated rate of native vegetation clearance in 1999.**

Australia had the fifth highest rate in the world and is the only developed nation in the top ten countries.

**Source:** After ACF.

*Permits to clear native terrestrial vegetation*

Governments are able to influence the rate of native vegetation clearance through enacting and enforcing

legislation that requires permits to clear vegetation. There is no uniform legislation of this type in Australia. At the Commonwealth level, in early 2001, the Minister for the Environment, following advice from the Threatened Species Scientific Committee, listed land clearing as a key threatening process to biodiversity under the Commonwealth EPBC Act (see *The Environment Protection and Biodiversity Conservation Act 1999* box on page 38). In general, where legislation for land clearance and vegetation management is in place at the state and territory level, it covers woody native vegetation and provides for many exemptions. The legislation rarely applies to all land tenures and is politically controversial in that private property rights, government involvement, economic growth, regional development, land stewardship, Indigenous land rights, land access and biodiversity conservation are contested (Glanznig & Kennedy 2000). In addition, if the legislation is not enforced, it matters little how much is in place.

*Number of permits granted* [BD Indicator 18.1]

During 1999, Australian governments granted permits for clearing a total area of well over one million hectares of vegetation. The State governments of Queensland and New South Wales, alone, granted permits to clear 713 515 ha. Since the completion of SoE (1996), the total area of land for which vegetation clearance permits have been granted each year has generally remained at a relatively high level or increased. Selected examples of the number of permits granted are given below.

*Queensland:* Permits on leasehold land in Queensland increased from 496 957 ha on average between 1995 and 1997, to 644 515 ha in 1999. Recent data reveal that there has been a 31% increase in Queensland land clearing permits for the first six months of 2000 (431 781 ha), compared with 1999 (329 714 ha), and a 104% increase compared with the first six months of 1998 (211 199 ha). Old growth vegetation (bushland) comprises 166 194 ha of the 431 781 ha, with over 90 000 ha of this vegetation type approved for clearing in May 2000 alone.

*New South Wales:* In New South Wales, about 86 000 ha of native vegetation was approved for clearing in 1998, and at least 69 000 ha were approved in 1999. Although few verifiable, concise figures are available, about 40 000 to 50 000 ha per year are reported to be converted to improved pasture or feed crops for cattle, and 5000 to 6000 ha cleared for mixed horticulture (e.g. bananas and mangoes). Numerous proposals exist for major irrigated agriculture and horticulture projects of up to 250 000 ha and some commentators estimate that between 500 000 and one million hectares of native vegetation are earmarked for clearing over the next 10 years (ACF 2000).

Significant areas of native vegetation have been cleared in several regions of New South Wales that support depleted ecosystems. For example, the annual mean clearing rate for 1995 to 1997 in the Cobar Peneplain is estimated to be 13 250 ha. More than one-third of this region's native vegetation has been cleared since European settlement and <2% of the region is protected in the conservation estate. Other regions of major concern because of high annual rates of vegetation clearance, depletion since European settlement and poor reservation include the Brigalow Belt South, Darling Riverine Plains and North Coast.

*Western Australia:* Clearance of native vegetation in south-west Western Australia has been historically high, but is now under strict control. However, even low levels of clearance can have major effects on biodiversity, as it is likely to affect a greater proportion of the remaining vegetation. Effect on issues such as salinity, erosion and water quality are also of serious concern.

*Tasmania:* The Tasmanian government has made a commitment to best practice vegetation management and relies heavily on incentives and cooperation with landowners to achieve this, rather than regulation. On the basis of the available empirical data, this approach is grossly inadequate. The estimated average annual rate of clearance of native vegetation in this State between 1988 and 1994 is 10 429 ha. For 1994 to 1999, the mean rate of vegetation loss declined to slightly under 7000 hectares per year, and vegetation types of conservation significance continue to be cleared (Kirkpatrick & Mendel 2000). This brings the estimated total area of vegetation cleared in Tasmania for 1972 to 1999 (since consistent quantification commenced) to 265 575 ha. The large-scale clearing of native vegetation remains one of the most significant issues affecting Tasmania's natural environment (DPIWE 2000).

*Northern Territory:* Some 10 000 ha of vegetation are estimated to have been cleared in the Northern Territory during 1999, but precise details of the clearing are limited. Data for the Shire of Litchfield indicate the success of clearance applications. The Shire is about 310 000

ha in area, of which 27 000 ha are zoned as conservation, and removal of vegetation is subject to the Litchfield Area Plan 1992. The Plan requires that where removal of vegetation is proposed for an area exceeding 50% of an allotment, the vegetation be removed in accordance with environmental guidelines. Since 1996, requests to clear over 2500 ha of vegetation have been made and all appear to have been granted. The reasons for clearing have included horticultural production (mainly mangoes). Eucalyptus woodland (48%) and Eucalyptus open woodland (25%) were the predominant vegetation types cleared.

*Vegetation clearance: An overview*

The estimates for rates of native vegetation clearance given above underestimate the true picture since they do not account for illegal clearing or clearing carried out under legislative exemptions (which covers regrowth and private forestry). In New South Wales, for example, such exemptions may include 'day-to-day farm management', and in Western Australia exemptions include clearing for urban development. Planning and environmental assessment processes are in place for many urban areas, but the expansion of residential areas is still of concern.

Current technical limitations associated with the use of satellite imagery also may introduce errors and inconsistencies in the estimates of vegetation clearance rates, as can the use of different definitions for vegetation communities. Of particular relevance, the continental-scale monitoring does not pick up clearance of native grasslands or areas where tree cover is sparse, including the large areas of southern Australia where individual scattered trees are a dominant, and very important part of the landscape (see *The nature of fragmented vegetation* on page 53).

The imprecision of data sets that are used to estimate rates of native vegetation clearance can be used by governments to delay action to protect biodiversity. Although not perfect, estimates of the rate of vegetation clearance are indicative of the high rate of clearance, its spatial extent and clearance 'hotspots'. The seriousness of the effects of these human activities on biodiversity is clear, and a far more comprehensive response by governments is required urgently.

The rates of vegetation clearance in Queensland have received particular attention. Although the total area of cleared land is extraordinary by Australian and global standards, the effects on biodiversity resulting from land clearance in States such as New South Wales and Western Australia may be as significant or even more significant. This is because the proportion of vegetation cleared versus the amount remaining might be more significant on biodiversity than the absolute amount cleared. Measures to control land clearance in States such as New South Wales, Western Australia and Tasmania are, therefore, essential to minimise further degradation of the biodiversity associated with the vegetation in these jurisdictions.

New remote sensing techniques, a standardised approach to determining land cover change and further evaluation of methods will undoubtedly improve the precision of current estimates. While these improvements are now actively pursued by government agencies and research institutions, it is very telling that Australia is unable to systematically report on the rate of clearance by vegetation type at the national scale.

*Vegetation modification and fragmentation*

McIntyre and Hobbs (1999) developed a framework describing the range of landscape alteration 'states'. Four landscape alteration states are recognised:

- intact
- variegated
- fragmented
- relictual.

These are associated with increasing amount of habitat destruction and decreasing levels of habitat connectivity. In intact landscapes (e.g. arid rangelands), less than 10% of the vegetation is destroyed and the landscape mosaic is, therefore, 'habitat' in various states of modification. At the other extreme are relictual landscapes (e.g. cropping or urban areas) where over 90% of the vegetation is destroyed and small areas must survive in a landscape matrix which may be hostile to the continued persistence of the vegetation.

The 'intact' landscapes described by McIntyre and Hobbs (1999) largely coincide with the ELZ, which covers around 60% of monsoonal, semi-arid and arid Australia. New data suggest that the relatively contiguous extent of overstorey vegetation in the ELZ, compared with that for the highly cleared ILZ, is not a reliable indicator of the conservation status of

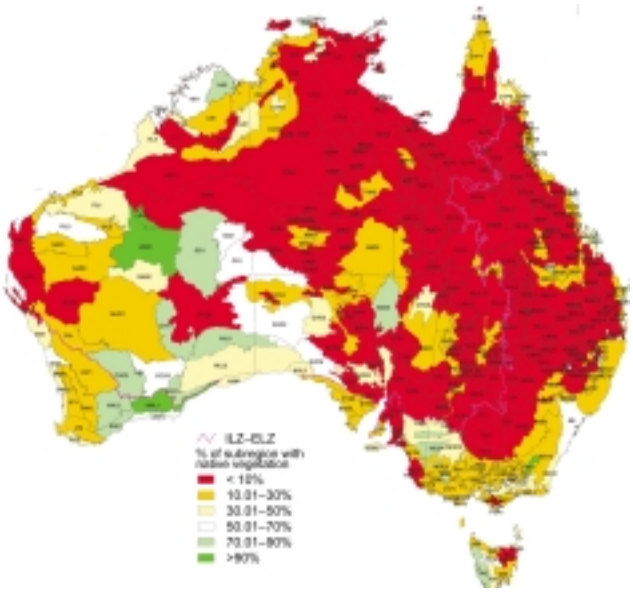



**Figure 12: Percentage of native vegetation in land tenures associated with conservative land use practices (indicative map only).**

**Source:** Bureau of Rural Sciences Landuse Grid; State vegetation coverages. Data currency: land use, 1999; vegetation, NSW 1986–1995; Qld 1997; SA 1985–1995; Tas. 2000; Vic. 1987; WA 2000; NT no data. Compiled by: NLWRA, Landscape Health Project, Canberra.

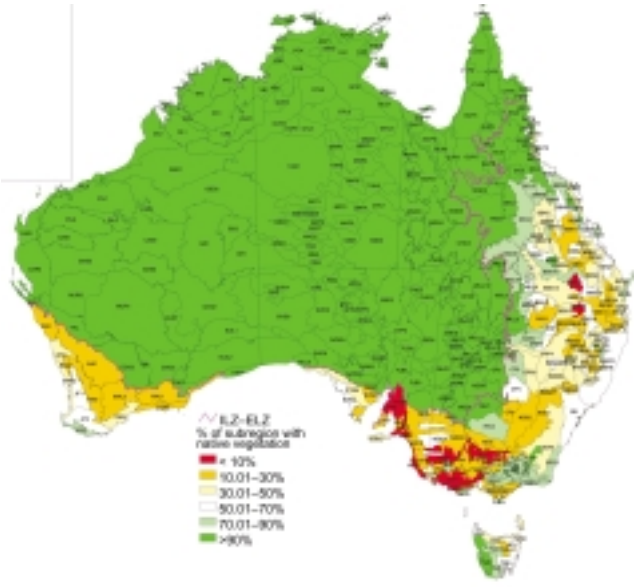



**Figure 13: Current extent of native vegetation by bioregion (IBRA).**

The information on this map has been classed according to the percentage of woody vegetation remaining uncleared, and natural grasslands remaining uncultivated (indicative map only).

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

ecosystems. The disproportionate extinction and regional loss of mammal species for the arid zone and related parts of the ELZ is well known. However, recent and ongoing biological surveys suggest that pervasive changes in these ecosystems (e.g. fire regimes and livestock grazing intensity) that are closely linked to land tenure threaten a diverse range of biota (e.g. Franklin 1999; Fraser 2000; Woinarski 2000). In most instances, the conservation status of native vegetation communities is poor, especially in most parts of the rangelands, arid and wet–dry tropics (Figure 12).

In the ILZ (mainly southern and eastern Australia), large areas of vegetation and its associated biota have been heavily modified (Figure 13) and they generally fall into the fragmented and relictual categories of McIntyre and Hobbs (1999). The clearance of native vegetation disrupts ecosystems and habitats and results in the creation of remnant islands or fragmented patches (e.g. near Jandakot airfield, WA) (Figure 14) and linear fragments along roadsides. These have become important reservoirs of plant and animal species that depend on native habitats. The degree of vegetation modification and fragmentation in these regions and beyond has intensified during the past five years (Figure 15). Figures 13 and 15 overstate the quality of the remaining native vegetation as they are based largely on structural information about the overstorey of communities, but this does not necessarily indicate the quality of the mid-storey and understorey which may be significantly modified as a result of grazing by introduced livestock, weed infestation and other agents of physical and biological change.

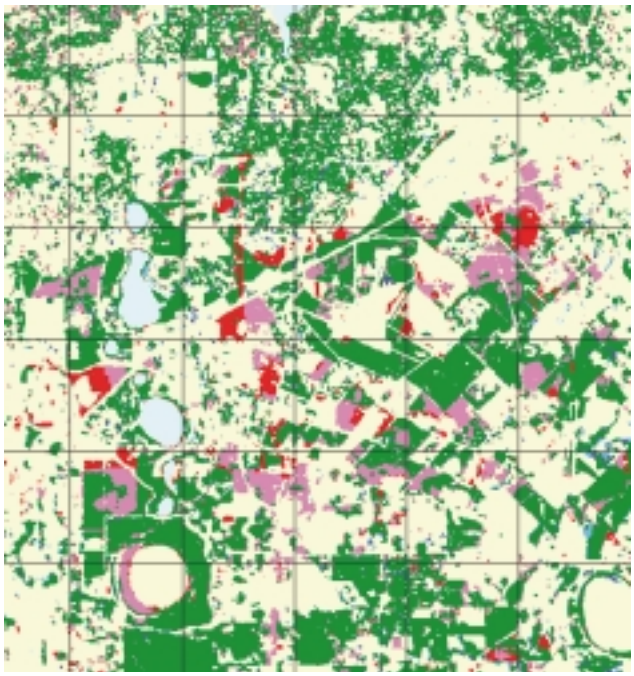
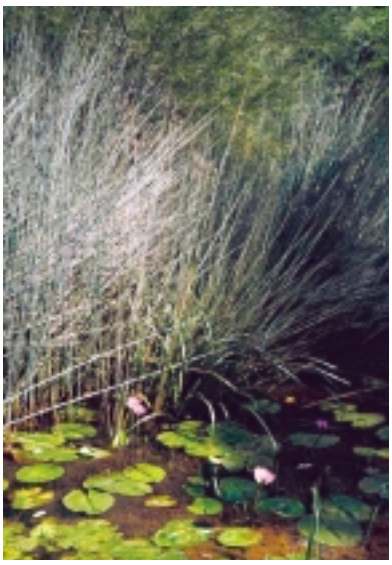


**Figure 14: Periurban clearing between 1988 and 1997 near Jandakot airfield, WA.**

Vegetation cleared 1988–1994 (red), 1994–1998 (pink) and perennial vegetation (green).

**Source:** Multidate clearing histories from Landsat TM data, Land Monitor Project, WA.

Few of the vegetation remnants remaining after clearing are large enough to sustain ecological processes such as water and nutrient cycling at the rates that existed before disruption. Many continue to be disturbed by threatening processes such as invasion by weeds or feral animals coming from the surrounding cleared land and firewood collection (see *Burning the bush* box on page 54).



**A roadside remnant with Giant Blue Waterlily (*Nymphaea gigantea*, foreground) and *Lepironia articulata* (mid-ground) in a coastal creek near Grafton, NSW, that has, as yet, not been highly modified. Both species are more common in Queensland, but reach their southern limit in northern New South Wales.**

**Source:** JJ Bruhl, The University of New England.

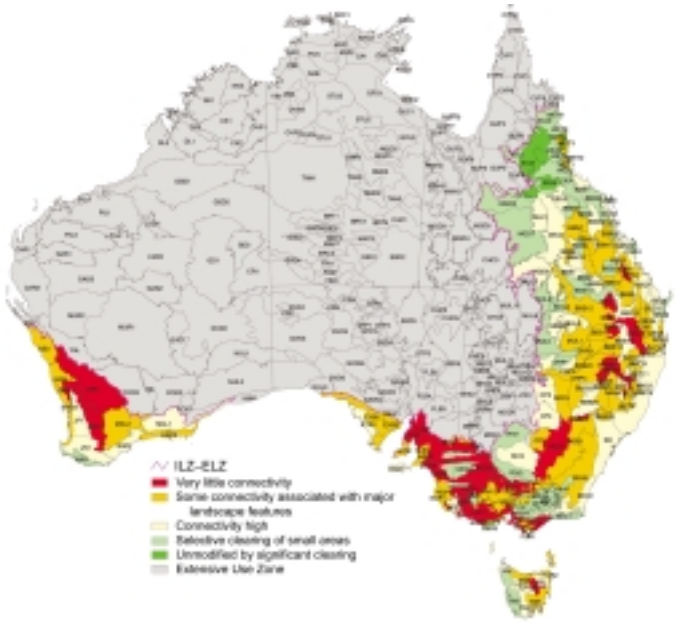



**Figure 15: Mapping of the degree of native vegetation fragmentation.**

Indicative map only.

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

More insidious threats like rising saline water tables and the inflow of fertilisers from surrounding lands are also of major concern. Despite the major threat that dryland salinity poses to native vegetation (see *The effects of vegetation clearance* on page 46 and the *Salinity, biodiversity conservation and a new National Action Plan* box on page 47), mapping of the distribution of major fragmented vegetation types in selected catchments and their likely response to projected hydrological changes has begun only recently (Figure 16). The issue of clearing by 'ecological action' is also critical. Putting a fence around patches of bush and keeping grazing animals out may not be sufficient to prevent further degradation, and in many cases loss, of remnants. Changes in the condition of remnant vegetation, such as the presence or absence of plant regeneration, therefore need to be assessed to guide and improve management.

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

**Source:** JE Williams.

The mapped area in Figure 16 is about 30 by 30 km and shows (in colour) remnant vegetation (green), present mapped salt-affected and low-productivity areas (red), and risk-areas (ghosted in blue and fringed with yellow) that are defined as low-lying areas with the potential for shallow water tables.

*The nature of fragmented vegetation*

The destruction and modification of native vegetation has left a legacy of patches of native vegetation of various sizes, shapes, connectivity and condition. Many of the ecological values associated with native vegetation (Kirkpatrick & Gilfedder 1999; Lambeck 1999) relate to medium to larger patches, although all native vegetation has some role in the landscape (Williams 2000). For example, individual trees provide shade for stock, nesting and foraging sites for wildlife (Lumsden & Bennett 2000), cycle nutrients, act as a source of seeds and may help to reduce ground water recharge and to recycle cations from depth (Reid & Landsberg 2000). The gradual decline in vigour and eventual death of many of these trees has led to a phenomenon known as 'rural dieback'. There are several different causes of this widespread condition and their relative effects can vary in different parts of the farm, on neighbouring farms, in adjacent districts and catchments and between regions (Reid & Landsberg 2000).

## Burning the bush: The implications of firewood collection for biodiversity conservation

Most of the firewood supply in Australia comes from stands of remnant native vegetation on private property (Driscoll et al. 2000; Wall 2000). Firewood collection includes the removal of fallen and standing dead trees from the bush, as well as living trees that are sometimes ringbarked for future use. Overall, the harvesting of wood for domestic heaters means that around five and a half million tonnes per year is burnt, a similar volume to the amount of eucalypt woodchips exported each year (ANZECC 2000c ; Williams 2000). Firewood is, therefore, the third largest source of energy used in Australia after electricity and gas. Around 60% of firewood is purchased through small collectors or suppliers rather than firewood merchants with established premises.

The removal of such large amounts of dead and living wood from patches of bush is considered to have a major effect on the whole spectrum of biodiversity, from ecosystems to genes (Driscoll et al. 2000). Fallen timber provides habitat for insects and other invertebrates, reptiles and ground feeding birds such as the Bush Stone-curlew (Traill 2000). Dead, standing timbers, also targeted by firewood cutters, are more likely to have hollows than live trees and are favoured as nesting sites by possums, parrots, bats and other wildlife. It is also a favoured foraging site for some insects and insect-eating species such as the Brush-tailed Phascogale (Traill 2000). The potential loss of highly specialised species of invertebrates and fungi associated with coarse woody debris is of particular concern (Driscoll et al. 2000). The disappearance of these species from native bushland could affect ecosystem services such as nutrient cycling and plant establishment.

Inland forests and woodlands in lower rainfall zones appear to be the ecological communities most threatened by the collection of firewood (Driscoll et al. 2000). In Victoria, 49 ecological communities have been listed as potentially threatened by firewood collection, emphasising the extent of the problem. At the species level, firewood removal has been implicated in the decline of birds at the local and regional level (see Driscoll et al. 2000), while at the national level, Garnett and Crowley (2000) identified 21 bird species threatened by firewood collection. Plants can also be affected. In Tasmania, 13 species have been listed as threatened by firewood collection. Many of these species have very restricted distributions and it is thought that firewood collectors could inadvertently damage a large proportion of the remaining populations of these plants. The spread of fungi such as *Phytophthora cinnamomi* by firewood collectors is also considered a threat (Driscoll et al. 2000).

Recently at the national level, government and NGOs have paid attention to firewood collection and its effects. For example, in mid-1999, the Victorian National Parks Association held the first national conference on firewood collection, and ANZECC is developing a national approach to firewood collection and use (ANZECC 2000c). The objectives of this strategy are to:

1 protect remnant native vegetation, threatened ecosystems and habitat for threatened and declining wildlife species
2 encourage ecologically sustainable firewood collection from native forest, woodlands and plantations
3 contribute to broader environmental objectives (e.g. improved air quality, dryland salinity, and contributing to carbon sequestration).

The codes of practice proposed for the firewood industry would be voluntary but given the scale of the industry and its significant impact on biodiversity, more concerted and urgent measures are required.

These authors have listed several factors that may cause rural dieback including insect damage, large numbers of Noisy Miners, secondary salinisation, pathogens, drought, nutritional disorders and old age. Most of these are made worse, or are associated with, the broad-scale clearing in the areas where rural dieback generally occurs.

Fragmentation of native vegetation creates new edges between remnants and cleared or disturbed land which leads to 'edge' effects. These include physical changes to the remnant in the border region such as different levels of exposure to the sun and wind and changes in water cycles and the local air temperature (Saunders & Hobbs 1991). Biotic changes include invasion by opportunistic species with good dispersal or colonising abilities such as weeds and feral animals. Fragmentation also isolates and creates barriers between patches of native bush. In most cases, recently isolated remnants can be expected to continue losing species (Saunders & Hobbs 1991). The loss of a population of a species (that has declined to a size that is not viable) may take considerable time if individuals are relatively long lived. For example, it may take several hundred years to lose species of long-lived trees, particularly since adult plants are often less sensitive to changed environmental conditions than plants in their seedling and juvenile stages. This phenomenon also applies to many fauna (e.g. Trapdoor Spiders in the wheat belt of Western Australia may live for at least 23 years (Main 1999)).

The consequences of habitat fragmentation on biodiversity depend on the interaction of many factors that may vary for different species and habitats (see *The Living Landscapes Project* box on page 56). To illustrate the implications of habitat fragmentation on a particular group

**Table 9: Threats to Australian birds**
Threats are divided into those that are continuing and those that no longer occur, either because the taxa are extinct or because the process has ceased and is no longer affecting the surviving birds (see *The relationship between habitat fragmentation and bird abundance and range* box on page 56).

| Clearance and fragmentation of habitat | Current threats | | Former threats | | Total |
|---|---|---|---|---|---|
| | Confirmed | Speculative | Confirmed | Speculative | |
| Agriculture | 32 | 4 | 22 | 9 | 67 |
| Mineral extraction | 2 | 4 | 3 | — | 9 |
| Softwood plantations | 2 | 1 | 2 | — | 5 |
| Urban development | 4 | 3 | 1 | — | 8 |
| Forestry operations | 3 | 14 | — | — | 17 |
| **Total** | **43** | **26** | **28** | **9** | **106** |

**Source:** Glanznig and Kennedy (2000).

of species, the effects of habitat fragmentation on birds is summarised (Table 9) (see *The relationship between habitat fragmentation and bird abundance and range* box on page 56).

*Other impacts on native terrestrial vegetation and associated biodiversity*

Significant modification of native vegetation may result from agents of change other than clearing such as grazing by introduced livestock and native herbivores, changes to the hydrological regimes leading to waterlogging and salinity and altered environmental flows, invasion by weeds and changes in fire regimes. Another threatening process that is receiving increasing attention is the effect of firewood harvesting on remnant native vegetation with current rates of extraction estimated at around 5.5 million tonnes per year, similar to the amount of wood that is exported as woodchips (see the *Burning the bush* box on page 54).

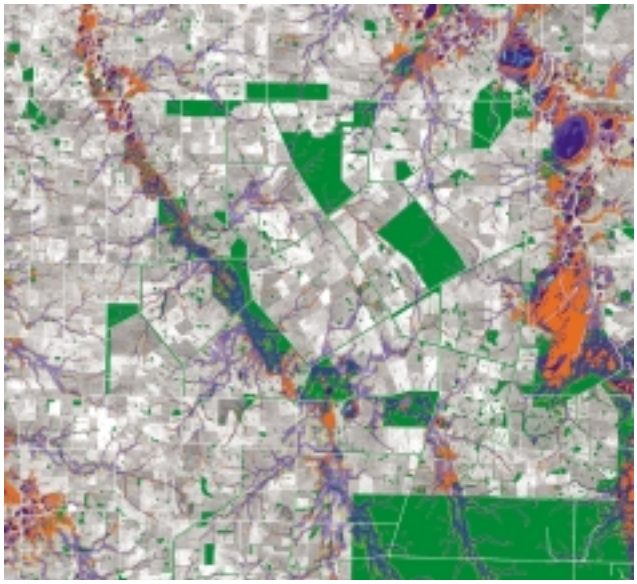


**Figure 16: Salinity risk to remnant vegetation in south-west Western Australia.**

**Source:** Map produced from processed Landsat images and DEM by the Land Monitor Project, WA.

The pressures on biodiversity in old growth forests were identified as a major issue in SoE (1996). At the time, the logging of native eucalypt forests was receiving considerable attention in the national media, especially since the level of wood-chipping of native forests had been very high throughout the decade and many ecologists were seriously concerned about the effects of intensive forestry practices on forest biodiversity and ecosystem services. For example, Norton (1996) argued that many forestry practices in eucalypt forests in eastern Australia were not ecologically sustainable, and that biologically significant forest ecosystems and many native forest biota were threatened. One response of governments to attempt to resolve the debate over native forest management was to initiate the RFA process. RFAs arose from the ESD process of the early 1990s and were intended, put simply, to take care of the reasonable conservation needs of the forests, and then to facilitate economic development in the remaining forests (Kirkpatrick 1998).

Unfortunately, the RFAs do not provide a comprehensive coverage of the native forest estate as there are important areas that have not been assessed. Further, within the regions where RFAs were undertaken, many important conservation needs have not been adequately addressed. For example, several biologically significant ecosystems and species have not been adequately protected, many additions to the conservation reserve network have not been determined using the best available scientific techniques, and the efficacy of a number of forestry management prescriptions remains to be determined (e.g. Kirkpatrick 1998). The implications of these limitations for biodiversity conservation may be amplified since government quotas on wood-chipping were removed on signing of an RFA. Hence, the potential for the intensification of wood-chipping in these regions on public and private lands has significantly increased.

## The Living Landscapes Project: A community based project to develop sustainable landscape management

The Living Landscapes Project is a community-oriented research and strategy development project in the wheat belt of south-west Western Australia, which is attempting to embed biodiversity conservation into catchment and agricultural planning. This pilot planning process considers both agricultural production and broader landscape issues such as nature conservation and ecological health (Frost et al. 2000). The aim is to assist community groups to develop landscape management practices that protect biodiversity within an ecologically viable and sustainable land use system. The Living Landscapes project involved an interdisciplinary team that used experiential learning as an overarching process (Frost et al. 2000). The other key process used was the focal species approach (Lambeck 1999). By combining these two approaches, Living Landscapes has developed a set of guiding principles for nature conservation planning in the context of sustainable land management. The approach is now being considered in several regions in eastern Australia.

## The relationship between habitat fragmentation and bird abundance and range: A case study

Studies have investigated the medium- to long-term effects of fragmentation on different groups of species, in particular, birds and mammals. In relation to birds, Table 9 summarises the threats to the 150 taxa described in a Royal Australasian Ornithologists Union report on threatened and extinct birds of Australia (Garnett 1992). The threats are divided into those that are continuing and those that no longer occur, either because the taxa are extinct or because the process has ceased and is no longer affecting the surviving birds. For instance, the clearance of mallee in the Western Australian wheat belt has now almost stopped but the effects on fragmented populations are continuing.

Table 9 highlights the prevalent threat of clearance and fragmentation of habitat, especially resulting from the conversion of land supporting native vegetation to use for agricultural purposes. Numerous studies in many States have concluded that bird abundances are directly related to the degree of habitat loss and fragmentation, and heavily fragmented areas will be accompanied by net losses of species which can continue long after the initial clearing (Recher & Lim 1990). In Western Australia, Saunders (1989) found that a rapid loss of species had occurred in wheat belt reserves since the clearance of the original vegetation 30 to 50 years ago. This finding has been reinforced by a more recent study which showed that 49% (95 of the 195 species) of birds recorded in the wheat belt (excluding vagrants) have declined in range and/or abundance since the region was developed for agriculture. Most of these losses result from loss of habitat and fragmentation of the remainder. This general pattern of regional loss and decline of bird species has been repeated in other States such as New South Wales (Reid 2000a, 2000b) and Victoria (Bennett & Ford 1997).

The degradation of habitat by removal of the understorey of forest and woodland ecosystems, through grazing for example, is also significant since it can simplify these ecosystems and result in the loss of species and genetic variability. For example, a study in the Latrobe Valley of south-east Victoria found that small, heavily grazed patches (less than 10 ha) supported fewer forest birds and an increased number of farmland birds, including Noisy Miners (*Manorina melanocephala*), which aggressively excluded other species. Few birds ate insects in the canopy of these patches, which showed signs of dieback due to insect damage. Planting understorey species may be the most effective way to exclude Noisy Miners and encourage other native bird species.

Recher (1999) predicted that if immediate action was not taken to reverse the decline of native birds, then Australia would lose half of its terrestrial bird species in the next century. The most urgent actions identified were to end the clearing of native vegetation, remove inappropriate fire regimes, control feral and native animals whose abundance threaten native species and restore functional ecosystems.

**Source:** after Glanznig and Kennedy (2000).

Climate change is another major threat to native vegetation (see *Human-induced climate change* on page 96).

Effects of grazing on vegetation and biodiversity in Australian semi-arid and arid rangelands have been quantified (Landsberg et al. 1999) using artificial sources of water (tanks and dams, bores, waterholes and wells) as a measure of potential effect by livestock. Most large mammals require regular access to drinking water, and in arid environments its availability determines where they graze. Thus, sources of water become foci of grazing activity. This may result in a zone of accentuated impact around each water point where the vegetation is browsed and perhaps killed, soils are compacted and habitat for various flora and fauna is modified or destroyed (see the *Land* Report). CSIRO Sustainable Ecosystems has mapped the location of artificial sources of water to evaluate the potential effect on biodiversity (Figure 17), and has concluded that vast areas of the rangelands previously beyond the reach of large grazing animals may now be exposed to sustained grazing pressure. Further, few potential reference areas for determining pregrazing patterns of biodiversity now remain (Figure 18).

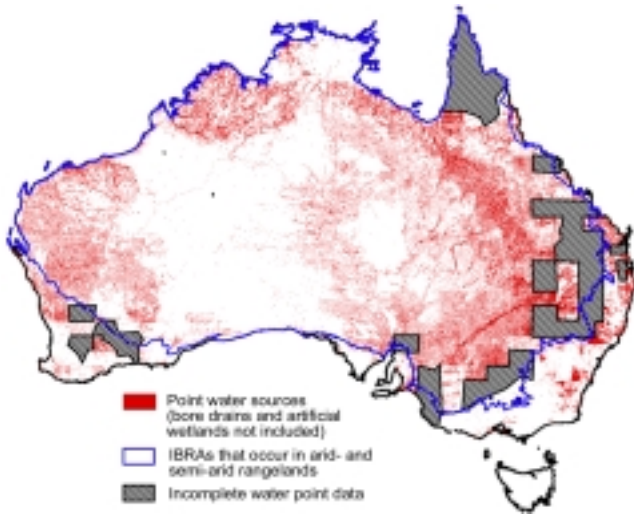



**Figure 17: Distribution of all water points named on the 1:250 000 and 1:100 000 topographic maps covering mainland Australia.**

**Source:** National Land Disturbance Database, AHC; CSIRO Sustainable Ecosystems.

Surveys of water points for the Biograze project revealed that the effect of grazing by cattle is minimal beyond 9 km and beyond 6 km for sheep. Therefore, the map is a conservative estimate of the impact of grazing for sheep. The water point data are accurate for rangeland regions in central, northern and western Australia. Areas closer to the coast, especially in south-west and south-east Australia, have too many water points to be mapped. Consequently the figures provided in these regions are an underestimate. The areas masked out of the analysis had incomplete datasets.

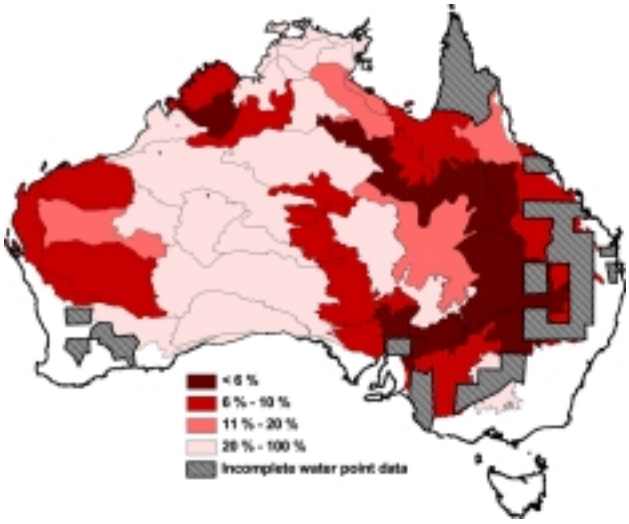



**Figure 18: Proportion of IBRA regions >9 km from a watering point.**

**Source:** CSIRO Sustainable Ecosystems.

Declines in temperate woodland ecosystems arise from proximate factors such as population reduction and species extinction, genetic loss, substrate modification and salinity (Sivertsen & Clarke 2000). Clearing for grazing and grazing of the understorey of these ecosystems by introduced livestock and feral animals have been identified as important threats (e.g. Kirkpatrick & Gilfedder 2000; Landsberg 2000; Lunt & Bennett 2000). Typically, grazing and related human-driven disturbances exacerbate the deleterious effects on biodiversity resulting from the extensive clearance of lowland woodland ecosystems. These types of degradation of ecosystems have been conceptualised as part of an underlying slow process of desertification (Bauer & Goldney 2000). In general, as grazing pressure increases, native species become less abundant and are replaced by exotic species (Yates et al. 2000). However, under certain circumstances, grazing animals do not need to be totally excluded from native vegetation and in some instances the presence of grazing has been associated with the maintenance of high conservation values at a site (Williams 2000).

*Regrowth vegetation*

Conservation of vegetation regrowth is vital for biodiversity conservation. Regrowth is important because it may provide habitat for key elements of biodiversity that have been affected by vegetation clearance and fragmentation. Regrowth is also important in supporting and sustaining biophysical and ecological processes. For example, as vegetation regrows, the structural, floristic and biological composition of areas change and may reduce the extreme nature of habitat fragmentation for resident species, and favourably modify local climate and environmental regimes (e.g. energy, radiation, light and exposure to extremes in ambient temperature) (Saunders & Hobbs 1991). The notion that regrowth vegetation has little or no value for biodiversity seems widespread, and one consequence of this is that regrowth

clearance may proceed without adequate planning, or may not be challenged even when it threatens significant components of biodiversity (Kirkpatrick & Gilfedder 1999).

*No net loss:* The policy of 'no net loss' of native vegetation (e.g. Bushcare's target within Australia by July 2001, as per Department of the Environment and Heritage—Porfolio Budget Statement 2000–2001), and the associated policy of offsets (to negate the negative effect of clearing by separate actions that have positive effects), are being considered by several jurisdictions. There are many issues associated with these policies that could have long-term effects on biodiversity. For example, replacing mature woodland with an equivalent area of saplings could satisfy the no net loss criteria, but these two vegetation types are very different in structure and function. Once the original vegetation disappears from a site, then it is difficult, if not impossible, to recreate it. And although revegetation projects are becoming increasingly sophisticated, it will take decades to develop the characteristics of the original vegetation (i.e. being self sustaining), especially the benefits provided by large trees. These not only provide hollows on which many Australian birds and mammals depend, but they produce a more reliable and extensive source of nectar for a range of fauna (Wilson & Bennett 1999). Consequently, there is general agreement that the first step to sustainable management is to retain existing native vegetation where possible (Williams 2000). The next steps are to protect and manage that vegetation and then, where appropriate, to revegetate cleared areas.

Offset actions for native vegetation clearing could include improving the management of existing native vegetation, revegetating a previously cleared area or establishing a tree plantation. Biodiversity conservation would be undermined by these types of activities if exemptions (e.g. vegetation of high conservation could not offset and thus be cleared) were not comprehensive and legally enforceable. State management agencies in New South Wales are attempting to benchmark the concept of biodiversity credits (biodiversity values in major ecological communities such as woodlands, rangelands and forests) to provide a basis for trading (see *The Australian private sector and biodiversity* on page 167).

In 1997, the Victorian government released Victoria's Biodiversity Strategy. One important goal of this strategy package is to achieve a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation. This is designed to lead to a 'net gain' in vegetation with the first target being no net loss by 2001 (The State of Victoria 1997). In this case, the goal of no net loss was based on the premise that (although 'natural' is best) it is possible to recover the extent and quality of native vegetation by active management intervention (The State of Victoria 1997). Questions relevant to this goal include whether the plant species in the vegetation patch are locally native, whether are there enough of the locally native species remaining in a patch to warrant inclusion of the patch in accounting for native vegetation and when revegetation could be classified as part of the State's native vegetation estate.

*Restoring vegetation:* Tree replanting schemes and similar activities are now supported by government, industry and community. However, frequently the amount of vegetation replaced may be orders of magnitude less than the loss of plants as a result of clearing, modification, dieback and other threatening processes. For example, the goal of the Bushcare program, which is the largest in the NHT, is to reverse the long-term decline in the quality and extent of Australia's native vegetation cover. This ambitious goal will not be met, at least in the short term, because of the continuing broad-scale clearing in areas such as Queensland and New South Wales.

Paton et al. (2000) reviewed the distribution, status and threats of woodland ecosystems in South Australia and suggest that future revegetation strategies in the State need to include a greater diversity of plants, use locally endemic species and plant these in natural dispersion patterns to maximise biodiversity benefits.

The removal of extensive areas of deep-rooted perennial native vegetation and replacement by shallow-rooted annual crops and pastures has significantly affected the hydrological cycles of many regions. As a result, the water table that was formerly drained by the deep-rooted vegetation is rising to the soil surface (see *Salinity, biodiversity conservation and a new National Action Plan* box on page 47) at rates of up to 0.5 m per year and at least 2.5 million hectares are affected by dryland salinity. Up to 80% of some catchments in Western Australia, for example, may need to be replanted with trees to reverse the rising salinity, and some salinised streams may already be beyond recovery in this region (Glanznig & Kennedy 2000). Clearly, where revegetation and restoration is possible, catchment-based strategies need to be consistent with biodiversity conservation.

Vegetation restoration is a relatively young science and until recently in Australia has focused on ecosystems and vegetation communities where mining and intensive forestry operations have been undertaken. Restoration of native vegetation can be attempted by active (e.g. planting and soil inoculation strategies) or passive (e.g. natural regeneration) means. While the ability to restore a cleared vegetation community or highly modified community to its original state in terms of species composition and ecosystem function is largely untested, substantial progress has been made in the development of techniques to restore some components of the biota to mine sites (e.g. Nabalco, Gove bauxite mine in northern Australia).

*Area cleared or modified to area revegetated* [BD Indicator 18.2]

Increases in woody vegetation (woody plants greater than 2 m in height and 20% cover) in Australia's more intensively used agricultural areas for 1990 to 1995 were found to be 414 000 ha (excluding that due to regeneration following fire and native forest harvesting) (Barson et al. 2000). The estimated loss of woody vegetation for the same period was 1 282 200, including clearing for agriculture, mainly cropping (213 680 ha), grazing (929 280 ha), on-farm tree planting (1 760 ha) and plantation management (90 160 ha). This shows a net loss of native woody vegetation for the period.

Recent work on landscape design principles and guidelines is attempting to enhance the rehabilitation and restoration of (at least) terrestrial landscapes. Examples of guidelines and principles are the perceived thresholds for vegetation cover (i.e. a minimum of 30% tree cover is being recommended in temperate and subtropical regions not experiencing severe salinity) (see Barrett 2000a; Williams 2000) and the focal species approach being used for revegetation of cleared agricultural landscapes (Lambeck 1999).

*Plantations:* The practice of commercial plantation forestry is expanding across many regions of southern Australia. A recent study based on computer modelling of 12 regions by the Australian Bureau of Agriculture and Resource Economics (ABARE) suggests that some 19 million hectares of cleared agricultural land may be suitable for commercial plantations (Burns et al. 1999). Potential expansions of this scale may have significant implications for regional development and infrastructure, and biodiversity conservation. For example, the preparation of land for plantation establishment may involve a significant input of fertiliser and the use of chemicals to control weeds and poisons to control native vertebrate herbivores. These inputs can directly and indirectly affect biota.

*Aquatic systems*

Vegetation clearance, vegetation modification and intensive land use also affect aquatic plant ecosystems and freshwater fisheries. Bunn et al. (1999) demonstrated that native vegetation that overhangs streams and rivers is important in moderating water temperature, which in turn affects native fish and other biota.

Acid sulfate soil poses another potential threat to biodiversity. These soils are rich in iron sulfide and are common in coastal areas. They are relatively stable while saturated with water, but the sulfide forms sulfate and sulfuric acid when drained and exposed to air. The sulfuric acid can kill fish, prawns, oysters and other aquatic life when washed into waterways by rain. Iron sulfate soils on which vegetation is regrowing can also cause problems once they become exposed. The Coastal Acid Sulfate Soils Program, which is managed by Environment Australia through the NHT, has provided funding for projects with onground works that demonstrate better options for managing coastal acid sulfate soils.

By area, most stream catchments have been subjected to medium to high levels of disturbance, including significant portions of the Gulf of Carpentaria Drainage Basin, Lake Eyre Drainage Basin and Bulloo Drainage Basin that support a relatively low human population density. Aquaculture also affects aquatic plant ecosystems and related parts of the catchments used for this purpose. Data on the current and potential effects of aquaculture on biodiversity are limited and disparate. The extent of aquatic systems for which cultivation permits have been granted are increasing and suggest this issue needs further investigation. For example, of the 567 lakes in western New South Wales, 70 (74 136 ha) have government permits for cultivation.

*Extent of each vegetation type within protected areas* [BD Indicator 13.1]

In a Statement on the Environment by the Australian Prime Minister in 1992 (Commonwealth of Australia 1992c), it was announced that 'The Government has adopted a policy that all ecosystems be surveyed and that a comprehensive, adequate and representative

system of reserves be established progressively by the year 2000'. The National Reserve System Program was designed to deliver this outcome.

The NRSP and related state and territory programs, the RFAs, the Indigenous Protected Areas (IPA) scheme of Environment Australia, new multitenure management schemes, and the enormous growth in contributions from the non-government sector (e.g. Trust for Nature and Bush Heritage Fund) have helped to increase the spectrum of the nation's system of conservation reserves. Even so, many anomalies exist and very few regions in Australia support a conservation reserve system that meets all of the requirements of comprehensiveness, adequacy and representativeness (CAR) (Figure 19).

The representation of major vegetation types within the Australian conservation reserve estate remains poor despite the long-standing recognition of the need to enhance the reservation and protection of these ecosystems. In Queensland, for example, native vegetation is typically underrepresented in the conservation estate, including in those areas (e.g. around Charleville and Emerald) where rates of land clearing are very high by international standards and threats to biodiversity are extraordinarily high. Sattler and Williams (1999) reported that over half of the 287 regional ecosystems in the Mulga Lands, Desert Uplands and Brigalow Belt bioregions in Queensland are endangered or threatened with extinction (Table 10). Only 63% of these endangered and threatened ecosystems are represented in the conservation reserve system of these bioregions and less than one-third of these ecosystems is found in more than one protected area.

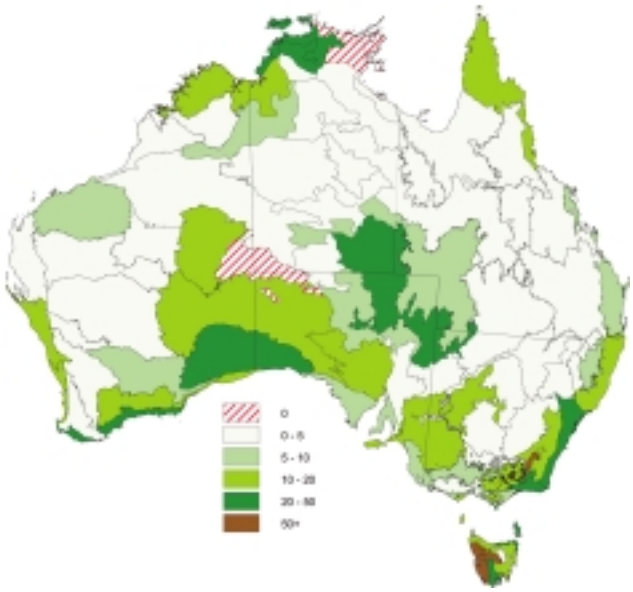



**Figure 19: Conservation status of Interim Biogeographic Representation for Australia (IBRA) in 2000 showing the percentage area reserved in each region.**

**Source:** Environmental Resources Information Network.

**Table 10: Reservation status of regional ecosystems (REs) in Queensland subject to high rates of clearing and their degree of replication in protected areas of over 1000 ha**

| Bioregion | Regional area (ha) | Protected area[A] | No. of REs in bioregion | REs endangered or threatened (%) | No. of REs in protected areas | REs in protected areas[B](%) | REs in >1 protected area[A](%) |
|---|---|---|---|---|---|---|---|
| Mulga Lands | 19 097 000 | 464 900 | 66 | 41 | 47 | 71 | 39 |
| Desert Uplands | 6 882 000 | 153 800 | 58 | 63 | 25 | 43 | 9 |
| Brigalow Belt | 35 158 000 | 730 400 | 163 | 43 | 110 | 67 | 39 |
| Total | 61 137 000 | 1 349 100 | 287 | 51 | 182 | 63 | 29 |

[A] Protected areas current to 28 February 1998; [B]Care should be taken in comparing this table with tables previously published (e.g. Sattler 1986), because of the progressive refinement of REs and bioregional boundaries, and additions to the protected area estate.

**Source:** after Sattler and Williams (1999).

New South Wales is one of the more 'data-rich' parts of Australia, although its detailed biological data sets, like others elsewhere, are localised. To overcome this limitation, Pressey et al. (2000) have developed a new classification of landscapes at a scale of 1:250 000 across the whole 802 000 square kilometres of New South Wales. The classification is derived mainly from abiotic data (e.g. topography, soils and climate) and, in conjunction with new data on native vegetation cover, has allowed the first quantitative state-wide review of protected areas and future priorities at a scale that approaches decisions about land use. Pressey et al. (2000) found that most of the 1486 landscapes in New South Wales are poorly reserved relative to an indicative conservation target of 15% of the total area of each.

In the eastern 60% of New South Wales, gaps in the reserve system are related to the concentration of reserves on land with high ruggedness and low potential for intensive land use. Pressey et al. (2000) mapped the relative priority of landscapes to indicate the urgency of conservation action to prevent conservation targets being compromised (or further compromised) by clearing of native vegetation. Mapping of priorities shows large differences within and between natural regions and land tenures. More than 9% of private land is occupied by high-priority native vegetation and, across the whole State, about 85% of

high-priority vegetation occurs on private land. This indicates the importance of controlling vegetation clearance on private land if biodiversity effects are to be avoided.

## Biodiversity effects of clearing, fragmenting and degrading marine habitat [BD Indicator 2.1]

Australia's marine environment extends from the shores and wetlands along the coastline to the abyssal deep, and from the coral reefs of Torres Strait in the north to the pack ice of the antarctic continent in the south. The warm tropical waters off northern Australia are only 1000 km from the equator while the nation's coolest waters are some 3700 km to the south (Zann 1995). From east to west, the coastline of the Australian continent spans a distance of almost 4000 km, from Cape Byron to Shark Bay. The marine environments include extensive, well-developed and specialised reef systems, giant kelp forests, seagrass meadows, mangrove ecosystems and near-shore systems, and sand and mud-bottomed habitats that cover much of the continental shelf.

### *Effects on marine and coastal biodiversity* [BD Indicators 2.1 and 2.2]

Several human activities destroy or significantly modify and degrade marine habitat and its associated biodiversity. These threatening activities and processes include eutrophication and pollution from elevated levels of nutrients, dumping of wastes including ballast water, overfishing and collecting, incidental bycatch, introduction of exotic organisms, loss of habitat, bioaccumulation of noxious materials like heavy metals, pesticides, herbicides, siltation, tourism (Figure 20), oil spills, downstream effects of dams and dykes and fishing litter (see the *Pollution sources on the Great Barrier Reef catchment* box on page 62) (see also Zann 1995). The destruction of habitat on the seabed has many parallels to habitat clearance on land, with sedimentation on the continental shelf being considered one of the most important factors in the decline of marine biodiversity (see also *Estuaries* below, *Impacts of pollution on biodiversity* on page 101 and the *Coasts and Oceans* Theme Report).

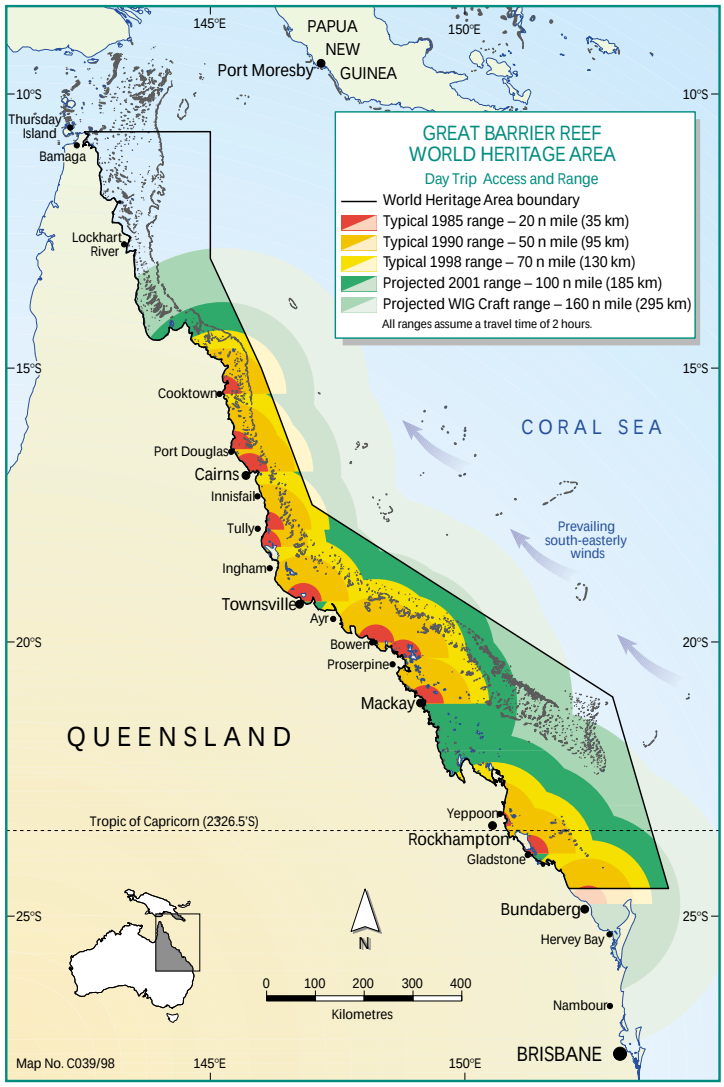



**Figure 20: Day trip access and range of the Great Barrier Reef World Heritage area.**

As boats become faster, the range of day trip operators increases (see legend). Processes are being put in place to manage this increase in access.

**Source:** Wachenfeld et al. (1998).

*Estuaries:* Estuaries are the meeting place of fresh and salt waters. Naturally rich in nutrients, estuaries are ecologically highly productive, and provide habitat for fish, migratory birds and other species. In Australia, estuaries and sheltered bays have also been the focus of urban and industrial development and recreation.

Australia has 783 major estuaries: 415 in the tropics, 170 in the subtropics, and 198 in temperate areas (Zann 1995). A recent national evaluation has shown that the geographical extent of relatively undisturbed estuaries continues to decline. The long arid coastlines in the south-west and west have few estuaries. Most river catchments in eastern and southern Australia have been extensively cleared (Table 11). This has resulted in land erosion, sedimentation of rivers, and increased sedimentation and levels of nutrients downstream in estuaries, bays and adjacent coastal waters. High sediment levels in the water reduce light penetration, which affects rates of photosynthesis. When sediments settle they can also smother seabed organisms. Sedimentation of estuaries and shipping channels causes shoaling and alters currents. Sedimentation is a major problem in ports and shipping channels, necessitating regular dredging. This resuspends sediments, creating further environmental problems (see also Zann 1995).

## Pollution sources on the Great Barrier Reef catchment

Human population densities in north Queensland are low and concentrated along the coastline. Only five cities have populations exceeding 40 000. Grazing of cattle for beef production is the largest single land use (77%) in the catchment with cropping, mainly of sugar cane (3%), and urban and residential development (3%) considerably smaller in areal extent. Other significant land uses include mining (coal and metalliferous) and cotton cropping.

Beef cattle numbers are about 4 500 000 with the highest numbers in the Fitzroy catchment. The sugar cane cultivation area has increased steadily over the last 100 years with a total of 390 000 ha reached by 1997. Other industries with significant expanding land use (and fertiliser use) are cotton (mostly in the Fitzroy catchment) and horticulture (in many catchments), particularly bananas.

Overall, 66% of the estimated nutrient and sediment flux is estimated to come from grazing lands, with 8% from cropping lands and 26% from 'pristine' areas. The total run-off flux of sediment is estimated to be four times the amount prior to European settlement.

**Table 11: Overview of Australia's estuaries showing the percentage of estuaries in a range of categories, in each state and the Northern Territory**

| State | Uncleared catchments | Excellent water quality | High fisheries value | High conservation value | Threats to conservation value | Adequate state of knowledge |
|---|---|---|---|---|---|---|
| NSW | 24.7 | 0.0 | 24.7 | 16.0 | 21.0 | 100.0 |
| Vic. | 22.9 | 14.3 | 14.3 | 48.6 | 22.9 | 31.4 |
| Qld | 55.4 | 48.5 | 18.9 | 21.8 | 2.3 | 11.1 |
| WA | 86.2 | 83.4 | 7.6 | 7.6 | 2.8 | 7.6 |
| SA | 0.0 | 0.0 | 6.7 | 20.0 | 6.7 | 13.3 |
| Tas. | 27.0 | 25.4 | 0.0 | 6.3 | 4.8 | 6.3 |
| NT | 99.3 | 97.1 | 17.5 | 22.6 | 0.7 | 5.1 |
| Total | 60.8 | 54.2 | 15.2 | 18.6 | 5.2 | 19.2 |

**Source:** Zann (1995).

*Water quality:* Where rivers drain disturbed acid soils, such as in northern New South Wales and southern Queensland, estuaries may become acidic periodically. This increases levels of dissolved aluminium and iron, which form compounds very toxic to fish. As a result, fish diseases such as 'red-spot' disease and fish kills are increasingly common in estuaries. At least 64% of estuaries in New South Wales and 22% in Victoria are considered to have poor water quality. Elevated nutrients in river systems may cause eutrophication, and the excessive growth of algae can smother other organisms and deplete oxygen levels. Catchments in the tropical north are less affected by human activities, but may carry heavy sediment loads resulting from soil erosion (see Zann 1995). Unnaturally elevated sediments and nutrients have led to major declines in seagrass beds in temperate Australia. Poor water quality and loss of habitat have also caused a decline in estuarine fisheries. For example, fisheries are thought to be threatened in 21% of estuaries in New South Wales and 23% in Victoria. However, eutrophication of some estuaries has enhanced their value for oyster aquaculture (Barratt et al. 2001).

*Coastal lakes and lagoons:* Of great concern in south-east and south-west Australia is the declining water quality and eutrophication of coastal lakes and lagoons and the effects these conditions have on biodiversity. Settings of particular concern are those that are insufficiently flushed by the sea, such as Tuggerah Lakes and Lake Macquarie (NSW), Gippsland Lakes (Vic.) and the Peel–Harvey system (WA). As coastal lakes are largely restricted to the densely inhabited south-east coastal strip, a significant proportion of Australia's coastal lakes have been degraded (Zann 1995). Conservation of these areas is essential as they may support habitat and feeding grounds for water and shore birds including migratory birds such as Whimbrel, Eastern Curlew, Terns and Sandpipers.

*Intertidal shores:* The intertidal shores are the meeting place of the land and sea. Shores are periodically immersed by sea and exposed to air, and thus subject to extremes in salinity. They are often enriched by land nutrients and have a high biological productivity. Shores have a

high diversity of very specialised animals and plants, and may require special conservation measures. Australia's shores include open coasts with rocky headlands, cliffs and sandy beaches; and sheltered coasts, bays and estuaries with muddy and sandy tidal flats. Intertidal rocky shore habitats are often limited in area. They are also potentially vulnerable to human impacts. Threats to shore communities include overharvesting of molluscs, crustaceans and sea urchins for food and bait, trampling by fishers and other visitors, oil slicks and other pollutants which float on the sea surface, and loss of habitat. In the more populous south-east, south and south-west of Australia, significant areas of shores around coastal cities and towns have been reclaimed or alienated by sea walls, port development, industry, housing and tourism, and recreational facilities (SoE 1996).

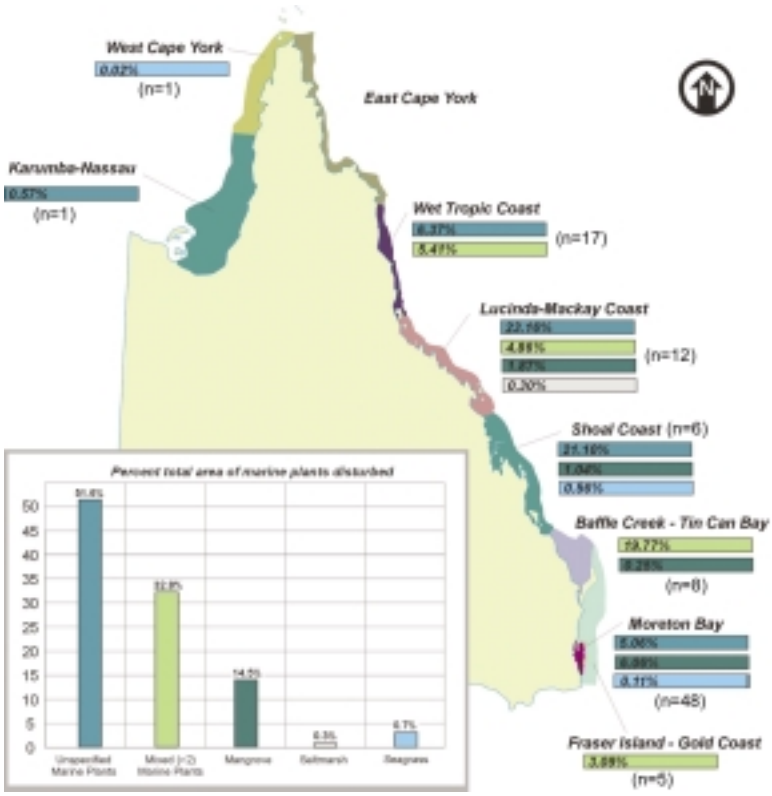



**Figure 21: Types of marine plants authorised for disturbance in Queensland marine bioregions in 1996.**

The total area of marine plants authorised for disturbance in 1996 was 3630 ha.

**Source:** Zeller (1998).

**Coastal disturbance**: A summary (Zeller 2000) of disturbances in Queensland resulting from human structures and activities (e.g. water diversion, dam building, disturbance of spawning habitats, increase in the number of sewage treatment plants, gravel and sand extraction, and port, resort and real estate developments) showed that during the 1990s, disturbance of fisheries habitats has generally increased as human activities have expanded and intensified along the coastline. For example, waste water generated by about 2.4 million people is treated by sewage treatment plants in the coastal zone of Queensland. In excess of 90% of the treatment plants located within 50 km of the coastline discharge into coastal freshwaters, estuaries or inshore marine waters. These discharges have been treated to a 'secondary stage' where most suspended solids and bacteria have been removed. However, few of these discharges have their nutrients removed.

Commercial channel dredging for sand and gravel occurred from around the turn of the 1900s in the Brisbane River estuary and probably in excess of one million cubic metres were removed during the 1990s. In 1996, 390 000 $m^3$ of sand was approved for extraction from northern Moreton Bay. From 1990 to 1996, about 2467 ha of tidal land supporting marine plants were reported as being disturbed by human activities, particularly for port expansion, tourist developments and marina/boat harbours (Figure 21) (Zeller 2000).

**Salt marshes**: Australia has some 13 595 square kilometres of salt marshes (Zann 1995). Coastal salt marshes are intertidal plant communities dominated by herbs and low shrubs, and are often associated with estuaries. Salt marshes are highly productive, and support key habitats for many organisms including migratory species such as the rare Orange Bellied Parrot (*Neophema chrysogaster*) in Victoria. A major threat to salt marshes in built-up areas is land reclamation. Extensive areas have been filled for ports, marinas, canal estates and urban and industrial sites. Other threats include degradation by rubbish dumps, off-road vehicles, invasion by weeds (particularly by introduced cord grass, pampas grass, para grass and rushes), periodic surges associated with low-pressure systems and drainage for mosquito and sandfly control. Human developments that result in the total loss of salt marshes have typically occurred in south-east Australia, where biodiversity and endemism are highest.

**Mangroves**: Mangroves are tree and shrub species that are adapted to the periodically inundated and salty conditions between the tides. Mangrove forests are very productive ecosystems and are of major ecological and economic importance (Figure 22) (see also Zann 1995). They provide habitats and nurseries for many fish, form a buffer for estuaries from sediments and for coastlines from storm waves, are natural nutrient filters, and are critical habitats for many birds and other wildlife. Australia has the third largest area of mangroves in

the world, and has some of the most diverse communities, but these are poorly protected from habitat destruction and degradation (Table 12).

Mangrove ecosystems, in general, exhibit a decline in the diversity of species from the tropics to temperate zones. Similarly, within the tropics, there is a decline in diversity of mangrove species from wet tropical environments to the arid tropics. At a finer scale again, mangroves in the Great Barrier Reef show a general decrease in diversity with increasing latitude and a cross-shelf decrease from the mainland coast to the islands.

Overall losses of mangroves in Australia are small compared with those from other countries. However, locally significant losses have occurred around Australian coastal cities and towns. For example, about 20% of mangrove ecosystems have been cleared in Moreton Bay, near Brisbane, for coastal development. Elsewhere, in areas such as the Hawkesbury and Parramatta Rivers in Sydney, it is thought that accelerated silting associated with poor land management has led to significant expansion of mangroves. The major threats to mangrove ecosystems include continued local clearing and development, and the effects of various human-induced catchment alterations. Only some 8% of Australia's mangrove communities are in protected areas (Table 12). Protection may be given through other avenues (e.g. in Queensland, mangroves are protected under Fisheries legislation).

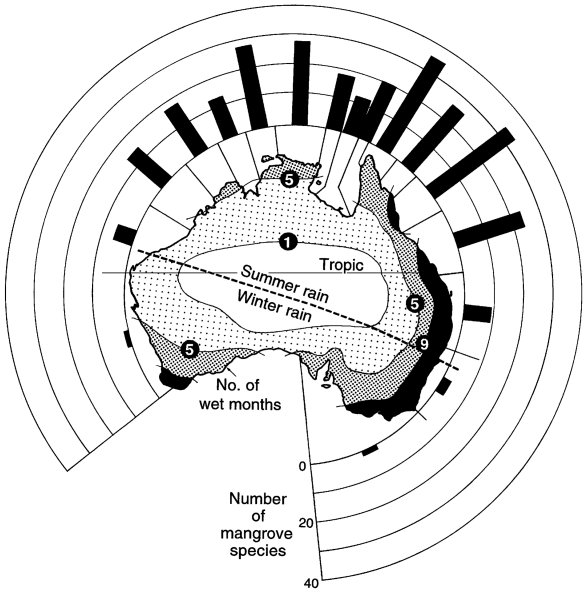



**Figure 22: Mangrove plant richness around the Australian coastline showing many more species in the wet tropics compared with temperate Australia.**

Species diversity also varies within the tropics, with a decline in diversity of mangrove species from wet tropical environments to the arid tropics.

**Source:** Duke (1992).

*Seagrasses:* Some of the world's largest seagrass habitats occur in Australian waters. Seagrasses are marine flowering plants and 30 of the world's 58 species are found in Australia (SoE 1996). Seagrass beds are ecologically important because of their high productivity, their ability to trap and stabilise sediments, their importance as fisheries habitats, and as the habitat for important species such as Dugongs and turtles. Australia has the highest biodiversity of seagrasses in the world, the largest areas of temperate seagrass and one of the largest areas of tropical seagrass. Anthropogenic changes that are degrading these habitats and threatening biodiversity include eutrophication, heavy metals and toxins, changes in hydrology, sediment run-off, mining and dredging, trawling, moorings and boat propellers and introduced species (Zann 1995).

Australia's unique temperate seagrass beds appear to be under particular threat. Increased sedimentation and nutrients from catchments have been linked with massive dieback of

**Table 12: Status of mangrove forests in Australia**

| State | Area ($km^2$) | No. reserves | Area reserved ($km^2$) | Reserved (%) |
|---|---|---|---|---|
| **Queensland** | 4 602 | 54 | 600 | 13 |
| Tropics | 4 117 | | | |
| Subtropics | 485 | | | |
| **New South Wales** | 99 | 8 | 5 | 5 |
| **Victoria** | 12 | 2 | 3 | 23 |
| **Tasmania** | 0 | 0 | 0 | |
| **South Australia** | 211 | 7 | 113 | 56 |
| **Western Australia** | 2 517 | A | A | A |
| Tropics | 2 507 | | | |
| Subtropics | 10 | | | |
| **Northern Territory** | 4 119 | 2 | 282 | 7 |
| **Total** | **11 558** | **73** | **3 520** | |

A Western Australia protects all mangroves.

**Source:** after Zann and Kailola (1995).

seagrasses in many areas. New South Wales has lost half of the *Zostera* seagrass in its estuaries. In Victoria, around 85% of the total biomass of seagrass in Western Port Bay has been lost. In Tasmania, there have been declines in the Hobart and D'Entrecasteaux region, Triabunna and St Helens on the east coast, and Tamar, Port Sorell and Duck Bay on the north. In South Australia's Gulf of St Vincent, around 5000 ha of seagrass has been lost, and this trend is continuing (Government of South Australia, Environment Protection Agency 2000). Some regrowth of seagrass is occurring in the Port Adelaide area, but its survival is uncertain. In Western Australia, around 97% of seagrass in Cockburn Sound have been lost. A serious loss of tropical seagrasses has occurred in Hervey Bay, Qld, causing major mortality of Dugongs.

Long-term monitoring of seagrass beds by the CSIRO in a study area located in the north-west Torres Strait revealed a 30% loss of seagrass between 1989 and 1993 (Long et al. 1997), and this trend apparently continues. An estimated 1119 square kilometres of seagrass were lost in the north-east region of the study area. Combined, the net losses that have been quantified in this area alone represented a 10% reduction in the estimated total area of seagrass in the Torres Strait (Long et al. 1997). Once lost, seagrasses do not readily recover and this has serious implications for the species these ecosystems support.

*Coral and rocky reefs:* Coral reefs are among the most productive, diverse and complex ecosystems in the world and support a significant proportion of the planet's marine biodiversity (Zann 1995). Coral reefs are also under global threat. A global assessment of reefs (Wilkinson 2000) shows continuing decline with 27% of the world's reefs having been effectively lost, with the largest single cause being the massive, climate-related coral bleaching event of 1998, which destroyed about 16% of the world's coral reefs in nine months. Climate change adds a new dimension to threats to reef ecosystems since changes in ocean temperature, ocean currents and flows of nutrients, disturbances regimes and sea level rise have the potential to destroy many reef ecosystems. Because of the general decline in many coral reefs, the biodiversity conservation values of Australia's reefs are of growing importance, and the management of reef ecosystems is attracting even greater attention (Zann 1995; Wachenfeld et al. 1998).

Australia has the largest area of coral reefs of any nation and the largest coral reef complex, the Great Barrier Reef (Zann 1995; Wachenfeld et al. 1998). Major areas of coral reefs are also present in Torres Strait, the Coral Sea Territories, and central and northern Western Australia. The Oceanic Shoals Bioregion, which consists mainly of submerged reefs, is also a very significant coral reef province, with many unexplored reefs on the Sahul Shelf and along the edge of the Timor Trough. The Tasman Sea reefs (Elizabeth and Middleton Reefs and the Lord Howe Island fringing reef) are the highest in latitude in the world, and thrive in conditions otherwise marginal for coral growth. High latitude reefs, such as the Abrolhos Islands, are also found on the west coast of the continent.

Of the reefs that have been well studied, a striking feature of coral reefs is the natural variation which can exist in reefs in close proximity to each other (Figure 23) (Zann 1995; Wachenfeld et al. 1998).

General issues affecting Australia's coral reefs include effects of sediments, agricultural chemicals and nutrients, effects of fishing and tourism, the threats of oil spills, and negative changes in habitats as a result of enhanced climate variability and climate change (Zann 1995; Wachenfeld et al. 1998). Specific threats include elevated nutrients in the inner Great Barrier Reef (see the *Pollution sources on the Great Barrier Reef catchment* box on page 62), outbreaks of Crown-of-Thorns Starfish (*Acanthaster planci*) in the outer central and northern Great Barrier Reef and Tasman reefs (see the *Coasts and Oceans* Report), damage from the passage of tropical cyclones, and outbreaks of coral-eating *Drupella* snails in Ningaloo Reef, WA. Wachenfeld et al. (1998) summarised the major environmental attributes on the Great Barrier Reef and the state, pressure and responses associated with them (Table 13). Coral reefs are relatively

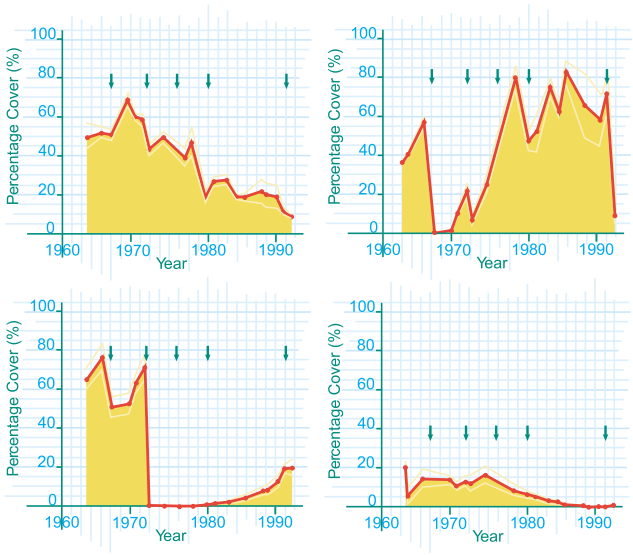



**Figure 23: Changes in coral cover at Heron Island, Qld.**

A 30-year study of four different coral reef zones at the island showed variation in coral cover to be as great as 80%. Most declines in coral cover were due to cyclones (indicated by arrows).

**Source:** Connell et al. (1997).

## Natural variation of biodiversity in coral reefs

Results from three, separate long-term studies of corals have emphasised variability of reefs through time. In one 30-year study on Heron Island in the southern Great Barrier Reef, coral cover was found to vary between 0 and 80% in different patterns depending on the site.

In another study covering six reefs in the central and northern Great Barrier Reef between 1980 and 1995, substantial changes occurred in the numbers of areas dominated by corals, bare substrate or other organisms, but by the end of the study, the proportions were similar to those at the beginning. However, this overall similarity in average conditions masked that some reefs had improved while others had degraded. At one inshore reef, an area once dominated by macroalgae was replaced by a coral-dominated community.

well represented in Marine Protected Areas in Australia, although only a small area is protected in zones where fishing is prohibited.

Because of the general decline in many of the world's coral reefs, tourism values of Australia's reefs are growing. Tourism on the Great Barrier Reef is actively managed, which should keep habitat destruction and degradation to a minimum. However, the annual increase in visitation rates and increased mobility of visitors to coral reefs as a result of new and improved forms of transport (see Figure 20) is likely to have some effect. The increased mobility of tourists is an important management issue for all marine environments, including shallow waters amenable to underwater tourism (Wachenfeld et al. 1998).

Despite their high conservation and economic values, Australia's temperate reefs are inadequately studied scientifically, and relatively few are protected. Although very little is known of the effects of human activities on temperate reef habitats, it is often assumed that outside metropolitan and industrial areas, they are relatively unaffected (Zann 1995).

*The continental shelf and sea floor communities:* Continental Australia has around 2.5 million square kilometres of geomorphic continental shelf, half of which is less than 50 m deep. The continental slope, which drops from a depth of 150 m to 4000 m, has an area of at least two million square kilometres (Zann 1995). An extensive continental shelf is also found adjacent to the AAT and there is much to be discovered about the biodiversity in this area.

Little is known of the effects of humans on sea floor communities, although seamount ecosystems have attracted study (see *Seamounts* on page 58 and the *Unexplored ecosystems* box below). The rate of sedimentation on the sea floor has greatly increased since European

## Unexplored ecosystems: Seamounts and terrestrial cliffs

Many ecosystems in Australia remain virtually unexplored because they are inaccessible, or because the species they support are cryptic or inconspicuous. Two such areas are oceanic seamounts, and the cliffs of the terrestrial environment.

In June 2000, CSIRO reported that hundreds of new species have been discovered on seamounts in the Coral Sea and the Tasman Sea between New Caledonia and Tasmania. The south-west Pacific contains the greatest density of seamounts and seamount ridge systems in the world. Each seamount is an ecological island and many different species have evolved independently in each area. The communities on seamounts are dominated by corals, sponges, sea fans and other organisms that filter their prey from the strong currents characteristic of this environment. There are about 30 000 seamounts in the world's oceans, but most species previously known from this deep ocean environment come from sampling only five of these. The study of 25 seamounts uncovered 850 species, more than previously reported from all studies of seamounts in the past 125 years. About one-third of these species are new to science and are likely to be restricted to the seamount environment.

Cliff environments are a unique combination of substrate and physical conditions that support unique biotas that depend only partly on mass effects from adjacent communities. Many are relatively undisturbed by human activities. Larson et al. (2000) reported on the substantial undersampling of cliff faces in terrestrial environments. The discovery of the Wollemi Pine (*Wollemia nobilis*) in a sandstone gorge in the Blue Mountains is symptomatic of this sampling bias. This very conspicuous species remained undiscovered close to Australia's largest human population for 200 years because there have been no studies of the vascular or non-vascular flora of the associated cliffs.

There is little doubt that many new species and unique communities remain to be discovered in cliff environments, on oceanic seamounts and in many other unique ecosystems.

**Table 13: The state, pressure and response model associated with various environmental attributes of the Great Barrier Reef**

| Attribute | State | Pressure | Response |
|---|---|---|---|
| Water quality | Status fairly well known<br>Limited trend data but no obvious adverse trends | Adjacent land use and associated nutrient and sediment run-off during flood events<br>Loss of freshwater wetlands | Direct inputs of pollutants prohibited or strictly regulated. Collaborative arrangements with state government agencies being developed to reduce indirect inputs through run-off. Comprehensive research and monitoring programs in place. |
| Mangroves | Status well known<br>Some medium-term trend data available<br>No obvious adverse trends | Principle pressure is clearing for coastal development | Mangroves protected by legislation from damage and removal. Further work on cumulative effects needed. |
| Island plants | Status fairly well known<br>No information on trends | Historical effects from plant introductions and grazing, some ongoing | Plants on most islands protected from direct damage or removal. Ongoing monitoring needed. |
| Seagrasses | Status fairly well known<br>Some information on trends<br>No obvious adverse trends | Some potential pressures from coastal run-off and trawling, but few major effects documented | Trawling prohibited by Marine Park zoning plans in nearly half of mapped seagrass area. Trawling prohibited in additional areas by coastal strip closures. Offshore beds less protected by effects not documented. |
| Macroalgae | Status poorly known<br>No information on trends<br>Anecdotal reports of increased abundance due to human effects | Potential effects on near-shore algae from increased nutrients in run-off | Status information being collected. Management needs uncertain. Trend monitoring needed. |
| Corals | Status fairly well known<br>No evidence of any major declines directly attributed to human effects<br>Some recent disturbances from Crown-of-thorns Starfish and bleaching | Potential pressure on inshore corals from increased sediments and nutrients in run-off, but no major effects documented | Comprehensive research and monitoring programs in place. Most major direct pressures regulated or prohibited. |
| Crown-of-thorns Starfish | Status fairly well known<br>Current outbreak in northern Great Barrier Reef<br>Cause of outbreaks uncertain | Role of human activities in causing outbreaks is uncertain | Comprehensive research and monitoring programs in place. Control measures developed for significant sites. Need for further action not clear, given uncertainty over causal factors. |
| Fishes | Status of commercial species and common reef fishes fairly well known<br>No evidence of any major declines caused by human activities | Commercial, recreational and Indigenous fishers<br>Heavy fishing pressure in some areas | Comprehensive research and monitoring programs in place. Variety of management measures to restrict and regulate fishing effort. |
| Birds | Status fairly well known<br>Trends known for some sites where some species have declined | Human disturbance from visitation<br>Habitat loss and deterioration | Some sensitive nesting sites closed to visitors. Research and monitoring programs in place at some sites. More information needed on status for many areas. Need for further action uncertain due to lack of trend data. |
| Marine turtles | Status well known for two species<br>Significant decline for one species, indications of decline for two others and no indication of decline for a fourth<br>No information on status of two other species, but both rarely seen | Bycatch in trawl and shark nets<br>Hunting both locally and in other countries<br>Predation of eggs and young by feral animals<br>Habitat removal and disturbance | Important nesting sites protected. Efforts under way to reduce bycatch in trawls. Need for international agreement to protect turtles. Ongoing monitoring. |
| Sea snakes | Status information needed | Bycatch in trawl nets | Management requirements uncertain. Processing of sea snake skins no longer allowed. |
| Dugongs | Status and trends fairly well known<br>Decline in southern Great Barrier Reef population | Bycatch in mesh and shark nets<br>Boat strike<br>Indigenous hunting | Dugong protection areas established. Voluntary cessation of traditional hunting by most Indigenous communities south of Cooktown. Traditional hunting south of Cooktown no longer permitted. Comprehensive research and monitoring programs in place. |
| Whales and dolphins | Status and trends for Humpback Whale fairly well known<br>No information on other whales or dolphins, but inshore species possibly in decline | Whale watching of Baleen Whales, particularly Humpback and Dwarf Minke<br>Inshore dolphins caught as bycatch in mesh nets | Whale-watching guidelines developed. Monitoring and protection measures for inshore dolphins needed. |
| Inter-reef and lagoon benthos | Status poorly known<br>Likely substantial effects in areas of high intensity of trawling | Trawling<br>Nearshore communities potentially affected by increased sediments and nutrients in run-off | Some progress towards understanding responses and recovery. Trawling prohibited by Marine Park zoning plans in over half of inter-reef area and about 10% of lagoon area. Management plans being developed which aim to reduce fishing effort. |

**Source:** Wachenfeld et al. (1998).

colonisation of Australia by factors of ten to 100, and even more in some areas. Dumping of wastes on the sea floor is controlled under international conventions (e.g. the London Convention) and various Commonwealth and state/territory legislation. However, dredging and dumping of wastes may still cause localised disturbances around ports.

*Trawling* [BD Indicator 2.2]: Some shelf and slope fish species have been severely overfished, and trawl nets may dislodge attached species such as sponges and modify the habitat and food chains. Barratt et al. (2001) reported that the South East Trawl Fishery is increasing in intensity of trawling, and that the Twofold Shelf Region may be the most disturbed of the Interim Marine and Coastal Regionalisation for Australia (IMCRA) regions in south-east Australia. Trawling intensity and the area in the Northern Prawn Trawl fishery decreased substantially during the 1990s, but appear to be slowly increasing.

Trawling is of serious concern for certain marine biodiversity and recommendations have been made to list prawn trawling as a threatening process to turtles. For example, about 3% of the Loggerhead Turtle (*Caretta caretta)* population that forages in the Northern Prawn Fishery is killed annually as a result of this fishing activity (Barratt et al. 2001). Trawling can also have considerable effect on invertebrate benthos, although these organisms are often ignored in bycatch studies, which focus on retained bycatch. Work on fish trawling in Western Australia, however, has indicated that each pass of the trawl removed 16% of the large (>20 cm) macrobenthos, with multiple passes effectively denuding the substrate. This is a marine form of habitat fragmentation. Trawling should, therefore, be considered for its effect on the entire range of species, not just target and non-target fish caught.

Trawling is prohibited in some areas (e.g. in parts of the Great Barrier Reef Marine Park). Changes in the design of trawl nets used to catch prawns should reduce the chances of catching unintended species such as cod and turtles (Figure 24). This will help to minimise unintended changes in species composition and trophic interactions in reef ecosystems.

*Hydrocarbon exploration:* Levels of hydrocarbon exploration of the seabed and production activity tends to fluctuate markedly annually, and there has been a relatively small increase in both types of activity since the early 1990s. Petroleum industry activities and facilities occupy a small surface area of the seabed and are concentrated almost entirely in the region of the Gippsland Shelf and Carnarvon Shelf. Six rigs were in operation at September 1999 and these drilled almost 100 wells with a total length of over 280 km. Seismic surveys and drilling affect the biodiversity of benthic marine environments. Seismic surveying involves the introduction of a high-energy acoustic pulse into the earth's crust, such as the release of a high pressure air blast into the water, dynamite, electromechanical vibrations and steam injection. Sonic echoes from the sea floor are then received by a cable, up to one nautical mile long (1852 m), which is filled with hydrophones and is dragged by the surveying ship. In 1998, the total length of 2-D (a single line or track) and 3-D (systematic grid coverage of a discrete area) surveys exceeded 900 line kilometres (Figure 25).

*Seamounts*

Seamounts are remnants of extinct volcanoes, typically cone-shaped, 20 to 500 m high and several kilometres across at their base. About 70 seamounts arise from water depths of between 1000 and 2000 m on the continental slope, between 50 and 170 km off southern Tasmania (Tasmanian Seamounts). This field of seamounts is a distinctive geological feature not known elsewhere on the continental margin of Australia. They support a distinct benthic (bottom-dwelling) community of animals, many of which are native to the Tasmanian Seamounts and do not occur elsewhere. A high proportion of species (24–43%) new to science has been discovered, including at least eight new genera. The species in the area appear to be representative of the seamount fauna of the Seamount Region (see the *Unexplored ecosystems* box on page 66) and have been protected recently by the Commonwealth government (Environment Australia 2000). Generally, however, most of Australia's sea floor is not actively managed.

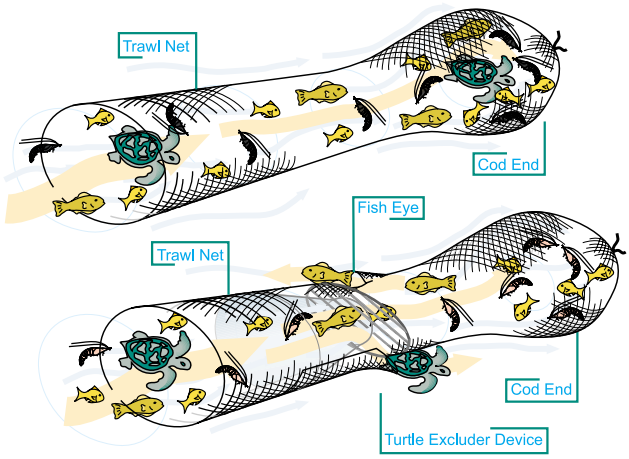



**Figure 24: A bycatch reduction device.**

The trawl net in the upper diagram has no bycatch reduction devices fitted. All animals that enter the net are caught in the cod end, including prawns, turtles and unwanted fish species. The trawl net in the lower diagram has two types of bycatch reduction devices fitted. The turtle excluder device prevents turtles from swimming into the cod end, forcing them out through a flap on the trawl net. Fish have a tendency to swim against the current and may swim out through the top of the trawl net. Prawns, however, are still caught in the cod end.

**Source:** Wachenfeld et al. (1998).

## Protected area management [BD Indicator 13.2]

Modern standards of best practice reserve management include the preparation and implementation of management plans or strategies that are well researched, developed in consultation with users, implemented, monitored and evaluated. Although the existence of a management plan does not describe the adequacy of that plan, the proportion of areas subject to a management plan is an important and basic indicator of the sophistication of protected area management within a jurisdiction.

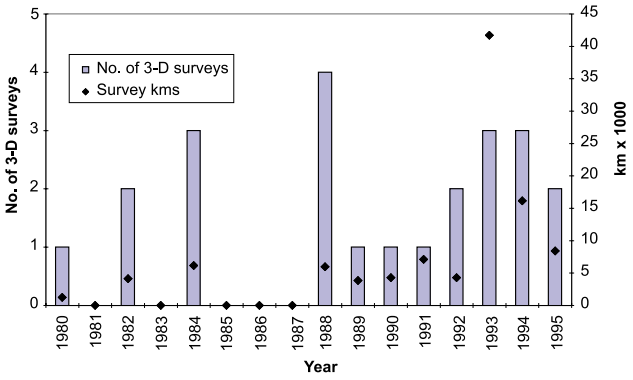



**Figure 25: Number and length of 3-D seismic surveys per year in the Twofold Shelf and Otway IMCRA regions.**

**Source:** Barratt et al. (2001).

*Protected area programs*

The NRSP, commenced in 1996, funds the acquisition of land as well as tying funding for new protected areas to the preparation of a management plan. ANZECC (2001) stated that 'management plans for major protected areas [funded under the Program] should be in place by the end of 2000'. Another focus of the Program is the development and application of 'best practice' standards of management. The Marine Protected Areas Program has a similar focus (see *Marine parks and reserves* below), and in addition, the development and management of the national Marine Protected Areas estate will be informed by an overall Strategic Plan of Action. The IPAP has a similar focus (see *The Indigenous Protected Area Program* box on page 70). All three programs are funded under the NHT.

*Marine parks and reserves*

There are 13 marine parks and reserves managed by the Commonwealth government and six protected areas with a marine component. Five of these have been declared since the SoE (1996): the Great Australian Bight Marine Park (April 1998), Tasmanian Seamounts Marine Reserve (May 1999), Macquarie Island (October 1999), Lord Howe Island Marine Park (June 2000) and Cartier Island Marine Reserve (June 2000). These marine parks range from 167 square kilometres (Cartier Island) to 19 769 square kilometres (Great Australian Bight) so represent a major addition to the marine conservation estate. In addition, the Heard Island Wilderness Reserve was established in 1996. Some state and territory governments have established, or plan to establish, marine reserves. For example, Western Australia has declared six marine parks and reserves with more expected to follow.

Significant marine areas are protected in all of the places where reefs are found, although management is often constrained by their great size and remoteness, and by lack of financial resources. The number of marine areas that are protected is small compared with the recognised diversity of marine environments, and the total area protected (outside of the Great Barrier Reef complex) is very small compared with that under Australia's jurisdiction.

*Number of protected areas with management plans* [BD Indicator 13.2]

Although a significant proportion of protected areas are subject to management plans, clearly there are gaps in coverage and management planning is an ongoing and unfinished task (Table 14).

It has not been possible to access historical data for this Report to show the pattern of increase or decrease in management planning activity. Wescott (1995) recorded the production of management plans for national parks (not other reserve categories) for Victoria in 1993 as follows: approved plan or strategy 20%, draft plan or strategy 26%, in preparation 21%, 'old' plan or strategy 10%, and without plan or strategy 23%. Changes in the way reserves are categorised, as well as in the number of reserves, make accurate comparison with the data for Victoria in Table 14 difficult. However, these data suggest, at least for one jurisdiction, the proportion of protected areas subject to management plans has increased in recent years.

In the 1990s, the conservation reserve estate has been expanded significantly in several jurisdictions in terms of gross area, number of reserves and the variety of ecosystems represented. Although Australia's conservation reserve system remains inadequate, this recent expansion is a positive and important advance compared to the status of protected areas in many parts of the world.

## The Indigenous Protected Area Program

The impetus for establishing Indigenous Protected Areas (IPAs) stems from the potential benefits that such arrangements can have in maintaining or enhancing biodiversity through the use of traditional management techniques and that many areas of unique conservation status under the IBRA system (see *Table 70*) are found only on lands owned or leased by Indigenous peoples. The Indigenous Protected Areas Program (IPAP) receives funding from the NHT and was initiated in 1995, the same year that the NHT was set up. It was not until 1997, however, that IPAP began in earnest. The NHT defines an IPA as being 'governed by the continuing responsibilities of Indigenous peoples to care for and protect lands and waters for present and future generations'.

The IPAP provides for two different forms of Indigenous involvement in protected area management:

- IPAs, where the establishment and management of protected areas is on Indigenous owned estates
- Cooperative Management, which involves the establishment of cooperative (joint) management arrangements over government-owned protected areas between Indigenous groups and the relevant government nature conservation agencies (Centre for Environmental Management 1999).

The first IPA was proclaimed in 1998 in the Flinders Ranges region of South Australia on 'Nantawarrina', a property owned by the Adnyamathanha people. As at March 2001 there were 13 formally declared IPAs in Australia covering an area of around three million hectares: Dhimurru IPA (NT), Warul Kawa IPA (Torres Strait), Deen Maar IPA (Vic.), Nantawarrina IPA (SA), Yalata IPA (SA), Oyster Cove IPA (Tas.), Risdon Cove IPA (Tas.), Preminghana IPA (Tas.), Mt Chappell Island IPA (Tas.) and Badger Island IPA (Tas.), Watarru and Walalkara IPAs (SA), Guanaba IPA (Qld). Also, the Mutawintji National Park joint management agreement between Indigenous owners and the NSW National Parks and Wildlife Service (NPWS) was supported through the Program.

The benefits of establishing IPAs have been well documented and are not only related to enhanced conservation of biodiversity but also social, educational and other aspects (e.g. De Lacey 1994; Thackway et al. 1996; Centre for Environmental Management 1999; Szabo & Chester 2000). These include:

- the preservation and/or enhancement of biodiversity by Indigenous peoples over many thousands of years in Australia is considered testimony to their superior ability over European practices to conserve nature
- management of protected areas by Indigenous peoples can be a very cost effective solution to conserve biodiversity for governments.

Information is not readily available to determine if the management of reserves is adequate to protect biodiversity, or indeed cater for human use, in the long term.

### Integrated bioregional planning [BD Indicator 12]

Bioregional planning has been a relatively recent policy and planning response to the myriad of land and water management issues that Australia faces. What precisely constitutes 'integrated bioregional planning ' is unclear and probably will remain so, partly because of the varying contexts where the concept is implemented in different jurisdictions. However, the core principle is that biodiversity occurs and functions across spatial scales that rarely match traditional political, administrative and other boundaries and functions, and that this feature needs to be explicitly catered for in policy, planning and management. The features of biodiversity are reflected in the NSCABD which includes the objective to 'manage biodiversity on a regional basis, using natural boundaries to facilitate the integration of conservation and production-oriented management techniques'. This objective has been assessed as 'partially achieved' (ANZECC 2001). The incorporation of biodiversity into an environmental management system (EMS) at both the bioregional and farm scale is starting to receive greater attention (Anderson et al. 2001).

*Biogeographical regions*

A key to making progress with bioregional planning is to have an agreed system of regionalisation, which has been achieved in recent years. Identification of biogeographical regions is well advanced across Australia through IBRA (Thackway & Cresswell 1995) and IMCRA (Thackway & Cresswell 1996) processes. IBRA was developed in the mid-1990s to support the NRSP, and has become well established as a land-planning framework. IMCRA, which addresses marine and coastal areas, was published in June 1998.

**Table 14: Status of development of protected area management plans for selected Australian jurisdictions**

| Jurisdiction | Protected area type | Total No. | Management plans |
|---|---|---|---|
| ACT | NA[A] | | |
| Commonwealth | IUCN Category | | |
| | Ia | 7 | 2 |
| | Ib | 1 | 1 |
| | II | 6 | 3 |
| | IV | 3 | 1 |
| | VI | 3 | 1 |
| Northern Territory | IUCN category | | |
| | 0 | 1 | 1 |
| | Ia | 3 | 2 |
| | II | 16 | 7 |
| | III | 5 | 5 |
| | V | 53 | 22 |
| | VI | 5 | 1 |
| | **Total** | **83** | **38** |
| Queensland | National Parks and Conservation Parks | NA | Final: 72 |
| | State Marine Parks | 6 | Draft: 47 |
| | Coastal & Island National Parks | 86 | 6 |
| | | | 18 |
| South Australia | All | 316 | Final: 118 |
| | | | Draft: 64 |
| Victoria | National Parks | 36 | 33 |
| | Wilderness Parks | 3 | 3 |
| | State Parks | 31 | 30 |
| | Other Parks | 16 | 6 |
| | Phillip Island Nature Parks | 1 | 1 |
| | Nature Conservation Reserves | 411 | 11 |
| | Natural Features Reserves | 2 059 | 15 |

[A] Not available.

**Source:** data supplied by state and territory nature conservation agencies.

Several recent initiatives advance capacities for bioregional planning and these fall into two groups: those directly concerned with biodiversity, and a much larger array of other 'regional' arrangements which may or may not integrate biodiversity issues.

*Regional planning directly concerned with biodiversity*

Significant examples of this category, indicating trends in planning approaches, are outlined under the Commonwealth and various states as follows.

*Commonwealth:*

- The EPBC Act contains provision for the Commonwealth Minister to prepare bioregional plans for any Commonwealth area, and a requirement for the Minister to take account of such a plan in decision making.
- The cooperative management of the Great Barrier Reef Marine Park by the Queensland and Commonwealth governments has been achieved since 1975 and stands as the most long-standing and most internationally recognised integrated marine conservation approach.

*Western Australia:*

- The State government, through the NRSP has continued a series of regional biological surveys.
- In late 2000, a large-scale integrated regional research and development and planning program was established, covering the Ord River catchment and Bonaparte Gulf in northern Western Australia. The Ord Bonaparte Program (OBP) will combine analysis of marine, coastal and terrestrial components to integrate biophysical data-gathering and analysis with social, economic and institutional research and development. The aim is to to develop regional resource management options to inform future decision-making.

*Queensland:* A basis for future planning and management has been established with the publication of *Conservation Status of Queensland's Bioregional Ecosystems* (Sattler & Williams 1999).

*South Australia:* A biodiversity plan for the south-east region has been prepared, and draft plans are under development for other regions.

*Victoria:* Victoria's Biodiversity, the state strategy, uses bioregions to assess and plan for nature conservation and threatened species and ecosystems, and to integrate these issues in land and water planning. Regional biodiversity strategies are being prepared and the first comprehensive draft strategy, for the Goldfields Bioregion, was released for discussion in August 2000 (Ahern et al. 2001). Victoria seems likely to be the first Australian jurisdiction to substantively connect bioregional and catchment planning and management, and this attempted coordination represents an important opportunity to monitor success and challenges.

**The Ord River diversion dam in north-west Australia.**

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

**Source:** C. Read.

*New South Wales:*

- Regional vegetation management committees have been established and RVMPs are under development for a range of areas across the state (as required under the *Native Vegetation Conservation Act 1997*).
- The NSW Biodiversity Strategy of 1999 lists bioregional assessment and planning as a priority. Several bioregional assessments are underway, such as the Darling Riverine Plains Project. This Project highlights the important role of the community in making decisions that will assist in the conservation of natural and cultural heritage.
- Conservation assessments for a series of IBRA regions in New South Wales, for example the NSW Riverina and the Cobar Peneplain, have also been funded under the NRSP to help determine priorities for protection.

*Northern Territory:* Bioregional conservation planning has been undertaken in the Finke, Daly Basin and Sturt Plateau regions.

*Australian Capital Territory:* Regional SoE reporting, including biodiversity, is being developed by the Australian Capital Territory and 17 regional local government bodies.

*Multijurisdictional planning:*

- Coordinated management of protected areas and biodiversity in the Australian Alps is enabled by a Memorandum of Understanding between the Commonwealth, New South Wales, Victorian and Australian Capital Territory governments. This is effected mostly through interaction at the regional and district level by operational staff, and is regarded as a leading international example of effective conservation planning and management across jurisdictions.
- Increasing integrative regional planning endeavours in the coastal zone in several jurisdictions. Examples are the regional coastal management plans specified under the *Coastal Protection and Management Act 1995* (Qld), and the preparation of six coastal management strategies in Tasmania. Such integration of development and conservation was a major focus of recommendations arising from the Resources Assessment Commission's Coastal Zone inquiry.

*Other regional initiatives*

This category encompasses a large range of regional initiatives that have arisen in recent years. These encompass social, environmental and economic issues and vary greatly in their structure, style of operation, issue and sectoral coverage, and stage of progress. A hallmark of new regional initiatives is their inclusion of, or more often initiation by, community groups—unlike most of the more biodiversity specific initiatives above. A comprehensive review of

emerging regional arrangements, including those examples mentioned here, was provided by Dore and Woodhill (1999).

Although the primary focus of many of these arrangements is regional economic development or land and water management, many include biodiversity. Examples include the Cape York Peninsula Land Use Strategy (CYPLUS), the Blackwood Catchment Initiative and the Lake Eyre Basin Management Group. The lack of government support for the associated Cape York Heads of Agreement, that was negotiated between pastoral, mining, Indigenous and conservation interests, diminished what many saw as a crucial precedent in negotiated regional strategic planning that had incorporated production, cultural and biodiversity issues.

The most long-standing and influential regional assessment and planning process that takes biodiversity into account was implemented by Victoria's LCC. The LCC provided the informational and consultative underpinning for Victoria's reserve estate. The LCC was reconstituted in a different form under the *Environment Conservation Council Act 1997*.

The RFA process involved assessment and conservation area planning for biodiversity and production values in publicly owned native forests at regional (but not bioregional) scale. The RFA process involved the development of conservation criteria for biodiversity values. Unfortunately, the development and application of the criteria for reservation targets have not been consistent with the stated objectives of the RFAs and therefore have not resulted in the protection of forests with high biological values or the development of a CAR reserve system at the regional level.

Most land and water planning exercises have biodiversity implications, whether explicit or implicit, and increasingly these are developed at regional scales (including catchments). For example, the Macquarie Marshes Land and Water Management Plan (Brock 1997) covers environmental water flows and vegetation and fauna conservation. Provision of environment flows, which have to be considered under the COAG water reforms, will influence both instream and riparian biodiversity (Fisher 2000).

## Harvesting

### Harvesting of native wildlife [BD Indicators 8.1 and 8.2]

The harvesting of native flora and fauna for domestic and export purposes is controlled by various legislation in each state and territory. The extent of native flora and fauna harvesting taking place in various states and territories is outlined in the following sections.

### State and territory-based policies and programs

*South Australia*

In South Australia, information is collected only for the number of permits issued for the harvesting of native flora (Table 15). Total permits issued for harvesting native flora have been increasing since 1996 when there were 36 issued. In 1997, 46 permits were issued, 1998, 56 and in 1999, 67.

**Table 15: Number of permits issued for the harvest of terrestrial flora, South Australia, 1999**

| Use | Number |
|---|---|
| Non-commercial | 22 |
| Commercial | 19 |
| Native food | 7 |
| Biological collectors | 8 |
| Other | 11 |
| Total | 67 |

For native fauna, data are kept on the number of permits issued. There are 98 permits issued to kangaroo shooters, eight permits issued to kangaroo processors and 815 permits (predominantly to property owners) issued to destroy protected animals (see also *Harvesting under Commonwealth government legislation* on page 78). Similarly, there are 58 Emu (*Dromaius novaehollandiae)* farming permits issued and 57 permits were issued to people who wish to keep and sell eggs of protected species (e.g. emu eggs may be collected by Indigenous people for carving and can attract high prices on domestic and overseas markets).

*Australian Capital Territory*

The only data available on native fauna harvesting (by calendar year) for the Australian Capital Territory indicates that the trade of native fauna is growing, with a steady increase occurring in each category every year since 1996 (Table 16).

**Table 16: Number of permits issued for the harvest of native fauna in the Australian Capital Territory from 1996 to 1999**

| Licence issued | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|
| Export | 11 | 44 | 84 | 116 |
| Import | 22 | 65 | 134 | 186 |
| Keep | 79 | 92 | 114 | 165 |
| Kill | 2 | 3 | 3 | 24 |
| Sell | 23 | 90 | 162 | 184 |
| Take | 21 | 39 | 46 | 48 |
| Total | 158 | 333 | 543 | 723 |

*Tasmania*

Data on native animal and plant harvest are limited and records are only kept for the harvesting of Brushtail Possum (*Trichosurus vulpecula)*, wallaby (e.g. *Macropus* sp.) and muttonbirds (*Puffinus* sp.), with annual values of production of around $400 000, $750 000 and $425 000, respectively. This industry provides a source of income for Indigenous communities in Tasmania. Statistics for the commercial harvesting of Brushtail Possum are available but these data do not document the non-commercial shooting of possums for crop protection purposes (Table 17). For example, permit returns indicate that an estimated 246 158 possums were taken between 1 July 1998 and 31 June 1999 and another 156 410 between 1 July 1999 and 23 May 2000. Harvesting statistics are also provided for the Short-tailed Shearwater (*Puffinus tenuirostis*) (Table 18).

*Northern Territory*

The main native fauna harvested in the Northern Territory are kangaroos and crocodiles, with crocodile harvesting mainly carried out on farms. Since 1971, crocodile species have been

**Table 17: Commercial harvest statistics for Brushtail Possums (*Trichosurus vulpecula*) in Tasmania, 1995 to 2000**

| Year | Permit holders (No.) | Estimate of harvest (No.) | Royalties paid on skins ($A) | Royalties paid on carcasses ($A) |
|---|---|---|---|---|
| 1995 | 40 | 6 012 | 561 | 1 435 |
| 1996 | 59 | 13 917 | 865 | 4 827 |
| 1997 | 35 | 12 364 | 3 | 11 325 |
| 1998 | 16 | 10 596 | 50 | 6 762 |
| 1999 | 38 | 11 635 | 100 | 8 739 |
| 2000[A] | 34 | 55 837 | 30 | 41 003 |

[A] Interim figures to 23 May 2000.

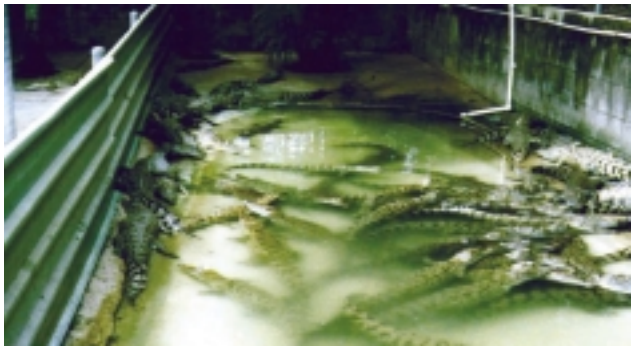
**Source:** Hocking (2000).

**Table 18: Harvest statistics for the Short-tailed Shearwaters (*Puffins tenuirostis*) in Tasmania, 1995–1998**

| Year | Total catch | No. of birds exported | Oil (L) | Feathers (kg) | No. of operators | No. of catchers |
|---|---|---|---|---|---|---|
| 1995 | 203 425 | 71 320 | 796 | 965 | 8 | 41 |
| 1996 | 98 330 | 46 635 | 640 | 0 | 6 | 26 |
| 1997 | 180 217 | 44 400 | 801 | 270 | 6 | 33 |
| 1998 | 112 823 | 48 000 | 270 | 0 | 5 | 26 |

**Source:** Tasmanian Parks and Wildlife Service (1998).

protected and only 16 adult crocodiles have been harvested from the wild (in 1997) since this time. Some adult and juvenile crocodiles have been taken from the wild for restocking, but over the last two decades this has totalled only 67. The Parks and Wildlife Commission (PWC) of the Northern Territory remove 'problem' crocodiles from native habitats and these animals are then used for breeding purposes on farms or sold for meat or skins. During the 1990s, between 130 and 240 crocodiles have been captured under the problem crocodile program in the Northern Territory (PWC of the Northern Territory 1998). The farms have worldwide sales of crocodile leather, skins, flesh and other crocodile products.



**Juvenile crocodiles in the Darwin Crocodile Farm, one of the largest commercial crocodile breeding farms in Australia.**

**Source:** C. Read.

The main form of harvest from the wild is for crocodile eggs that are used to stock crocodile farms. Provisions for harvesting eggs, hatchlings and subadults are made in management programs. The total number of eggs collected from the wild has increased from 2320 in 1984 to around 20 000 from 1997 to 2000. Since 1993 to 1997, the number of farms, skins and meat produced from these farms has steadily increased (Table 19).

**Table 19: Harvest of farmed crocodiles (*Crocodylus porosus* and *Crocodylus johnstoni*) in the Northern Territory, 1993 to 1997**

| Year | No. of farms | Skins (No.) (*Crocodylus porosus*) | Skins (No.) (*C. johnstoni*) | Meat (kg) (*C. porosus* & *C. johnstoni*) |
|---|---|---|---|---|
| 1993 | 6 | 4 796 | 4 066 | 13 850 |
| 1994 | 7 | 3 595 | 4 034 | 17 401 |
| 1995 | 8 | 6 917 | NA[A] | 26 626 |
| 1996 | 8 | 6 410 | 505 | 35 411 |
| 1997 | 8 | 8 448 | 604 | 34 621 |

[A] Not available.

**Source:** PWC of the Northern Territory (1998).

*Western Australia*

Since 1993, detailed records have been kept for harvest data of native flora in Western Australia. These data indicate no clear trend in the total number of stems harvested from 1993 to 1999 (Table 20). The harvest of native species from Western Australia is carried out predominantly for the export market and therefore often follows styles and fashions required by other markets. Harvest of individual species can fluctuate from year to year (Table 21).

**Table 20: Harvest of native flora (number of stems) in Western Australia, 1993 to 1995 and 1999**

| Botanical name | 1993 | 1994 | 1995 | 1999 |
|---|---|---|---|---|
| *Acacia merinthophora* | 0 | 0 | 188 227 | 38 473 |
| *Adenanthos cuneatus*[A] | 144 730 | 96 548 | 0 | 0 |
| *Adenanthos cygnorum*[A] | 0 | 15 680 | 0 | 26 300 |
| *Agonis juniperina*[A] | 3 155 058 | 804 541 | 1 439 962 | 568 987 |
| *Agonis parviceps* | 1 347 650 | 4 306 688 | 2 956 146 | 1 053 640 |
| *Anigozanthos manglesii* | 14 790 | 63 560 | 164 413 | 0 |
| *Anigozanthos pulcherrimus* | 294 750 | 607 700 | 864 795 | 42 050 |
| *Anigozanthos rufus* | 257 300 | 57 960 | 407 707 | 0 |
| *Banksia ashbyi* | 8 087 | 46 951 | 34 312 | 0 |
| *Banksia baxteri* | 1 707 537 | 1 353 115 | 520 743 | 1 339 752 |
| *Banksia burdettii* | 0 | 18 651 | 33 477 | 26 232 |

**Table 20: Harvest of native flora (number of stems) in Western Australia, 1993 to 1995 and 1999 *(continued)***

| Botanical name | 1993 | 1994 | 1995 | 1999 |
|---|---|---|---|---|
| *Banksia coccinea* | 410 658 | 274 786 | 354 904 | 167 245 |
| *Banksia hookeriana* | 2 133 480 | 4 687 107 | 1 276 829 | 2 500 178 |
| *Banksia prionotes* | 1 335 498 | 1 835 382 | 968 149 | 1 058 128 |
| *Banksia sceptrum* | 227 563 | 298 880 | 0 | 144 879 |
| *Banksia speciosa* | 119 103 | 342 136 | 178 621 | 0 |
| *Banksia victoriae* | 117 000 | 0 | 0 | 0 |
| *Beaufortia sparsa* | 752 782 | 527 811 | 738 039 | 476 430 |
| *Boronia heterophylla* | 0 | 72 920 | 210 622 | 132 957 |
| *Bossiaea aquifolium* | 383 690 | 656 190 | 441 290 | 0 |
| *Bracteantha bracteata* | 0 | 0 | 26 000 | 0 |
| *Callitris preissii* | 0 | 17 800 | 21 700 | 0 |
| *Caustis dioica* | 282 770 | 295 690 | 0 | 33 294 |
| *Chamelaucium megalopetalum* | 0 | 150 000 | 0 | 0 |
| *Chamelaucium uncinatum* [B] | 750 681 | 1 011 203 | 900 556 | 8 561 080 |
| *Conospermum triplinervium* [A] | 98 660 | 0 | 0 | 0 |
| *Corynanthera flava* | 119 320 | 0 | 214 240 | 65 475 |
| *Daviesia cordata* | 0 | 215 073 | 604 166 | 0 |
| *Dryandra formosa* | 549 402 | 334 550 | 187 404 | 179 106 |
| *Eucalyptus marginata* | 0 | 0 | 127 320 | 0 |
| *Eucalyptus tetragona* | 0 | 511 581 | 0 | 67 564 |
| *Geleznowia verrucosa* | 173 910 | 150 640 | 198 798 | 50 312 |
| *Juncus holoschoenus* | 412 720 | 602 080 | 0 | 0 |
| *Kingia australis* | 187 100 | 0 | 0 | 0 |
| *Lachnostachys eriobotrya* [A] | 263 020 | 211 233 | 154 225 | 58 913 |
| *Lawrencella rosea* | 15 000 | 0 | 0 | 0 |
| *Leptocarpus scariosus* | 1 047 200 | 344 160 | 373 001 | 0 |
| *Leptospermum sericeum* | 0 | 0 | 260 800 | 0 |
| *Lysinema ciliatum* | 157 100 | 0 | 0 | 0 |
| *Macropidia fuliginosa* | 86 875 | 0 | 0 | 72 661 |
| *Melaleuca nesophila* | 9 380 | 0 | 0 | 0 |
| *Pericalymma ellipticum* | 0 | 0 | 138 000 | 0 |
| *Persoonia longifolia* | 732 398 | 1 086 682 | 1 352 687 | 1 754 737 |
| *Podocarpus drouynianus* | 2 910 325 | 3 347 805 | 3 181 632 | 6 299 426 |
| *Scholtzia involucrata* | 948 330 | 1 448 610 | 889 200 | 249 739 |
| *Stirlingia latifolia* | 2 894 100 | 2 949 068 | 2 268 430 | 1 161 947 |
| *Verticordia eriocephala* | 802 190 | 10 020 | 547 451 | 108 180 |
| *Verticordia nitens* | 293 020 | 337 854 | 987 772 | 284 368 |
| *Verticordia plumosa* | 0 | 0 | 34 806 | 0 |
| *Verticordia serrata* | 8 440 | 0 | 0 | 0 |
| *Xylomelum occidentale* | 272 344 | 302 729 | 381 003 | 228 136 |

[A] Probably bush picked on private property.
[B] Probably cultivated.

**Table 21: Total harvest of native flora (millions of stems) in Western Australia, 1993 to 1999**

| Year | Cultivated | Picked on private property | Picked on Crown land | Total |
|---|---|---|---|---|
| 1993 | 2.2 | 9.2 | 18.4 | 29.8 |
| 1994 | 2.5 | 10.6 | 21.4 | 34.5 |
| 1995 | 3.0 | 9.6 | 15.4 | 28.0 |
| 1996 | 10.1 | 8.0 | 14.1 | 32.2 |
| 1997 | 7.2 | 5.2 | 16.1 | 28.5 |
| 1998 | 5.6 | 9.5 | 20.0 | 35.1 |
| 1999 | 12.1 | 4.0 | 14.7 | 30.8 |

Successful captive breeding of the Australian Saltwater Crocodile (*Crocodylus porosus*) has occurred on crocodile farms in Western Australia and Johnston's Crocodile (*C. johnstoni*) has been bred at farms in Broome and Wyndham. During 1994, 639 *Crocodylus porosus* were bred in captivity, with a further 746 in 1995. As in the Northern Territory, the taking of crocodiles from the wild is subject to quota limitations and since the mid-1980s, the numbers taken have fluctuated. The rate of harvesting depends on the requirements for restocking and also the climatic conditions that may limit the supply of eggs and young (Table 22). Similarly, there has been no discernible trend in the number of crocodiles processed under licence for the seven years to 1998 (Table 23).

**Table 22: Collections of the Australian Saltwater Crocodile (*Crocodylus porosus*) from the wild in Western Australia, by location of capture**
Data include 'problem' animals and farm stock acquisition captures.

| | Cambridge Gulf system | | | | |
|---|---|---|---|---|---|
| | East Arm/Ord River | West Arm | Total | Elsewhere (King Sound) | Total |
| **Non-hatchlings** | | | | | |
| 1983–85 | 8 | 0 | 8 | 6 | 14 |
| 1986–88 | 6 | 0 | 6 | 7 | 13 |
| 1989–July 1992 | 34 | 81 | 115 | 18 | 133 |
| 1992–93[A] | 50 | 38 | 88 | 6 | 94 |
| 1993–94[A] | 12 | 2 | 14 | 0 | 14 |
| 1994–95[A] | 8 | 4 | 12 | 15 | 27 |
| 1995–96[A] | 14 | 1 | 15 | 2 | 17 |
| 1996–97[A] | 7 | 1 | 8 | 0 | 8 |
| Total | 139 | 127 | 266 | 54 | 320 |
| **Viable eggs/hatchlings** | | | | | |
| 1983–85 | 0 | 0 | 0 | 0 | 0 |
| 1986–88 | 0 | 0 | 0 | 30 | 30 |
| 1989–92 | 0 | 268[B] | 268 | 0 | 268 |
| 1993 | 0 | 0 | 0 | 0 | 0 |
| 1994–95[C] | 0 | 6 | 6 | 0 | 6 |
| 1995–96 | 0 | 19 | 19 | 0 | 19 |
| 1996–97 | 0 | 20 | 20 | 0 | 20 |
| 1997 | 0 | 20 | 20 | 0 | 20 |
| Total | 0 | 333 | 333 | 30 | 363 |

[A] Figures are from July to June; [B]Taken from the King River; [C]Taken January 1994 to June 1995.

**Source:** CALM (1999a).

**Table 23:** **Crocodiles processed under licence in Western Australia, 1991 to 1998**

| Year | *Crocodylus porosus* | *Crocodylus johnstoni* |
|---|---|---|
| 1991 | 70 | 11 |
| 1992 | 90 | 21 |
| 1993 | 89 | 167 |
| 1994 | 158 | 517 |
| 1995 | 426 | 60 |
| 1996 | 807 | 231 |
| 1997 | 191 | 173 |
| 1998 | 349 | 216 |
| **Total** | **2 180** | **1 396** |

*New South Wales*

The harvesting of kangaroos in New South Wales is undertaken to use the full carcass (as opposed to skin-only shooting). Since 1996, New South Wales has harvested a higher percentage of the available commercial quota than any other State. Kangaroo populations continue to fluctuate, primarily in response to seasonal conditions. Populations are monitored annually by aerial surveys, fixed-wing and helicopter.

New South Wales NPWS issues licenses for the commercial harvesting of protected native plants from private property and some Crown lands such as state forests. The agency also issues licences for the commercial cultivation of protected plant species. However, some common species of native flora that are harvested commercially, particularly for the cut-flower/filler industry, are not protected species under current legislation and there is accordingly no statutory ability for the NPWS to manage or monitor the harvest or utilisation of those species.

## Harvesting under Commonwealth government legislation

Better and more uniform data exist for some harvests that are undertaken in various Australian jurisdictions, but are listed under the Commonwealth's *Wildlife Protection (Regulation of Exports and Imports) Act 1982*.

Around 62% of the available quota for kangaroo harvesting takes place in Queensland (Tables 24 and 25). Nationally, around 63% of the total quota allowed is used. The quota levels set are well within the estimated population levels of the commercial harvest area (Tables 26 and 27). Numbers of the Wallaroo (*Macropus robustus*) have almost doubled since

**Table 24:** **Commercial kangaroo harvest quotas in Australia in 1998**
Base and supplementary quotas are given in the lower part of the table.

| State | Red Kangaroo (*Macropus rufus*) | Eastern Grey (*Macropus giganteus*) | Western Grey (*Macropus fuliginosus*) | Euro/ Wallaroo (*Macropus robustus*) | Whiptail Wallaby (*Macropus parryi*) | Bennetts Wallaby (*Macropus rufogriseus*) | Tasmanian Pademelon (*Thylogale billardierii*) | Total |
|---|---|---|---|---|---|---|---|---|
| NSW | 655 540 | 460 500 | 163 700 | 29 400 | 0 | 0 | 0 | 1 309 140 |
| Qld | 610 000 | 970 000 | 0 | 270 000 | 25 000 | 0 | 0 | 1 875 000 |
| SA | 327 000 | 0 | 206 000 | 88 000 | 0 | 0 | 0 | 621 000 |
| WA | 180 000 | 0 | 74 000 | 10 000 | 0 | 0 | 0 | 264 000 |
| Flinders Island, Tas. | 0 | 0 | 0 | 0 | 0 | 7 000 | 14 000 | 21 000 |
| Total | 1 772 540 | 1 430 500 | 443 700 | 397 400 | 25 000 | 7 000 | 14 000 | 4 090 140 |
| NSW Base quota | 618 540 | 382 500 | 151 700 | 22 400 | — | — | — | 1 175 140 |
| NSW Supplementary quota | 37 000 | 78 000 | 12 000 | 7 000 | — | — | — | 134 000 |
| SA Base quota | 206 000 | — | 64 000 | 55 000 | — | — | — | 325 000 |
| SA Supplementary quota | 121 000 | — | 142 000 | 33 000 | — | — | — | 296 000 |

**Table 25:** **Kangaroos species killed under commercial harvest quotas across Australia in 1998**

| State | Red Kangaroo (*Macropus rufus*) | Eastern Grey (*Macropus giganteus*) | Western Grey (*Macropus fuliginosus*) | Euro/ Wallaroo (*Macropus robustus*) | Whiptail Wallaby (*Macropus parryi*) | Bennetts Wallaby (*Macropus rufogriseus*) | Tasmanian Pademelon (*Thylogale billardierii*) | Total |
|---|---|---|---|---|---|---|---|---|
| Qld | 510 622 | 486 379 | 486 379 | 167 422 | 217 | 0 | 0 | 1 164 640 |
| NSW | 495 100 | 314 328 | 123 826 | 7 535 | 0 | 0 | 0 | 940 789 |
| SA | 227 904 | 0 | 0 | 24 981 | 0 | 0 | 0 | 326 589 |
| WA | 110 588 | 0 | 0 | 4 851 | 0 | 0 | 0 | 160 539 |
| Flinders Island, Tas. | 0 | 0 | 0 | 0 | 0 | 149 | 70 | 219 |
| **Total** | **1 344 214** | **800 707** | **242 630** | **204 789** | **217** | **149** | **70** | **2 592 776** |

**Table 26:** **Population estimates for kangaroos within commercial harvest areas in 1998**

| State | Red Kangaroo (*Macropus rufus* ) | Western Grey (*Macropus fuliginosus* ) | Eastern Grey (*Macropus giganteus* ) | Euro/Wallaroo (*Macropus robustus*) |
|---|---|---|---|---|
| NSW | 3 595 700 | 1 202 594 | 3 564 500 | 466 738 |
| Qld | 4 870 000 | — | 9 440 000 | 2 660 000 |
| SA | 2 007 000 | 963 000 | — | 412 000 |
| WA | 1 935 000 | 664 700 | — | 168 000 |
| **Total**[A] | **12 407 700** | **2 830 294** | **13 004 500** | **3 706 738** |

[A] The actual national population would be significantly higher as these figures do not include population estimates for areas not surveyed, such as the area east of the Great Dividing Range.

1998, showing the fluctuations that can occur from year to year. Between 1998 and 1999, populations of all kangaroos increased, particularly for the Wallaroo and particularly in Queensland (Tables 26 and 27). In 1999, population estimates for South Australia, New South Wales and Western Australia were based on fixed wing aerial surveys. Population estimates for Queensland were based on extrapolation of helicopter counts in monitor blocks using line transect methodology.

In South Australia and New South Wales, however, the population of Red Kangaroo (*Macropus rufus*) declined over these years. For animals whose numbers fluctuate dramatically with rainfall, statistics from such a short period of time may have limited use.

Beginning in 1997, New South Wales has included a provision for kangaroos previously killed in the commercial zone under non-commercial permits to be included as an identified component of the quota. In 1996, South Australia refined the setting of the commercial harvest quota to provide for the separate identification of a sustainable use component to the quota and an additional land mitigation component. This latter component is to be released only when there is an identified threat to land management goals in areas where the 'sustainable' component of the quota has been taken.

**Table 27:** **Population estimates for kangaroos within commercial harvest areas in 1999**

| State | Red Kangaroo (*Macropus rufus*) | Western Grey (*Macropus fuliginosus*) | Eastern Grey (*Macropus giganteus*) | Euro/Wallaroo (*Macropus robustus*) |
|---|---|---|---|---|
| NSW | 2 952 442 | 1 273 779 | 3 427 554 | 462 418 |
| Qld | 5 440 000 | —[A] | 11 100 000 | 5 250 000 |
| SA | 1 708 000 | 969 000 | — | 412 000 |
| WA | 2 330 000 | 688 300 | — | 168 000 |
| **Total** | **12 430 442** | **2 931 079** | **14 527 554** | **6 292 418** |

[A] NA; [B]the actual national population would be significantly higher as these figures do not include population estimates for areas not surveyed, such as the area east of the Great Dividing Range.

**Table 28: Most commonly recorded Australian exports of native plants and animals**

| Scientific name | Description | Unit[A] | 1990 | 1995 | 1999 |
|---|---|---|---|---|---|
| *Acacia merinthophora* | Stems | No. | 135 | 146 995 | 0 |
| *Acanthophis antarcticus* | Venom | NS | 0 | 5 488 | 0 |
| *Acrosterigma reeveanum* | Shells | No. | 181 | 46 | 3 |
| *Actinopyga mauritiana* | Dried bêche-de-mer | kg | 0 | 0 | 1 645 |
| *Adenanthos cuneatus* | Stems | No. | 0 | 127 019 | 0 |
| *Adiantum formosum* | Dried plants | No. | 0 | 0 | 55 000 |
| | Fronds | No. | 120 000 | 80 000 | 0 |
| | Stems | No. | 32 280 | 95 878 | 20 000 |
| *Agonis parviceps* | Stems | No. | 173 844 | 2 087 045 | 0 |
| *Banksia baxteri* | Stems | No. | 279 060 | 702 552 | 0 |
| *Banksia hookeriana* | Stems | No. | 344 695 | 1 855 013 | 0 |
| | Flowers | No. | 0 | 0 | 33 060 |
| *Banksia prionotes* | Stems | No. | 182 730 | 1 069 158 | 240 |
| *Bowenia serrulata* | Stems | No. | 0 | 33 370 | 1 845 |
| *Calochlaena dubia* | Dried plants | No. | 0 | 0 | 5 000 |
| | Dried flowers | No. | 0 | 0 | 15 000 |
| *Caustis blakeii* | Stems | Nb | 84 420 | 0 | 0 |
| | Stems | No. | 320 001 | 0 | 0 |
| *Caustis dioica* | Flowers | No. | 0 | 0 | 40 000 |
| | Stems | No. | 56 190 | 71 647 | 0 |
| *Caustis flexuosa* | Stems | No. | 0 | 143 270 | 0 |
| | Fronds | No. | 15 000 | 0 | 10 000 |
| *Cecidomyiidae* | Live invertebrates | No. | 0 | 4 000 | 3 000 |
| *Chaceon bicolor* | Live or dead crabs | Kg | 0 | 0 | 3 243 |
| *Culcita dubia* | Fronds | No. | 105 000 | 0 | 0 |
| *Dicksonia antarctica* | Live plants | No. | 16 | 504 | 28 828 |
| *Durvillea potatorum* | Seaweed | L | 1 636 | 0 | 8 740 |
| | Fronds | kg | 1 318 995 | 32 460 | 0 |
| | Seaweed | tn | 0 | 3 515 | 460 |
| *Exocarpos cupressiformis* | Stems | Nb | 500 | 0 | 0 |
| *Hemiergis* spp. | Live animal(s) | No. | 0 | 0 | 460 |
| *Holothuria (Metriatyla) scabra* | Dried, fresh and Frozen bêche-de-mer | kg | 0 | 0 | 30 830 |
| | Dried bêche-de-mer | No. | 0 | 0 | 319 000 |
| | Dried bêche-de-mer | kg | 0 | 7 570 | 7 296 |
| | Meat | kg | 0 | 13 600 | 0 |
| | Frozen bêche-de-mer | No. | 0 | 17 105 | 2 518 |
| *Hypothalassia armata* | Live or dead crabs | kg | 0 | 0 | 2 671 |
| *Juncus holoschoenus* | Stems | No. | 524 794 | 326 710 | 0 |
| *Lepidoptera* | Eggs | No. | 20 | 0 | 0 |
| | Live invertebrates | No. | 22 | 0 | 0 |
| *Lycopodium cernuum* | Live plants | Nb | 4 400 | 0 | 0 |
| *Macropus eugenii* | Scientific specimens | No. | 0 | 5 000 | 0 |
| *Macropus fuliginosus* | Meat | kg | 0 | 71 248 | 8 168 |
| | Skin | No. | 65 061 | 179 451 | 25 344 |
| | Scientific specimens | g | 2 100 | 0 | 0 |
| *Macropus giganteus* | Hat accessories | No. | 996 | 0 | 239 |
| | Belt | No. | 392 | 0 | 311 |
| | Hat | No. | 0 | 0 | 4 253 |
| | Leather (skins) | No. | 0 | 0 | 173 275 |
| | Skin | No. | 1 300 481 | 0 | 213 591 |
| | Meat | kg | 156 457 | 1 494 230 | 651 908 |
| | Golf accessories | No. | 0 | 1 479 | 0 |

**Table 28: Most commonly recorded Australian exports of native plants and animals *(continued)***

| Scientific name | Description | Unit[A] | 1990 | 1995 | 1999 |
|---|---|---|---|---|---|
| | Hat accessories | No. | 0 | 2 956 | 239 |
| | Toy koalas | No. | 22 379 | 4 410 | 0 |
| | Meat | No. | 0 | 33 922 | 9 600 |
| | Meat products | kg | 0 | 83 328 | 0 |
| | Leather (skins) | No. | 0 | 488 630 | 173 275 |
| | Skin | No. | 0 | 995 690 | 214 191 |
| *Macropus rufus* | Leather (skins) | No. | 0 | 190 628 | 2 537 |
| | Skin | No. | 872 351 | 1 102 282 | 240 710 |
| | Meat | kg | 333 418 | 1 326 173 | 1 049 429 |
| *Macropus* spp. | Meat | kg | 0 | 0 | 18 000 |
| | Skin | No. | 0 | 0 | 28 395 |
| *Macrozamia miquelii* | Fronds | Nb | 2 300 | 0 | 0 |
| | Fronds | No. | 12 400 | 600 | 0 |
| | Stems | No. | 800 | 0 | 420 |
| *Neotrigonia bednalli* | Shells | No. | 144 | 140 | 75 |
| *Nothofagus cunninghamii* | Stems | No. | 0 | 616 | 1 200 |
| *Persoonia virgata* | Live plants | Nb | 4 400 | 0 | 0 |
| | Stems | No. | 0 | 6 900 | 0 |
| *Phyllopteryx taeniolatus* | Live fish | NS | 0 | 0 | 69 |
| *Podocarpus drouynianus* | Flowers | No. | 0 | 11 100 | 5 220 |
| *Pseudocarcinus gigas* | Live or dead crabs | kg | 0 | 0 | 8 636 |
| *Pteridium esculentum* | Dried plants | No. | 0 | 0 | 20 000 |
| | Stems | No. | 118 | 74 945 | 0 |
| *Pycnosorus globosus* | Flowers | No. | 0 | 0 | 534 150 |
| *Wodyetia bifurcata* | Seeds | No. | 0 | 1 250 | 27 090 |
| *Xanthorrhoea johnsonii* | Leaves | Nb | 79 550 | 148 000 | 0 |
| | Fronds | Nb | 6 120 | 0 | 0 |
| | Live plants | Nb | 39 350 | 0 | 0 |
| | Leaves | No. | 39 700 | 0 | 0 |
| | Live plants | No. | 0 | 0 | 827 |
| | Stems | No. | 0 | 28 000 | 0 |
| *Xanthorrhoea semiplana* | Extract | kg | 0 | 25 000 | 18 000 |

[A] No. = number; NS = not specified; kg = kilograms; Nb = number of bunches; L = litres; tn = tonne; g = gram.

Export data for Australian native plants and animals are available for permits issued (Table 28). Table 28 shows only those taxa most commonly appearing in the permit database for the years shown. Over 250 species were subject to permit approvals, most for small and/or occasional quantities. There is substantial year-to-year variation in the volumes of individual species exported. Data are collected and reported in a range of units such as 'stems' and 'bunches' which makes comparisons between years and the determination of any trends difficult. It has not been possible to assess the significance of harvest levels of specific taxa, or the location of harvest.

Data on plants and animals exported illegally come from prosecutions and will thus be an underestimate. From the data provided it is usually impossible to determine what species are involved in prosecution or what crime was involved unless each individual file is analysed, a task beyond this report (Table 29).

## Management plans for sustainable harvesting [BD Indicator 17.1]

Overall there are 11 management plans approved under the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (Table 30). Most of the management plans are for species of kangaroo.

The Act provides for management programs to be declared where there is sufficient information available on the biology of the species proposed for harvesting to ensure that the activity will not be to the irreversible detriment of the species, or its habitat. Management programs are usually administered by state or territory government agencies and reflect state/territory-wide management for the particular species concerned.

**Table 29:** **Prosecutions and trials under the *Wildlife Protection Act 1982* (Cwlth) for illegally importing/exporting wildlife, 1990 to 1999**

| Year | Guilty plea | Not guilty plea | Total | Fined or sentenced |
|---|---|---|---|---|
| 1990 | 13 | 1 | 14 | 10 |
| 1991 | 17 | 4 | 21 | 10 |
| 1992 | 13 | 5 | 18 | 13 |
| 1993 | 7 | 4[A] | 11 | 10 |
| 1994 | 25 | 7 | 32 | 20 |
| 1995 | 12 | 10[A] | 22 | 18 |
| 1996 | 14 | 3[A] | 17 | 14 |
| 1997 | 15 | 2 | 17 | 15 |
| 1998 | 15 | 4 | 19 | 18 |
| 1999 | 8 | 0 | 8 | 7 |

[A] Includes some 'not applicable' and 'changed' pleas.

**Source:** Commonwealth Office of the Director of Public Prosecutions (pers. comm. 2000).

**Table 30:** **Management programs approved under S10 of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (Cwlth)**

| Management program name | Approval period |
|---|---|
| A Management Program for *Crocodylus porosus* and *Crocodylus johnsoni* in the Northern Territory of Australia | 1 Jan. 1999 –31 Dec. 2003 |
| Management Program for the Saltwater Crocodile *Crocodylus porosus* and the Freshwater Crocodile *Crocodylus johnsoni* in Western Australia | 1 Jan. 1999–31 Dec. 2003 |
| The Short-tailed Shearwater *Puffinus tenuirostris* Management Program in Tasmania | 1 Jan. 1998 –31 Dec. 2000 |
| Management Program for the Brushtail Possum *Trichosurus vulpecula* (Kerr) in Tasmania 1997 to 1999 | 1 Jan. 2000 –31 Dec. 2004 |
| The New South Wales Kangaroo Management Program | 1 Jan. 1998 –31 Dec. 2002 |
| The Kangaroo Conservation and Management Program in South Australia | 1 Jan. 1998 –31 Dec. 2002 |
| 1998 to 2002 Management Program for Commercially Taken Macropods in Queensland | 1 Jan. 1998 –31 Dec. 2002 |
| Management Program for the Red Kangaroo *Macropus giganteus* in Western Australia 1998 to 2002 | 1 Jan. 1998 –31 Dec. 2002 |
| Management Program for the Western Grey Kangaroo *Macropus fuliginosus* in Western Australia 1998 to 2002 | 1 Jan. 1998 –31 Dec. 2002 |
| Management Program for the Euro Kangaroo *Macropus robustus* in Western Australia 1998 to 2002 | 1 Jan. 1998 –31 Dec. 2002 |
| Management Program for Bennett's Wallaby *Thylogale billardierii* and Tasmanian Pademelon on Flinders Island, Tasmania 1998 to 1999 | 1 Jan. 2000 –31 Dec. 2002 |

## Harvesting indicators: An overview [BD Indicators 8.1, 8.2 and 17.1]

Analysis of the available data for Indicators 8.1, 8.2 and 17.1 reveals that, with the exception of kangaroo harvest and permit data and flora harvest data from Western Australia, there is an acute lack of accessible comparable data for most states on harvesting of native flora and fauna. There is a urgent need for improvements in the reporting system for prosecutions involving illegal exports of Australian wildlife so that it is possible to determine what species are being threatened.

## Fisheries

Australia has sovereign rights to explore and exploit resources within the Exclusive Economic Zone (EEZ), which is the second biggest in the world, and also has a claim over the continental shelf where it extends beyond the EEZ outer boundary. It also has the

responsibility to manage and use these resources wisely, as well as to conserve biodiversity. The total Australian Marine Jurisdiction (AMJ), which includes the EEZ and continental shelf off the Australian mainland and external territories, covers a total surface area of around 16 million square kilometres—about twice the size of the Australian mainland.

Australian fisheries are based on the harvest of wild, native organisms, and this represents a highly significant direct use of elements of the species level of biodiversity. Traditionally, fisheries management has concerned itself primarily with the management of targeted fish stocks. In recent years, fisheries management has broadened in scope to include consideration of the incidental mortality or injury of other species and to the effects of fishing operations on the environment. Such an approach is termed 'ecosystem management', a principle that dates from reform of national fisheries policy in the late 1980s to include ESD.

## Proportion of numbers collected over size of reproducing population [BD Indicator 8.3]

Catch levels and management of major fisheries stocks are covered in the *Coasts and Oceans* Report.

## Fisheries bycatch [BD Indicator 8.4]

Bycatch species are those species that are not targeted in fisheries operations and are caught or affected incidentally. The definition of bycatch is complex, and can vary from fishery to fishery. Bycatch includes other fishery species, some of which may be retained and sold, as well as other species, including marine mammals and seabirds. In some fisheries, especially those using trawl techniques and comprising a mixture of species, bycatch is common due to the gear and methods used. In others, the specific nature of the gear and methods used mean that lower bycatch rates are possible. The Bureau of Rural Sciences used the approach outlined in Table 31 for defining bycatch as a proportion of total catch (Barratt et al. 2001). In general, bycatch describes a subset of the actual species present, with invertebrates and algae either grouped or ignored.

**Table 31: Definitions of bycatch**

| Component of total 'catch'[A] | Target species | Non-target species |
|---|---|---|
| Retained | A | B |
| Discarded | C | D |
| Other[B] | E | F |

[A] **Total catch:** A+B+C+D; **Retained catch:** A+B; **Discarded catch:** C+D; **Bycatch:** B+D+F; **Byproduct:** B;
[B] Organisms affected by fishing gear but which do not reach the deck.

**Source:** Barratt et al. (2001).

The National Bycatch Policy (NBP) adopts the definition of bycatch given in Table 31, but restricts attention to categories D and F (i.e. not to incidentally caught, retained catch). Bycatch has become a widely recognised issue, mostly because of the mortality of high-profile species such as Dugongs, seals and albatross (see the *Albatross and bycatch policy* box on page 43). However, for most fisheries and bycatch species, measurement is limited at best to broad estimates of weight of bycatch versus weight of total catch.

Published reviews of fisheries bycatch note that data are very poor for most fisheries, and that an accurate overview of the whole fisheries sector is not available. In some fisheries, discarded catch need not be recorded in fishers' logbooks and, where such recording is required, compliance may be low. This situation, in part, reflects the difficulty of identifying many species that are caught incidentally. In some fisheries, the bulk of bycatch is discarded, usually with high mortality rates. There is a significant bycatch problem in some fisheries, notably those utilising trawl and longline methods. The problem appears to be reduced in highly targeted fisheries such as those using jigging or diving.

The Barratt et al. (2001) report estimated discarded catch as a proportion of total catch for 144 managed fisheries in Australia. They classified the 23 Commonwealth managed fisheries for which data are available according to the components of total catch used in Table 31. Information on discarded non-target species is only available for 26% of the 23 Commonwealth fisheries used in the analysis (Table 32).

**Table 32: Percentage of fisheries in Australia for which information is available on different components of their catch**

| Category | Percentage of fisheries for which information is available |
|---|---|
| A (retained target catch) | 100 |
| B (retained non-target catch) | 70 |
| C (discarded target catch) | 39 |
| D (discarded non-target catch) | 26 |
| E (other target species) | 9 |
| F (other non-target species) | 39 |

## Other effects of fisheries on biodiversity

'Ecological effects' refers to a range of other impacts of fisheries relevant to the species level of biodiversity. Recognition of such effects is a result of the beginning of the adoption of an 'ecosystem management' approach to fisheries, where management is intended to cater for impacts other than on the target stock. Ecological effects of some major Australian fisheries include:

- removal or mortality of one or more species (target or non-target), to the point where populations of that species may be rendered vulnerable
- the effect of 'fishing debris', such as the entanglement, pollution and possible drowning of wildlife in discarded or lost lines and nets
- impact on feeding or other behaviour of species such as Dugongs (e.g. through disturbance and boat-strike by vessels)
- disturbance of habitat, especially of seabed plant and animal communities through trawling
- indirect changes or destabilisation of ecosystems through the removal of important predator or prey species that may affect other populations
- impact on scavenging populations through the discarding of large quantities of bycatch and processing waste.

The effect of fisheries such as the Bass Strait Central Scallop Fishery on the biodiversity of benthic communities is likely to be high, but few reliable data are available.

## Management plans for ecologically sustainable harvesting [BD Indicator 17.1]

Management plans are now provided for in all Australian fisheries legislation (Table 33). Fisheries without management plans are managed in accordance with the general

**Table 33: Management plans for Australian fisheries (at June 1999)**

| Statute (jurisdiction) | Statutory provision for management plans | No. of fisheries managed | No. of fisheries with management plans | No. of plans dealing with non-target species |
|---|---|---|---|---|
| *Fisheries Management Act 1991* (Cwlth) | Yes | 23 | 4 | 3 |
| *Fisheries Act 1994* (Qld) | Yes | 17 | 2 | 1[A] |
| *Fisheries Management Act 1994* (NSW) | Yes | 8 | 0 | 0 |
| *Fisheries Act 1995* (Vic.) | Yes | 9 | 0 | 0 |
| *Living Marine Resource Management Act 1995* (Tas.) | Yes | 9 | 5 | 1[B] |
| *Fisheries Act 1982* (SA) | Yes[C] | 13 | 13 | 0 |
| *Fisheries Resources Management Act 1994* (WA) | Yes | 48 | 33 | 1[D] |
| *Fisheries Act 1988* (NT) | Yes | 17 | 3 | 0 |

[A] Draft trawl fishery plan mentions bycatch targets; [B]Bycatch targets mentioned in scale fish policy document; [C]Term 'scheme of management' is used in the Act; [D]Reported, not analysed in source document.

**Source:** Barratt et al. (2001).

requirements of the relevant legislation. Although the situation across jurisdictions varies, the generally small proportion of fisheries with management plans, and the even fewer catering for bycatch, is a matter of concern from a biodiversity perspective.

Given that most of the legislation is less than one decade old, and that it has only been in recent years that ecosystem management and bycatch have been accorded real attention, the status may be viewed as transitional, and one that should be expected to improve markedly in the next few years and monitored accordingly. Requirements for environmental assessments and management plans under the EPBC Act and related legislation will speed up this process. A remaining issue even where management plans exist is of coordination of management where stocks cross jurisdictions.

### The policy setting

Some policy and management changes have been initiated in the past decade affecting both target stock management, bycatch and other environmental effects. For example, Dugong Protection Areas have been introduced in waters adjacent to Queensland where the use of mesh nets are restricted or prohibited.

At the national level, a NBP was released in 1999 following cooperative development of the Commonwealth, states and territories, and expressly stated as being consistent with the National Strategy for Ecologically Sustainable Development and the NSCABD. The Policy states several guiding principles that should be adhered to in all legislation and management plans, including: promotion of stewardship, cooperation and transparency, integration of short-term and long-term approaches, and application of the precautionary principle. The overarching objective of the Policy is to ensure that bycatch species and populations are maintained at sustainable levels.

The NBP committed the Commonwealth to the development of bycatch action plans (BAPs) for all fisheries through a defined, multistep policy formulation. The Policy lists a range of strategies and a checklist of considerations to be taken into account when developing BAPs. BAPs do not have legal standing, and are not based on minimum standards of performance.

### Effectiveness of bycatch controls [BD Indicator 17.2]

Investigation of Commonwealth fisheries (Barratt et al. 2001) suggest that 114 or 79% of Australia's 144 commercial fisheries have low to very low discard rates (defined as <25% of total catch discarded) while 11 fisheries have high discard rates (>50% discarded) (Table 31, C+D). Fishing conducted by longline and dropline has increased in intensity (Figure 26), while the estimated level of bycatch for some significant fisheries is very high. The Northern Prawn Fishery, Southern Bluefin Fishery and South East Trawl Fishery, in particular, have high levels of bycatch and have, at least, a significant effect on marine biodiversity (Figure 27). For example, discard figures of 95, 83 and 50 to 86% are reported for these three fisheries, respectively. Some 30 000 to 60 000 t of marine life might be discarded to harvest 10 300 t of Northern Prawns. The 'discard' may involve over 500 species including turtles, snakes, sawfish, sharks and seabirds.

Various strategies are being investigated or adopted in other jurisdictions that could help reduce bycatch levels. In Queensland, the East Coast Trawl Fishery management plan includes the compulsory use of turtle excluder devices (TEDs). In New South Wales, research is being undertaken to establish methods of reducing juvenile fish bycatch in estuarine prawn and fish hauling. Release devices are also being introduced into prawn trawl fisheries in estuarine and ocean areas. In Western Australia, the issue is being attended to through action plans for individual fisheries. In general, the efficacy of the various bycatch reduction strategies and technologies requires ongoing monitoring.

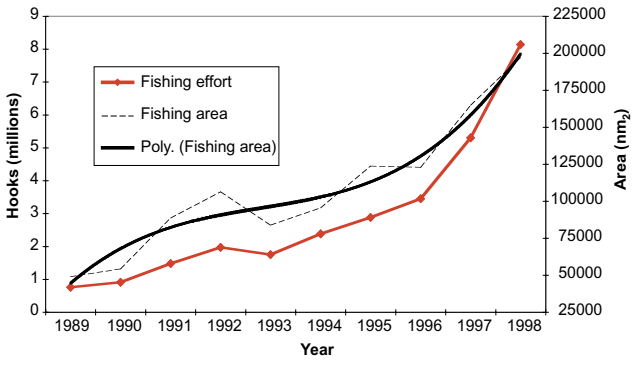



**Figure 26: Change in fishing effort (hooks) in the eastern sector of the Australian Pelagic Longline Fishery and the area of the fishery (square nautical miles) between 1989 and 1998.**

Poly.; polynomial curve fitted to the data.

**Source:** Barratt et al. (2001).

## Altered fire regimes

### Fire regimes

Fire is as much a part of the natural environment of Australia as wind, sun and rain. As a natural element, it has

not only helped shape the environment, it also has been among the driving forces in the evolution of native fauna and flora (Gill et al. 1981; Whelan 1995). This has contributed to adaptations such as resprouting of many species after fire, especially the dominant eucalypts. The seeds of other plant species, such as hakeas and banksias, are held in the canopy and released by the heat of a fire. Smoke is an important cue for the germination of hundreds of plant species, particularly in south-west Australia (Roche et al. 1997). Whereas one fire alone may determine the response of an organ or organism, consideration of the fire regime (i.e. type, frequency, season and intensity of a fire experienced at a specified location, Gill 1975) is necessary to better understand responses of species and assemblages of species. A combination of fire and other environmental factors, such as life-history stage, plant condition, fire edge to area ratio, and the post-fire environment, may interact to affect biological patterns. Interactions with grazing animals and weeds can also affect the response of native biota.

Fires help create and modify the mosaic of landscape and biological patterns within their sphere of influence and may increase the susceptibility of some areas to erosion. The complexity of fires and the way they may change native ecosystems should not be underestimated; fire effects can still be detected 20 to 30 years after the event. Much is still to be learnt about the long-term effects of both single and repeated fires on natural ecosystems.

Despite the intimate relationship between fire regimes and the biota of Australia, fire is perhaps one of the least understood of the 'natural elements'. The popular view is that it is an element of destruction. Images on television of raging bushfires both in Australia and other countries tend to reinforce that perception, particularly within the ever-increasing urban community. Such coverage portrays fires as individual events, whereas it is the conditions of the ecosystems and their characteristics, together with the history of fires and their properties that determines the effect of fires (Bradstock et al. 2001).

## Fire and humans

The use of fire by humans has made an indelible impact on many species, including humans. For millennia, Indigenous peoples have used fire for a range of purposes including warmth, hunting, communication, ceremonies and cooking (Bowman 1998). Prior to the European occupation of Australia, landscape burning was widely used by Indigenous peoples and their effect on the environment is considered one of the most complex and contentious issues in Australian ecology (Bowman 1998). Indigenous peoples' knowledge of landscapes and use of fire remains extraordinarily detailed, particularly in central and northern Australia. A recent study on fire patterns and their impacts across northern Australia illustrates the lessons that can be learnt from traditional burning (see the *Pre-contact Indigenous* box on page 87). It also emphasises the different fire regimes that can occur on different land tenures, making the description of fire patterns across the country even more complex.

A unique study in the remote desert west of Lake Mackay (WA) (N. Burrows, unpublished data) provides quantitative evidence of traditional patterns of burning in arid Australia. Aerial photographs taken in the early 1950s,

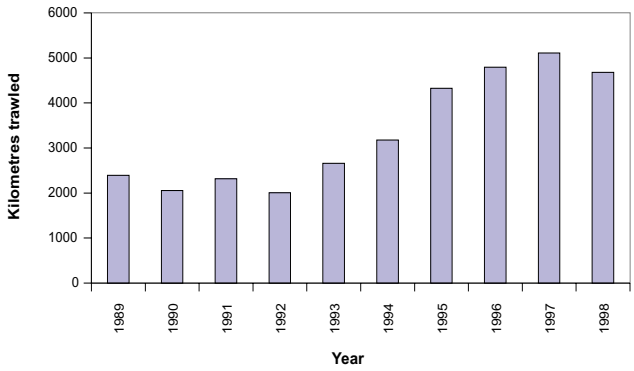



**Figure 27: Total kilometres trawled in the South East Trawl Fishery between 1989 and 1998.**

**Source:** Barratt et al. (2001).

**Resprouting eucalypts after a wildfire on Black Mountain, ACT.**

**Source:** JE Williams.

**Fruits of the Desert Banksia (*Banksia ornata*) split open after fire to release their seeds, in Wyperfeld National Park, Vic.**

**Source:** TW Norton.

## Pre-contact Indigenous, and contemporary fire regimes of the savanna landscapes of northern Australia

Ethnographic, historical and contemporary observations concerning traditional burning, while sparse and geographically biased towards coastal and subcoastal regions in northern Australia, consistently show that burning was undertaken throughout the dry season following landscape patterns of the curing of grassy fuels, but particularly in the early-season to mid-dry season under cooler, milder conditions for fire. Burning of clan estates was/is undertaken systematically and purposefully. Contemporary evidence (from coastal and subcoastal situations) indicates at least half of any clan estate might be burnt in any one season. It is evident that, in accord with regional human population densities, burning was undertaken more frequently in higher rainfall coastal and subcoastal regions.

Based on regional mapping of fires from satellite imagery (mostly National Oceanic and Atmospheric Administration-Advanced Very High Resolution Radiometer, NOAA-AVHRR and LANDSAT) from the 1980s, two broad contemporary patterns have been identified concerning the application of fire in northern Australia. In north-west and northern Australia, and around the Gulf of Carpentaria, vast tracts are burnt annually, typically by intense wildfires late in the dry season. Conversely, elsewhere across northern Australia, but especially on more productive pastoral lands, landscape burning is infrequently applied.

Major differences (and similarities) between traditional Indigenous peoples and contemporary fire regimes may be summarised as follows:

- Whereas burning was undertaken across northern Australia under Indigenous custodianship, burning today is concentrated mainly in non-pastoral, relatively high rainfall regions, especially in the Kimberley, in the Top End, and around the Gulf of Carpentaria.
- Whereas burning traditionally was concentrated in the early- to mid-dry season, today it generally occurs mostly in the late dry season. Generalisation of the contemporary situation, however, masks considerable early dry season burning in some limited locations (e.g. Darwin region, Kakadu and Litchfield National Parks).
- Whereas it is evident that burning traditionally was/is undertaken systematically for a diverse range of purposes, today where burning occurs, it often emanates from uncontrolled wildfire.
- Importantly for biodiversity conservation, whereas an essential feature of burning by Indigenous peoples was/is that it tended to be highly patchy and thus contributed to developing habitat heterogeneity, today northern Australian savanna landscapes are either burnt frequently by typically intense, extensive fires, or seldom burnt.

**Source:** Russell-Smith (2000).

when Pintupi people still lived a traditional lifestyle, reveals a broad-scale pattern of numerous small patches, 75% of which were less than 32 ha, and occasional large fires up to 6000 ha. In contrast, images taken in 1988 reveal a very different pattern of burning. The main exodus of Pintupi people from the remote desert into European settlements occurred in the early 1960s (N. Burrows, pers. comm.) and the cessation of traditional burning in the region is considered to have led to the much larger fires. Information such as this can be used to support contemporary fire management, especially where the reintroduction of more traditional approaches is the goal.

In temperate Australia, the ecological connectivity and functionality has been disrupted by broad-scale clearing and other major modifications, and traditional Indigenous land management has long been replaced by management for very different aims (e.g. Williams & Gill 1995). However, a range of other techniques can be used in southern Australia to gain some understanding of historic fire regimes and their effect on the biota. These include palaeoecology, dendrochronology, ethnography and an understanding of the life-history strategies of plants and animals (Williams & Gill 1995; Kohen 1996; Benson & Redpath 1997).

### Current fire regimes

In southern Australia, one of the main objectives in the use of prescribed burning is to reduce the rates of spreads and intensities of 'wildfires'. Experience, rather than empirical data, seems to be a major factor in assessing the value of fuel-reduction burning as a management technique.

Altered fire regimes have been implicated in local extinctions of several vascular plant species across Australia (Gill & Bradstock 1995; Keith 1996) and inappropriate fire regimes have been associated with 19 plant species threatened with extinction at the state or Commonwealth level (Leigh & Briggs 1992). Gill and Bradstock (1995) also list 19 examples

of local plant extinctions that span a wide range of life histories, habitats and locations. The changes in habitat structure that come with the decline and elimination of woody plant species under frequent fire regimes have demonstrable implications for the persistence of other groups of biota (e.g. Catling 1991; York 1999).

Single fire events, especially of high intensity, can eliminate species as recorded for alpine conifers in Tasmania (Kirkpatrick & Dickinson 1984). Other kinds of fire regimes have also been implicated in declines and extinctions of plants. For example, the decline of woody heathland understorey species under low frequency fires has been linked to competitive exclusion (Keith & Bradstock 1994) and the lack of fire in isolated remnants in the highly cleared landscapes of southern Australia (Lunt & Morgan 2001) is of concern.

Many Australian birds have declined since European settlement. The involvement of altered fire patterns in this decline has long been recognised (Ashby 1924). The 2000 Action Plan for Australian Birds estimated that changes in fire management affects 43% of mainland bird species (Garnett & Crowley 2000). In many cases, birds that are threatened by altered fire regimes require long-unburnt vegetation and intervals between fire longer than those which have been imposed since European settlement (Woinarski 1999). This is especially so for birds of heathlands, mallee and coastal 'scrub', and birds reliant on hollows for nesting or roosting. A major change in fire regimes is not needed to trigger biodiversity loss: even minor changes in fire regimes may be critical for some bird species and can lead to almost imperceptibly gradual, but inexorable decline, especially where habitats have been extensively fragmented (Brooker & Brooker 1994).

The study by N. Burrows et al. (unpublished data) in the Western Desert shows that since the 1950s fire patterns in the hummock grasslands of the Great Sandy Desert have changed from small interlocking burnt patches to a simpler mosaic consisting of large tracts of long unburnt or recently burnt vegetation. This pattern has been repeated across arid and semi-arid Australia (i.e. Griffin et al. 1983; Griffin & Friedel 1985) and such changes have been implicated in the decline of small mammals in these areas (Burbidge & McKenzie 1989). Other factors such as increased levels of predation, drought and competition for resources from exotic animals also appear to have been important in the demise of small mammals (Morton 1994).

## Monitoring fire patterns [BD Indicator 6]

Remote sensing by satellites has opened the way for mapping and monitoring the areal extent of fire activity on a continental scale. The NOAA-AVHRR satellite sensor has already been used for several years for real-time fire monitoring by the WA Department of Land Administration to identify potentially damaging bushfires in northern Western Australia and the Northern Territory. This technique was also used for a pilot study to assess fire patterns across Australia between April 1998 and March 2000 (Craig et al. 2000).

Data were collected on fire hotspots (FHS) and fire-affected areas (FAA) and have been analysed on a seasonal basis and by IBRA. Figures 28 and 29 demonstrate the patterns of FHS and FAA across the country between April 1998 and March 2000. During this two years, 13% (1 023 189 km$^2$) of the Australian continent was burnt. Table 34 lists the area affected by fire between 1998 and 2000 for each Interim Biogeographical Regions of Australia (IBRA) (Figure 4). The large amount of fire activity in northern Australia is immediately apparent, with large fire 'scars' (greater than 4 km$^2$) being mapped in

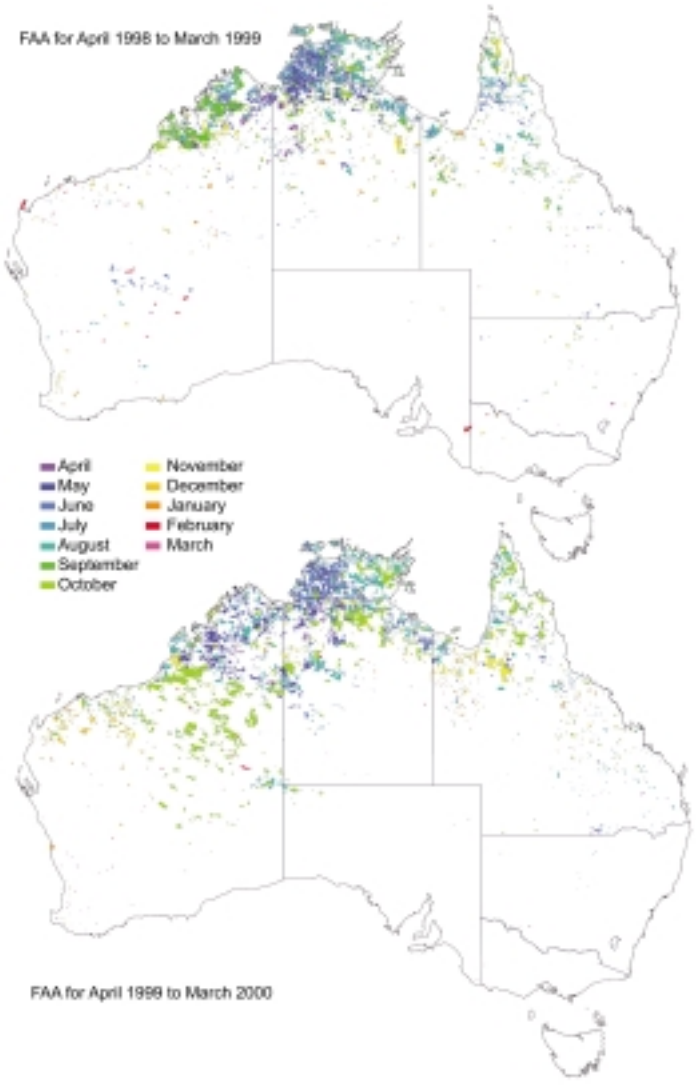



**Figure 28: Fire-affected areas recorded for Australia between April 1998 to March 2000 derived from NOAA satellite imagery.**

Daylight passes of this satellite pick up fire 'scars' greater than 4 km$^2$ and for the two years of the pilot study (1998–2000) showed large-scale burning occurring annually across northern Australia.

**Source:** Craig et al. (2000).

autumn and winter. This occurred in both years of the study, emphasising the flammable nature of northern Australia. Significant levels of burning were also recorded in the wheat belt of Western Australia and inland Queensland, thought to be related to agricultural practices.

NOAA satellite images detect FAAs greater than 4 by 4 km and FHSs at a scale of 1 by 1 km. The resolution of NOAA images is, therefore, too coarse to pick up the fine-scale management fires in conservation reserves, where Landsat images tend to be used (Allan & Southgate 2001). Because major fires in southern and central Australia can be decades apart in the one area, longer-term monitoring would be required to quantify the frequency and extent of fires at a national scale.

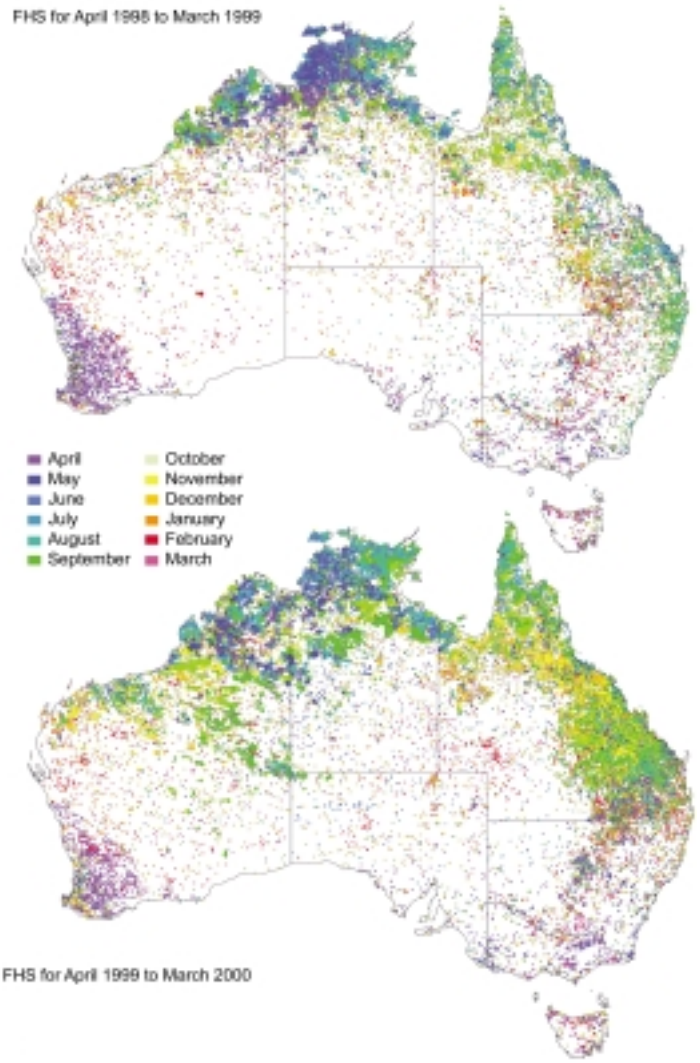



**Figure 29: Fire hotspots recorded for Australia between April 1998 and March 2000 derived from NOAA satellite imagery.**

Evening passes of the satellite were used to pick up the heat signal from fires.

**Source:** Craig et al. (2000).

## Legislative, policy and management framework for fire management

Historically, much of the legislation concerning fire management in Australia has been about fire prevention and suppression, aimed at minimisation of loss to property and life. Legislators respond to deaths in bushfires by attempting to impose control on fire. In many cases, this legislation narrows the range of acceptable or achievable fire regimes, and in some cases outlaws regimes which are required for the conservation of some biota (Hughes 1995).

At the state level, there are some strong legislative responsibilities related to fire planning and management for biodiversity conservation. For example, the fire management plan for Tarawi Nature Reserve in western New South Wales operates under the *Rural Fires Act 1997* (NSW) which defines the statutory obligations of the land manager and provides for establishment of District Bushfire Management Committees as a means of integrating fire management across landscapes that comprise multiple managers with varying goals. The plan also operates under the *National Parks and Wildlife Act 1974* (NSW), which defines the role of Nature Reserves and requires that fire management is not in conflict with the Plan of Management adopted for the reserve, and the *Threatened Species Conservation Act 1995* (NSW), which defines requirements for impact assessment, planning and implementation of recovery for listed species.

Keith et al. (2001) proposed several principles and approaches for the use of fire as a management tool that recognises the importance of setting explicit goals, precautionary management practices, experimentation, risk assessment (see the *Risk assessment and management approaches to biodiversity* box on page 92) and the need to implement monitoring so that management practices can be evaluated and potentially modified. An important element of this approach is to try and include the unpredictable (especially unplanned fires) in management planning.

## Reducing the impact of altered fire regimes [BD Indicator 21]

In recent years, there has been an increasing emphasis on the development of fire management plans that specifically incorporate biodiversity conservation. The current regimes for conservation reserves in each state are described as well as national parks that the Commonwealth government has responsibility for. It does not, however, address other land tenures such as State Forests and Indigenous peoples' lands (except for jointly managed conservation reserves) where fire is also important in the maintenance of biodiversity.

**Table 34: Fire-affected areas (FAA) for each IBRA region (version 4) for 1998 to 1999 and 1999 to 2000**
See *Figure 4* for locations of each IBRA region.

| IBRA region name | IBRA area ($km^2$) | 1998–1999 FAA ($km^2$) | 1999–2000 FAA ($km^2$) |
|---|---|---|---|
| Australian Alps | 11 577 | | |
| Avon wheat belt | 95 316 | 260 | 83 |
| Ben Lomond | 8 670 | | |
| Brigalow Belt North | 112 493 | 919 | 3 614 |
| Brigalow Belt South | 287 534 | 335 | 3 320 |
| Broken Hill Complex | 56 975 | | |
| Burt Plain | 71 815 | 33 | 493 |
| Cape York Peninsula | 117 318 | 16 354 | 37 527 |
| Carnarvon | 90 755 | 849 | 1 899 |
| Central Arnhem | 36 972 | 7 474 | 30 931 |
| Central Highlands | 11 034 | | |
| Central Kimberley | 77 128 | 15 749 | 32 681 |
| Central Mackay Coast | 14 622 | | 339 |
| Central Ranges | 97 741 | 38 | 9 696 |
| Channel Country | 305 309 | 269 | 1 684 |
| Cobar Peneplain | 73 664 | 216 | 37 |
| Coolgardie | 127 076 | 305 | 11 |
| Daly Basin | 21 030 | 13 413 | 14 724 |
| Dampierland | 90 196 | 23 870 | 38 906 |
| Darling Riverine Plains | 106 787 | 1 243 | 745 |
| Dentrecasteaux | 4 318 | | |
| Desert Uplands | 68 666 | 1 935 | 1 333 |
| Einasleigh Uplands | 129 326 | 8 177 | 13 297 |
| Esperance Plains | 35 329 | 160 | 15 |
| Eyre and Yorke Blocks | 61 447 | | |
| Finke | 55 820 | | 13 |
| Flinders and Olary Ranges | 77 381 | | |
| Flinders Lofty Block | 23 773 | | |
| Freycinet | 6 503 | | |
| Furneaux | 2 409 | | |
| Gascoyne | 181 185 | 449 | 3 663 |
| Gawler | 64 439 | | |
| Geraldton Sandplains | 37 639 | 171 | 466 |
| Gibson Desert | 145 389 | 367 | 18 595 |
| Great Sandy Desert | 385 885 | 1 779 | 51 381 |
| Great Victoria Desert | 421 637 | 710 | 5 889 |
| Gulf Coastal | 28 054 | 7 719 | 13 660 |
| Gulf Fall and Uplands | 119 810 | 30 490 | 61 122 |
| Gulf Plains | 213 301 | 13 662 | 45 969 |
| Hampton | 11 875 | | |
| Jarrah Forest | 46 385 | 529 | 166 |

**Table 34:** **Fire-affected areas (FAA) for each IBRA region (version 4) for 1998 to 1999 and 1999 to 2000** ***(continued)***

| IBRA region name | IBRA area ($km^2$) | 1998–1999 FAA ($km^2$) | 1999–2000 FAA ($km^2$) |
|---|---|---|---|
| Little Sandy Desert | 104 090 | 232 | 7728 |
| MacDonnell Ranges | 37 010 | | 2 |
| Mallee | 80 052 | 10 | 3 |
| Mitchell Grass Downs | 318 113 | 3 366 | 2 610 |
| Mount Isa Inlier | 67 362 | 4 506 | 4 347 |
| Mulga Lands | 264 571 | 296 | 807 |
| Murchison | 275 282 | 3 147 | 1 393 |
| Murray–Darling Depression | 201 234 | 1 816 | 11 |
| Nandewar | 27 560 | | 27 |
| Naracoorte Coastal Plain | 28 397 | 13 | 17 |
| New England Tableland | 29 386 | | |
| Northern Kimberley | 87 081 | 32 276 | 38 117 |
| NSW North Coast | 61 050 | 8 | |
| NSW South Western Slopes | 84 037 | 55 | |
| Nullarbor | 196 418 | | |
| Ord Victoria Plain | 125 785 | 11 471 | 28 122 |
| Pilbara | 178 712 | 1 576 | 19 564 |
| Pine-Creek Arnhem | 51 622 | 25 015 | 39 944 |
| Riverina | 90 288 | 178 | 16 |
| Simpson Strzelecki Dunefields | 274 902 | 281 | 613 |
| South East Coastal Plain | 18 893 | | 10 |
| South East Corner | 27 073 | | |
| South Eastern Highlands | 80 836 | 166 | |
| South Eastern Queensland | 68 774 | 31 | 285 |
| Stony Plains | 181 431 | 11 | |
| Sturt Plateau | 99 698 | 14 176 | 48 025 |
| Swan Coastal Plain | 15 173 | | |
| Sydney Basin | 35 933 | 58 | |
| Tanami | 320 207 | 8 004 | 56 308 |
| Tasmanian Midlands | 7 719 | | |
| Timor | 0 | | |
| Top End Coast | 69 454 | 24 014 | 35 649 |
| Victoria Bonaparte | 73 208 | 33 855 | 34 321 |
| Victorian Midlands | 37 158 | | |
| Victorian Volcanic Plain | 21 980 | 13 | |
| Warren | 10 472 | | 48 |
| West and South West | 18 498 | 30 | |
| Wet Tropics | 18 257 | 48 | 621 |
| Woolnorth | 9 731 | | |
| Yalgoo | 36 032 | 215 | |
| **IBRA totals** | **7 668 062** | **312 342** | **710 847** |

## Risk assessment and management approaches to biodiversity

An increasingly important issue is the applicability of risk management approaches to biodiversity (e.g. AS/NZS 4360, revised version, Standards Australia 1999) and the Standards Australia (2000) handbook. This Standard is based on subjective interpretation of the likelihoods and consequences of hazards, and is becoming the standard for the development of risk management systems in industry and institutional risk management in Australia.

Conservation biology embarked on a different path for risk assessment two decades before the Australian standards were developed. From its earliest inception, risk assessment for biodiversity has typically been informed by model-based (Shaffer 1981; Boyce 1992; Burgman et al. 1993; Possingham et al. 1993), or at least rule-based (IUCN 1994) risk analysis. These methods have continued to develop into a formidable array of analytic and decision-support tools. These risk assessment tools are valuable mainly because they set the decision-making process in a formal framework in which the costs and benefits of management alternatives can be explored and updated, they are relatively transparent and free of semantic ambiguity, and they provide some assurance of internal consistency. These benefits are difficult, if not impossible, to achieve in a subjective risk assessment framework.

An example of the application of subjective risk assessment methods is provided by the protocols used by the Interim Office of the Gene Technology Regulator, and its Genetic Manipulation Advisory Committee (GMAC). GMAC relies on subjective interpretation of available data to evaluate the risks and consequences of the various potential ecological, social and economic costs and benefits posed by GMOs. The lack of transparency and robust interpretation of data has lead the Commonwealth government to invest several million dollars in a CSIRO study aimed at developing formal, quantitative tools for assessing the ecological risks posed by genetically modified species.

*New South Wales*

The New South Wales NPWS has responsibility for 4.6 million hectares of national parks and reserves. The Service has a systematic program in place to develop fire management plans that specifically address biodiversity conservation for over 200 fire-prone reserves. The system uses a flexible, adaptive management approach based on fire regime thresholds defined for broad vegetation groupings. This enable managers to adjust fire management strategies on an ongoing basis to encompass changes in fire regimes that result form both planned and unplanned ignitions.

Effective use of the system requires commitment to continual monitoring and mapping of fires and assessment of their additive effects (the fire regime). Strategies for the protection of life and property and the management of heritage sites are also addressed. The resolution of these objectives with biodiversity conservation is accomplished through a zoning system. The use of Geographic Information Systems (GIS) is an integral element, and a range of other databases are being developed to support the planning process. More than 30 Reserve Fire Management plans have been finalised, and over 150 are in draft form or advanced preparation.

At a broader scale, the first round of Bushfire Risk Management Plans have been completed for major bushfire districts in the state. This initiative of the Rural Fire Service is a broad-scale attempt to coordinate cross-tenure planning for protection of lives and property, while taking into account the requirements of specific land tenures (forests, farms, parks and private property). A major focus of the Plans has been to ensure that bushfire management is ecologically sustainable. A process for assessment of risk to humans along with the ecological requirements of threatened species and biological communities is a feature of the planning approach. The completion of Risk Management Plans has necessitated major inputs from state government agencies (e.g. State Forests, Land and Water Conservation, NPWS), local government and community groups.

*Western Australia*

Fire management on public land in Western Australia is primarily the responsibility of the Department of Conservation and Land Management (CALM). For each area managed by CALM, a Management Plan is prepared and approved. Each plan contains a section on fire management that explicitly deals with the need to manage for biodiversity through the application of appropriate fire regimes or fire exclusion. Plans are developed both at a regional level for groups of similar geographically related areas, as well as for single conservation parks and nature reserves.

There are 39 approved Management Plans for terrestrial conservation reserves in Western Australia (includes National Parks, Conservation Parks and Nature Reserves) and 26

Management Plans in preparation, out of a total of 1283 conservation reserves. For many of the conservation areas that do not yet have a fully developed management plan, interim management guidelines (IMG) are prepared to enable managers to proceed with operations considered necessary for the conservation and protection of the biodiversity and ecological values of the reserve. Even though these IMG are primarily focused on fire protection strategies, they also include consideration of fire to enhance the ecological values of the area.

Management plans for forested areas provide for a variety of fire regimes. One of the key management objectives for fire is to minimise the likelihood of entire reserves being burnt at the one time. Plans include burning for fuel reduction on varying cycles, vegetation management (with a medium-term to long-term rotation) and reference areas with no planned burning. Plans for fauna-rich areas have long-term fire regimes. Monitoring programs are also implemented in some areas to assess the effect of the prescribed burning regime on indicator flora and fauna (e.g. vulnerable species).

In south-west Western Australia, CALM has undertaken many years of research into fire ecology and is using this information to apply varied fire regimes that will conserve natural systems as well as protect life and property. An interesting research tool has been the determination of the past fire history of jarrah forests from fire scars on the Grasstree (*Xanthorrhoea* spp.). Grasstrees, which live over 200 years, provide an insight into the fire frequency prior to European settlement (CALM 2000b). These data, combined with information from historical literature and consultation with the Nyungar Indigenous community from the south-west area, will better inform current fire management practices for the conservation of natural systems.

*Australian Capital Territory*

The Nature Conservation Strategy of the Australian Capital Territory (from the *Nature Conservation Act*) identifies fire as a key threatening process to biodiversity. This is recognised in the ACT Bushfire Fuel Management Plan 1998 (BFMP), which identified 'the maintenance of biodiversity and natural processes' as a management objective. The BFMP is a requirement of the *Bushfire Act 1936* (ACT) and provides a framework for fire management on most government lands. The plan provided some coarse-scale recommendations for the conservation of biodiversity, based on general principles of fire ecology. Recommendations include indicative burning intervals for various forest and woodland communities. However, extensive research and monitoring is required to develop appropriate burning regimes for wildlife habitat management and for the conservation of biodiversity.

ACT Parks and Conservation is the agency with primary responsible for fire management in conservation reserves, and is required to develop fuel management plans for these areas. It is the role of the Bushfire Service to implement these plans, and they have the power to accept or reject them.

*South Australia*

There is no formal process for fire management in South Australia. In the *Native Vegetation Management Act 1985*, burning was considered as vegetation clearance and needs approval by the Native Vegetation Council. There are no explicit criteria for the approval of burning, and instead the Council assesses each application in terms of the NVM Act and also considers advice from scientific officers. Fire management in conservation reserves is considered mainly from the perspective of fire risk and prevention. Although work is in progress by National Parks and Wildlife to develop a decision support system for ecological burning, there are no policy or management plans explicitly directed at fire management for the enhancement and conservation of biodiversity.

*Northern Territory*

The Bushfires Council (BFC) of the Northern Territory is a statutory body set up to coordinate fire management within the Northern Territory and to provide an organisational framework. Established under the *Bushfires Act*, the BFC operates under policy guidelines designed to achieve fire management objectives. Although the primary objective of the BFC is to reduce the total area burnt by wildfire in the Northern Territory, the maintenance of native ecosystems, by the use of appropriate fire regimes, is a key purpose of the BFC fire management strategy. To enhance the coordination of fire management, the Northern Territory has been divided into nine fire control regions, based on characteristics such as land systems, vegetation type, climate, location and service centres. Although a fire management plan is written for each region, the focus is primarily on operations for prevention and

mitigation of wildfires, rather than detailing appropriate fire regimes for the conservation of biodiversity.

As an umbrella organisation, the BFC works closely with the PWC to manage fire within Conservation Parks and Reserves across the Territory. The PWC is responsible for about 90 parks and most of these have plans of management. Each plan has a lifetime of five to 10 years and many plans are now in their second version. The PWC recognises that fire plays an important role in reaching their objective of maintaining and encouraging optimum biodiversity. In this light, most park management plans identify fire as an issue for biodiversity. Several parks also have Fire Management Plans, but specific guidelines outlining appropriate fire regimes for the long-term conservation of biodiversity are generally not provided.

Monitoring programs have been established in both Litchfield and Nitmiluk National Parks to increase understanding of the effects of fire on the vegetation communities, and to better inform fire management practices.

*Tasmania*

In Tasmania, the Department of Primary Industries, Water and the Environment (DPIWE) is responsible for the development of fire management plans. Generally, management plans are prepared only for parks where fire protection is an issue. Prior to 1996, management plans were almost totally concerned with excluding fires from areas. Over the past four years, ecological burning has increased in importance in the plans, but most plans still focus on reducing fuel loads. Because of the wet and cool climate and associated vegetation types, fires are not considered an issue in many of Tasmania's parks. Consequently, management plans for fire are not developed for all areas.

There are four implemented fire management plans for conservation parks and reserves in Tasmania that specifically consider the interactions between fire and biodiversity. There are a further ten plans for which fire–biodiversity interactions are considered, but are not a significant component. Four fire management plans do not consider biodiversity, but these are under revision and are not being implemented.

The most extensive fire management plan considering biodiversity conservation in Tasmania is for the south-west Tasmanian lowland buttongrass moorlands, in the southern half of Tasmania's Wilderness World Heritage Area. This plan provides burning prescriptions, based on detailed modelling, to enhance the development of a high level of species richness and structural diversity. The plan is intended to be an interim one until a more comprehensive plan is produced during the next three years, and incorporates principles of adaptive management to ensure research is undertaken so that management prescriptions can be refined if necessary.

*Queensland*

The Queensland Parks and Wildlife Service (QPWS) drafted a state-wide fire policy in mid 2000 specifying that fire management in the conservation estate will be for ecological purposes. Fire management plans are drawn up by QPWS for individual protected areas. Most fire management plans consider biodiversity; however, the detail to which they address biodiversity-related issues varies. A new template structure was adopted in Queensland in 2000, which will require that biodiversity aspects be detailed in all fire plans over the next two to three years. The protection of ecological systems and hence, biodiversity, is one of the two main purposes for these fire management plans, the other being the safeguarding of life and property.

*Victoria*

Fire management on Victoria's public land is the responsibility of the Department of Natural Resources and the Environment (DNRE). The DNRE has been moving gradually from a sole focus on fire protection to one of fire management that takes into account the ecological effects of fire. All public land within Victoria is covered by five regional fire protection plans that have been established under the Code of Practice for Fire Management on Public Land (DCNR 1995). Determined in consultation with relevant park and forest managers, these plans divide the State into five fuel management zones, of which two zones incorporate management for the protection of the flora and fauna values of the region. Victoria is also starting to accumulate fire management plans for specific parks and conservation reserves.

Although management plans for national parks outline objectives and strategies for fire management within the park, specific guidelines for ecological burning are generally lacking.

The paucity of ecological data relating to fire regimes has meant that consideration of biodiversity in fire management has been minimal. However, recent initiatives by DNRE and Parks Victoria have begun to address this issue. Workshops with managers of public land were held in Victoria during 1998 to discuss fire management for the conservation of biodiversity. A set of guidelines for ecological burning has been drafted, and pilot studies established to research and develop ecologically based fire regimes for a variety of vegetation types. The ultimate aim of fire management in Victoria will be to provide sufficient information on each Ecological Vegetation Class across the state, for informed decision making about fire frequency and requirements.

*Commonwealth*

The Commonwealth, through Environment Australia, manages parks and reserves established in those parts of Australia which come under its direct responsibility, such as the External Territories. The EPBC Act is the principal Commonwealth legislation for establishing and managing protected areas. The Director of National Parks is a statutory office established under the Act with responsibility to administer Commonwealth reserves. Six national parks and five national nature reserves are declared under the Act. The other nine reserves are either marine parks or botanic gardens and will not be considered further here.

Three of the six Commonwealth national parks, namely Kakadu and Uluṟu-Kata Tjuṯa National Parks in the Northern Territory and, more recently, Booderee National Park in the Jervis Bay Territory are managed jointly by the Indigenous owners and Parks Australia. The other three national parks protect unique island ecosystems in the Territory of Cocos (Keeling) Islands, the Christmas Island Territory (in the Indian Ocean) and the Norfolk Island Territory (in the South Pacific). The management of exotic plant and animal species, rather than fire, is a key management issue on these islands.

*Kakadu National Park:* The Kakadu National Park Plan of Management (Kakadu Board of Management and Parks Australia 1998) has four main aims in relation to fire management. These are to:

- promote traditional Indigenous peoples' ways of burning within the park
- protect life and property within and adjacent to the park
- restrict fire from spreading so that it does not enter or leave the park
- maintain biodiversity through effective fire management of species and habitats.

Langton (2000) stated that the continuance of traditional Indigenous fire management in parallel with park management efforts in Kakadu is particularly noteworthy because of the high standard of research and documentation on these efforts and the ready acceptance of the importance of traditional knowledge of fire.

*Uluṟu-Kata Tjuṯa National Park:* The most recent Plan of Management for Uluṟu-Kata Tjuṯa National Park (Uluṟu-Kata Tjuṯa Board of Management and Parks Australia 2000) has the following aims for fire management:

- maintain traditional Aṉangu burning practices and promote their integration into scientific knowledge, to protect and enhance the Park's biodiversity
- protect life, property and culturally significant sites and mitigate the effects of wildfire
- maintain community education and interpretation programs dealing with the role of fire in the Park
- maintain a research and monitoring program and operate within a regional context, and to help neighbours suppress wildfires when resources are available.

Tjukurpa ('the Law' governing that Indigenous community's actions and culture) is a guiding principal for fire management in the Park. A patch burning strategy is used, based on traditional patterns of burning. Aṉangu (the traditional owners) and Parks Australia work together to determine which areas should be burnt each year. This combines traditional ecological knowledge with the use of GIS (Allan 1997) and the results of ecological studies by western scientists. Saxon (1984) has also been used to guide fire management in the Park but it is acknowledged that this requires updating. Comprehensive, long-term monitoring is

required to determine the effects of the current approach to fire management on biodiversity in the Park.

## Human-induced climate change

The Third Assessment Report from the Intergovernmental Panel on Climate Change (IPCC) was due to be released in mid 2001, and the Summaries for Policy Makers for the three working groups were released in early 2001 (IPCC 2001). This report and the regional climate projections released by the CSIRO in May indicate that Australia can expect to be generally warmer and drier, but with increased floods and storm surges. Australia's natural systems will have difficulty adapting, with vulnerable areas including the Great Barrier Reef, alpine ecosystems, wetlands and riverine systems and woodlands.

Climate change will affect biodiversity and it presents serious challenges for management aimed at conserving biodiversity. Several potential changes arising as a result of climate change (Table 35) will directly and indirectly affect biota. The degree of adverse climatic effects depends on the ability of the system to adapt to climate change.

**Table 35: Some potential changes resulting from global warming that have implications for biodiversity in Australia**

| Climate changes |
|---|
| Changing weather patterns |
| Increased number, range and severity of cyclones |
| Changes in rainfall and run-off |
| Changes in cloudiness |
| **Coastal effects** |
| Inundation of coast lines |
| Coastal recession changes in coastal vegetation (e.g. salt marshes) |
| Storm surge levels |
| Increased drowning of reefs |
| Changing fishery production |
| **Hydrology and water resources** |
| Increased erosion due to wind and water |
| Changes in ground water recharge and salinity |
| Increased salinity of streams |
| Greater probability of large and damaging floods |
| Changes in soil moisture during the growing season |
| Changes in extent and duration of snow cover |
| **Natural biosphere** |
| Shifts in bioclimatic zones |
| Changes in the distribution and abundance of native flora and fauna |
| Local and regional extinction of species |
| Increased plant growth due to $CO_2$ fertilisation |
| Increase in diseases |
| Increased frequency of natural hazards such as bush fires |
| **Food production** |
| Reduced grain production capacity in southern Australia |
| Increased year-to-year crop variability |
| Reduced production due to increases in cloudiness |
| Reduced yields of warm temperate crops due to less winter chilling. |

**Source:** after Williams et al. (1994).

The difficulties in predicting the effects of climate change arise because:

- detailed regional forecasts of potential changes in climate have only emerged recently
- understanding of the potential response of biota and ecological systems to these changes is limited.

## Regional forecasts of climate change [BD Indicator 7]

The *Atmosphere* Report provides a detailed discussion of forecasts of climate change under an enhanced greenhouse effect. By 2030, most of Australia will be warmer by 0.4 to 2.0°C. For 2070 the warming is 1.0 to 6.0°C (estimates for 2030 and 2070 are subject to spatial variation). In summer and autumn, projected rainfalls for most of Australia are –10% to +10% by 2030 and –35% to +35% by 2070 and tend towards an increase. In winter and spring, most locations tend towards decreased rainfall and are estimated at –10% to +5% by 2030 and –35% to +10% by 2070 (CSIRO 2001). Soil moisture changes are expected as a result of changes in rainfall characteristics and evaporation. Higher average temperatures are likely to increase evaporation. The global increase in sea level is expected to be between 9 and 88 cm by 2100, or 0.8 to 8.0 cm per decade.

## Direct effects of climate change

The potential responses of biodiversity to climate change can be considered in terms of changes in the distribution and abundance of taxa, species performance, and interactions between species which have implications for the structure and function of ecosystems (IPCC 1998). The potential ecological trajectories induced by climatic change encompass processes over the entire range of magnitudes from the level of leaf physiology to biome physiognomy and distribution. At least two conceptual views of biome response to climatic change have been proposed: ecotones gradually shifting in space, or ecosystems rapidly undergoing change over large areas in response to catastrophic disturbance such as drought (IPCC 1998). The view of gradually shifting ecotones in space arises largely from an emphasis on demographic processes, whereas the concept of catastrophic change arises largely from an emphasis on ecosystem function (water and nutrient) processes. These two models present different images of future change and biosphere responses.

### *Changes in the distribution and abundance of taxa*

Large-scale changes in the distribution of species and biomes has occurred. However, the anticipated changes in global climate are expected to occur at a rate most biologists acknowledge as simply too fast for evolutionary processes, such as natural selection, to keep pace (Table 36). Such constraints on the ability of species to adapt to their rapidly changing habitat could substantially increase their probability of extinction. In addition, landscape fragmentation related to human activities will markedly limit the opportunity for some species to migrate. It has been suggested that habitat destruction and climate change will act together, setting the stage for greater rates of extinction than when considering human encroachment alone (IPCC 1998).

**Table 36: Rates of migration for several European and North American taxa under past climate change, as estimated from fossil pollen records**

| Species | Period | Rate (km/decade) |
|---|---|---|
| *Alnus* spp. | Holocene | 0.25 |
| *Castanea* spp. | Holocene | 1 |
| *Fagus grandifolia* | Holocene | 2.5–3 |
| *Fraxinus ornus* | Holocene | 20 |
| *Pinus banksiana* | Holocene | 3.5–5 |
| *Tsuga canadensis* | Holocene | 2–3 |
| *Pinus strobus* | Late Holocene | 5 |
| *Corylus* spp. | Early Holocene | 10 |
| *Picea glauca* | Late Pleistocene | 2–3 |

**Source:** after Williams et al. (1994).

*Species performance*

The intrinsic ability of a species to colonise will depend on its ecological characteristics, including reproductive rate, viability and growth, the way it disperses, and its ability to tolerate inbreeding. Species disperse at different rates, which may result in dramatic alterations of the species composition of all biological communities. The biology of a species will be crucial in determining the rate at which it can respond to climate change. A species can extend its geographical range only if humans move it, or by natural processes individuals disperse to, and establish in, areas beyond their current distribution.

Physical constraints of a locality will restrict migration and increase vulnerability. For species on small offshore islands, southernmost coasts, the northern boundary of the central Australian desert, the tops of mountains, riparian zones, and forest remnants separated by urban development, there may be no migration options. Soil differences, inadequate rainfall, or excessive wind may also prove to be barriers to migration (IPCC 1998). Conversely, changes in temperature and rainfall may remove an existing barrier to migration, such as frost.

The physiological adaptations of most species to climate are conservative, and it is unlikely that most species could evolve significantly in the time allotted by the coming warming trend. Most of the available data on the effects of elevated carbon dioxide levels on vegetation have been derived from short-term treatments in controlled environments. Many of these studies report increased growth rates (particularly of $C_3$ species), although there have been striking interspecific variations in responses to higher temperatures and carbon dioxide levels (IPCC 1998).

*Response of plant communities*

The ability of plant communities to accommodate climate change will be influenced by plant–soil–soil moisture interactions (IPCC 1998). This relationship among soil, soil moisture, vegetation and climate needs to be better understood in order to project responses.

*Disturbance regimes*

Disturbance regimes are often a main factor in determining the suitability of habitat for species and, hence, will be of major importance in facilitating turnover from one species or vegetation type to another in response to climate change. Studies in other countries have identified the importance of altered fire regimes under climate change for a range of ecosystems. Fires are also integral in the dynamics of most Australian ecosystems. Therefore, the response to disturbance regimes must be considered when predicting ecosystem dynamics. Changes in climate and fuel dynamics will affect future fire regimes. Factors such as ignition sources will also be important.

*Ecosystem functions*

In natural ecosystems, the timing of plant fruiting and flowering, which at least in the tropics is largely determined by the temporal distribution of droughts and rainy periods, may be adversely affected if rainfall patterns change. Most research efforts into the affect of elevated carbon dioxide levels do not include an examination of the plant's reproductive responses, despite their importance to ecosystem function.

As well as the effect on plants, pollinators may be affected by climate change. This can be expected to have significant consequences for plant reproduction. Long-lived species such as established trees might show a muted response to climate change, exhibiting substantial time lags assuming they are not significantly altered by other human activities or by catastrophic disturbance. Disturbances such as fire, however, will create opportunities for more rapid change by reducing the inertia of, at least, established forests. Even if adults of a species can tolerate changes in climate, their ability to produce propagules and the ability of those propagules to recruit to maturity may be adversely affected. Many Australian animals, particularly birds such as the Yellow-tailed Black Cockatoo (*Calyptorhyncus funereus*), are relatively long-lived. Without knowledge of the fecundity of these species, the presence of adults in a population may not be a reliable guide to the longer term persistence of a population or the species (IPCC 1998).

*Parasitic and invasive organisms*

The geographical distribution of many parasitic species are limited by the distributions of potential host species or by environmental constraints on the parasite's rates of development (IPCC 1998). The effect of changing climate will depend, therefore, to some extent on the

response of the host to the altered conditions. Where members of the parasite community are important in mediating competition between hosts, this may lead to further changes in the structure of the host community and the possible extinction of particularly susceptible hosts.

If the temperature increases significantly, parasites and disease will do well as they are by definition organisms that colonise and exploit, particularly in relation to stressed individuals on the edge of their environmental range. The details of where and when these changes will occur, and what effect they may have on the distribution and abundance of species, are relatively poorly understood (IPCC 1998). Predictive models have focused principally on species important from an economic perspective, such as the cattle tick.

Human-induced changes to climate and habitat could dramatically increase the frequency of invasions by organisms from outside their current biogeographical boundaries. Therefore, planning for the movement and invasion of species into new areas is essential. However, understanding the consequences of global change on species invasions requires a much better understanding of the community and ecosystem roles of individual species.

*Aquatic systems*

Changes in hydrology associated with climate change may have serious implications for wetland biota. Although some aquatic plants are able to survive water fluctuations, it is unknown how wetland biota will respond to the potentially major changes in rainfall and subsequent run-on and run-off characteristics. Several migratory birds that utilise Australian wetlands may also be affected if wetland dynamics alter under climate change. Potential changes to wetlands resulting from climate change will be aggravated by the modification of wetlands through draining, fragmentation and rising water tables (IPCC 1998).

The responses to climate change of the large, arid, ephemeral lake systems of interior Australia are difficult to predict. Although these systems already experience significant seasonal and interannual variations, and the associated ecosystems are attuned to this high variability, their resilience to long-term change in the frequency and intensity of events is less certain. Significant water level changes may occur for non-ephemeral lakes in dry evaporative drainages or small basins where, at present, evaporation is comparable with rainfall inputs.

Estuaries and coastal wetlands have survived historical rises in sea level, usually by migration landward; salt marshes and mangroves have survived where the rate of sedimentation approximates the rate of local sea level rise; beaches have grown or decayed according to changes in prevailing winds and seas; and coral reefs have demonstrated the capacity to grow vertically in response to past rises in sea level. However, these past rates of adaptation may be insufficient for the higher rates of future rises in sea level, and in many cases landward migration will be blocked by human infrastructure, such as causeways, flood protection levees, and urban development, leading to a reduction in the area of the delta or mangrove (IPCC 1998).

*Coral reefs*

Coral reefs and atolls in the region, and in neighbouring South Pacific countries, are among the most sensitive environments to rises in sea level and climate change, through potential inundation, flooding, erosion, saline intrusion and death of corals. Coral bleaching and decline from prolonged increases in seawater temperature can inhibit their capacity to grow at the rates required by sea level rise. Managing reef ecosystems such as the Great Barrier Reef may be more problematic as a result of climate change.

Increased sea temperatures seem to be the main concern, rather than sea level rise per se. The potential sensitivity of coral reef ecosystems to climate change was demonstrated in 1998 when a global episode of coral bleaching showed that many reef corals live near the limits of their thermal tolerance. Where corals bleached, sea temperatures were several degrees above normal summer values and were some of the highest on record. Climate change is believed to be a major threat to coral reefs and could be a major driver of change across one of the most productive ecosystems on earth (AIMS 2000).

## Minimising the effects of climate change [BD Indicator 22]

The international community is engaging in considerable scientific research to deepen understandings of climate change. Australian scientists are prominent in many areas, with the focus on developing models of regional climates and carbon sequestration (through the CRC for Greenhouse Accounting). Research on the direct effects of climate change on biodiversity

is relatively limited, with some work underway on the response of different organisms to elevated carbon dioxide levels.

SoE (1996) presented modelling results that illustrated changes in the potential distribution of several species under different climate change scenarios (Dexter et al. 1995). More recently, modelling has demonstrated similar effects on different species (Figure 30). These studies show the potential for significant effects on native species under the current models for climate change.

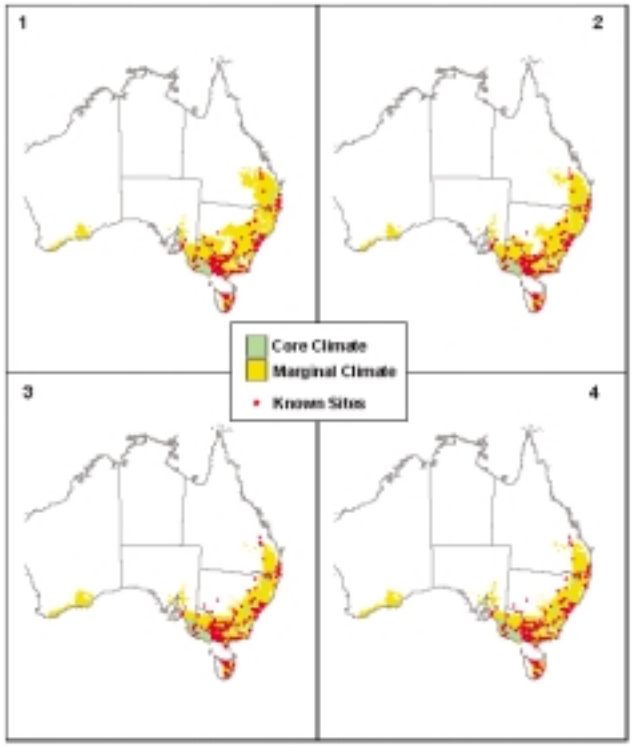



**Figure 30: Changes in the distribution of the Swift Parrot (*Lathamus discolor*), under various scenarios of climate change**

Scenario 1, present day; Scenario 2, small temperature increase, no rainfall changes; Scenario 3, large temperature increase, small rainfall increase; and Scenario 4, large temperature increase, large rainfall increase.

**Source:** Chapman and Milne (1998).

*Stabilising greenhouse gas emissions*

Much of the focus on minimising the effect of climate change has attempted to stabilise greenhouse gas emissions. Because of the global threats imposed by climate change, these approaches have also been undertaken at an international level. Australia became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The Convention aims to stabilise emissions of greenhouse gases at a level that would prevent dangerous human-induced interference with the climate system.

The UNFCCC has led to the Kyoto Protocol, agreed in December 1997. The Protocol aims, inter alia, to enhance the energy efficiency of national economies, protect and enhance sinks and reservoirs of greenhouse gases, promote sustainable forms of agriculture, limit and/or reduce emissions of greenhouse gases, and remove economic instruments that undermine such outcomes. The Protocol outlined emission targets for developed countries, with Australia having a target of restricting greenhouse gas emissions for 2008 to 2012 to an increase of 8% over 1990 levels. To date, Australia has submitted two reports (Commonwealth of Australia 1994, 1997) on its commitments under the Convention and these reports were reviewed by independent committees appointed by the UNFCCC Secretariat.

*Carbon sinks*

Some mitigation actions that are promoted by Australia to meet greenhouse gas emission targets could have considerable effects on biodiversity, especially those related to carbon sinks. For example, the potential for vegetation clearance to be reduced to maintain carbon sinks could have a positive impact. Clearing of native vegetation is a major source of emissions in Australia and accounts for 13 to 18% of the total annual emissions. Significant reduction in, or elimination of vegetation clearing, would remove of one of Australia's most serious threats to biodiversity, and would help meet international greenhouse gas commitments. Similarly, biodiversity will benefit both directly and indirectly from measures to improve national energy efficiency and put agriculture on a sustainable footing.

In calculating net emissions of greenhouse gases for 2008 to 2012, Australia is likely to be allowed to count the removal of carbon dioxide from the atmosphere to sinks such as vegetation and soils. The sequestration (or storage) of carbon into vegetation and soil sinks is one way to reduce net emissions of greenhouse gases. These sinks have the potential to be linked in with carbon 'credit' schemes that provide a basis to make carbon a tradeable commodity. Under such schemes, vegetation has a quantifiable value as a carbon store, irrespective of its value for biodiversity, and may provide stronger investment incentives for landscape revegetation.

Carbon sequestration schemes have focused mainly on plantation trees in Australia, although other opportunities exist to sequester carbon by adopting changes in land use. One example is the retirement of land from conventional agriculture, and promoting the thickening of understorey vegetation of native grasses and woody shrubs, which in turn become carbon sinks. These types of activities and strategies may benefit biodiversity if

biodiversity conservation is treated as an integral or strong complementary aim. Revegetation strategies can markedly change the biophysical and ecological processes of a region and help reverse habitat degradation (e.g. lowering water tables and the affects of salinity). However, poorly conceived strategies of this nature may be as bad for biodiversity as many current threats and human activities.

Despite the benefits for carbon sequestration and climate change, the planting of large areas with tree monocultures can have serious socioeconomic, as well as biodiversity, implications (e.g. Gill & Williams 1996). In many regional areas, the rapid growth of the plantation industry is changing employment opportunities and investment strategies and requires the upgrading of road infrastructure and networks for use by heavy transport.

Overall, the future of much of the biodiversity of the Australia is threatened by climate change. Australian governments must adopt enhanced measures to achieve genuine and significant reductions in greenhouse gas emissions and prevent human activities that seriously compound the potential effects of climate change on biodiversity.

## Pollution

### Impacts of pollution on biodiversity [BD Indicators 5 and 20]

The release of pollutants into the environment can kill organisms outright, change the biogeochemical conditions and processes occurring within a system and result in systemic changes that degrade habitats and make ecological processes dysfunctional. Biodiversity associated with sites intensively used by humans may be most at risk, although the non-point based effects of pollution on biodiversity such as downstream water pollution and downwind air pollution can be significant. Urban stormwater may contain high levels of contaminants such as faecal bacteria, nutrients, chromium, cadmium, lead, nickel, hydrocarbons and chlorinated hydrocarbons. In rural areas, irrigation run-off from farming activities may sometimes contain insecticides, fertilisers and herbicides that have been applied to crops. This run-off may affect aquatic and marine organisms living in the catchment and its associated estuaries and in-shore marine ecosystems.

*Sediments and nutrients*

Sediments and nutrients from urban effluent and agricultural chemicals are known to be polluting the inshore reefs of the Great Barrier Reef World Heritage Area, killing coral, encouraging the growth of sessile algae and changing the energy balance and dynamics of marine ecosystems (Wachenfeld et al. 1998). Increased sediment loads lead to muddier systems with less light for bottom communities and disturbance to benthic fauna as a result of siltation. Sediment and nutrient delivery to the Great Barrier Reef from land-based discharges (sources) has increased four-fold in the last 140 years. For the central reef system, 39% of all nitrogen and 52% of all phosphorus originated from river inputs, while sewage discharges accounted for 2.3 and 7.7% of nitrogen and phosphorus, respectively (Figures 31 to 34).

Soil loss that results in sedimentation and a reduction in water quality may also affect aquatic and marine biodiversity. Much of the estimated four-fold increase in sediment on to the Great Barrier Reef has occurred during the last 40 years. This loss results from land uses such as grazing, cropping and urban development that are being undertaken on an unsustainable basis (see the *Pollution sources on the Great Barrier Reef catchment* box on page 62). During cyclones, sediment plumes have been recorded at least 100 km offshore. Non-lethal sediment loads may become lethal if the nutrient levels are also elevated (Wachenfeld et al. 1998).

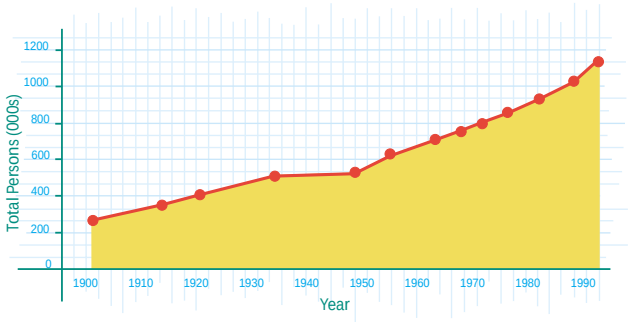



**Figure 31: Increase in the human population in the Great Barrier Reef catchment area, 1900 to 1990.**

**Source:** Queensland Year Book (1998).

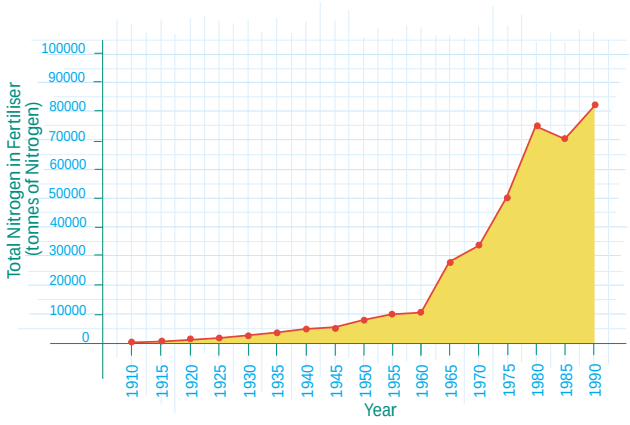



**Figure 32: Increase in the use of nitrogen fertiliser in the Great Barrier Reef catchment area, 1910 to 1990.**

Excess fertilisers can cause run-off that may affect aquatic and marine ecosystems living in the catchment and associated estuaries and in-shore marine systems.

**Source:** Pulsford (1996).

## Impacts of pollutants

Potential effects of pollutants on ecosystems include changes in the abundance of species, interruption to energy and nutrient flows, modification of habitats, reduction in soil, water and air quality, and changes to the stability and resilience of ecosystems. Where species consumed by humans are affected by pollution, there is the potential for serious human health problems. The release of total nitrogen and phosphorus into the environment results in many changes including the likelihood of more frequent and intensive algal blooms in waterways. The dominant release of nitrogen across the Murray-Darling Basin is from unimproved pastures (45% of total aggregate emissions of nitrogen) and cropping (31%), while cropping provides the source of over 50% of phosphorus emissions.

Pollutants can act synergistically to cause uncertain long-term effects on biodiversity. Examples of these interactions can be observed in western Tasmania where acid run-off and acid rain has killed mountain vegetation and affected aquatic ecosystems (e.g. 'dead' sections of river systems such as the Queen and King Rivers). These effects are compounded by the cyclical nature of ecosystem processes, which disperse pollutants widely from their sources and may affect biodiversity at considerable distances in a variety of surprising ways. One reason that mining uranium in Australia remains controversial is the potential effect of these operations on unique environments such as the wetland ecosystems of Kakadu National Park. This is despite two decades of research and monitoring that has not revealed any significant environmental impact on the Park from uranium mining (see *Uranium and biodiversity* box on page 103).

## The National Pollutant Inventory [BD Indicator 20]

The Commonwealth government supports a National Pollutant Inventory (NPI), an Internet database designed to provide the community, industry and government with information on the types and amounts of selected chemicals being emitted to the environment.

Australian industrial facilities such as petroleum refineries, chemical manufacturing plants and sewerage treatment plants using more than a specified amount of the chemicals listed on the NPI reporting list are required to estimate and report emissions of these substances annually. The location of these facilities is maintained by the NPI and is largely tied to major human settlements (Figure 35).

The NPI substance list, compiled by its Technical Advisory Panel, lists 20 substances most hazardous to humans and the environment (Table 37). Mining of coal and metal ores may lead to the production of acid run-off, which can severely pollute water bodies and kill many species.

Emission sources for an airshed typically include motor vehicles; solid fuel burning; agricultural-related burning, fuel reduction and bushfire controls; and domestic/commercial solvents and aerosols. Industrial discharges into Cockburn Sound in Western Australia have been associated with massive loss of seagrasses and substantial levels of contamination of sediments and fishes.

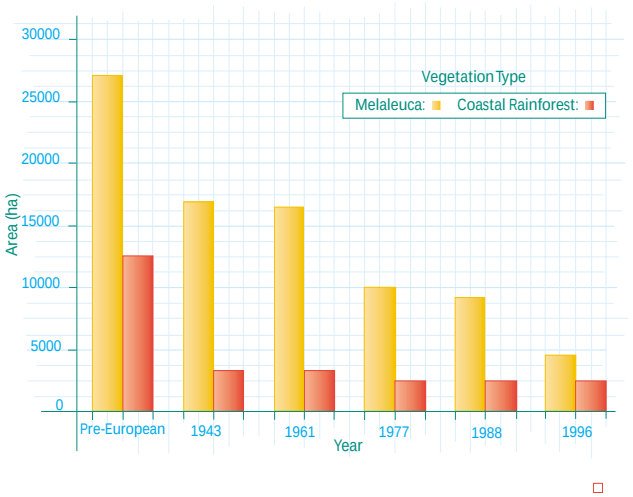



**Figure 33: Decrease in the area of native vegetation in the lower Herbert Catchment in northern Queensland from pre-European times to 1996.**

**Source:** Johnston et al. (1998).

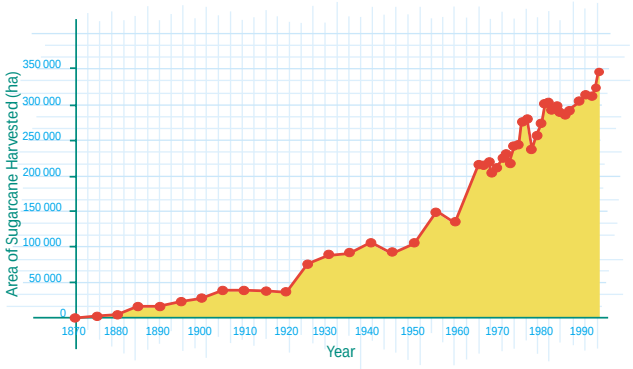



**Figure 34: Increase in the total area of sugar cane (*Saccharum* spp.) harvested in Queensland, 1870 to 1990.**

Intensive land use such as sugar cane requires the broad-scale clearing of native vegetation and this activity can threaten or destroy biodiversity.

**Source:** Queensland year books, compiled from many different years.

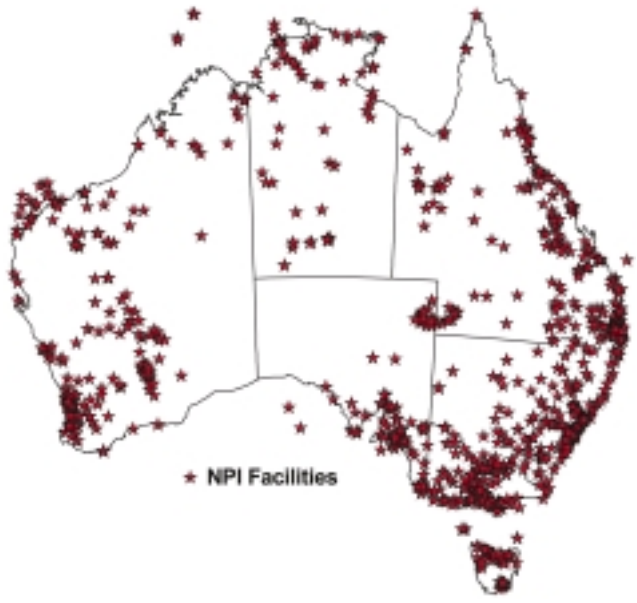



**Figure 35: National Pollutant Inventory (NPI) reporting facilities.**

**Source:** The National Pollutant Inventory reporting facility as at 31 January 2001, Environment Australia.

## Uranium and biodiversity

Uranium is a naturally occurring, radioactive element that is capable of nuclear fission and is used as a source of nuclear energy and for nuclear weapons. Naturally occurring isotopes of uranium have half lives ranging from 4.5 billion years to 250 000 years. About 99% of uranium is in the form of U-238, which has a half life of 4.5 billion years. Mine tailings contain uranium ore with the uranium removed—the remaining radionuclides have a half life of 77 000 years. Uranium and its decay products give off alpha, beta and gamma radiation. This radiation can cause lethal genetic mutations and kill living organisms.

Uranium is mined at three locations in Australia, including the Alligator Rivers Region of the Northern Territory in which lies Kakadu National Park. Surrounded by Kakadu, Ranger Uranium Mine has been operating for 20 years. Uranium mining is controversial from an environmental and biodiversity protection perspective because of the perception of potential accidents that could occur at all stages of the nuclear fuel cycle, including the storage and disposal of various levels of radioactive wastes. Most uranium mining occurs in remote areas of the country that are considered to be of value as wilderness. During the milling of uranium ore, the uranium is removed from the crushed rock and concentrated for transport, but other radioactive substances are left in the residue, which is referred to as tailings. Initially, about 85% of the original radioactivity present in the ore is discarded in the tailings. After several months, the level of radioactivity in the tailings decays to about 70% of that originally present in the ore. The tailings then decay with a half-life of around 77 000 years. Safe management of all stockpiles and mining wastes is essential to prevent release of contaminants and ensure proper protection of the environment.

Uranium mining has attracted considerable attention since 1996 as a result of proposals for new mines (e.g. 11 identified deposits in Western Australia) and the use of remote, arid regions of the country for storage of radioactive waste. For example, during January 2000, the Commonwealth Department of Industry, Science and Resources was conducting drilling and other investigations of six potential sites for storing radioactive waste around Woomera (SA). One concern is that if radioactive waste were to be held at these sites, it may leak into the underground water and find its way into aquatic ecosystems, mound springs and the terrestrial food chain.

The Jabiluka Uranium Mine, 25 km to the north of the Ranger mine in the region of the Kakadu World Heritage Area, is controversial. In October 1996, Energy Resources Australia (ERA) submitted a draft environmental impact statement (EIS) for mining uranium at the site. Following the completion of assessment of the EIS and a Public Environment Report for alternative development options at Jabiluka, the Minister for the Environment found that there did not appear to be any environmental issue that would prevent either alternative from proceeding. The Minister made environmental recommendations that were subsequently endorsed by the Minister for Resources and Energy. A principal requirement was that all mill tailings would be returned underground to the mine void and to specifically constructed stopes or silos instead of tailing pits as proposed by ERA.

During October and November 1998, a mission from the World Heritage Committee visited the region and site to assess any ascertained or potential threats to the World Heritage values of Kakadu National Park that might arise from the proposal. Wasson et al. (1998), among others, made a submission to the mission specifying environmental concerns arising from weaknesses in the mine design at the mine site (e.g. geomorphology, hydrology and biology). These concerns included the effect that severe weather events may have on the mine storage facilities, leaching of chemicals from the tailings into the ground water, catchment and surrounding wetlands, effects on the aquatic ecosystems of the region, and the effects of climate change given that the tailing storage must be viable for millennia. The mission reported to the World Heritage Committee noting severe ascertained and potential dangers to the cultural and natural values of Kakadu National Park posed by the proposal for uranium mining and milling at Jabiluka and recommended that the proposal should not proceed. Because the Australian authorities had not had sufficient time to respond to the report, the World Heritage Committee made no firm decision on the future status of Kakadu at the November 1998 meeting. The Committee requested that the Supervising Scientist conduct a full review of the areas of scientific uncertainty. The issues specified were hydrological modelling, prediction and effect of severe weather events, storage of uranium ore on the surface and the long-term storage of mine tailings. The Supervising Scientist's assessment of the Jabiluka project was submitted to the World Heritage Committee in April 1999. The overall conclusion drawn was that the natural World Heritage values of Kakadu National Park are not threatened by the development of the Jabiluka mine and that the degree of scientific certainty that applies to this assessment is very high (Johnston & Prendergast 1999).

An independent scientific panel (ISP) was convened by the International Council of Science Unions (ICSU) at the request of the World Heritage Committee to review the report by Johnston and Prendergast (1999). The ISP report was provided to the Supervising Scientist in May 1999. The Supervising Scientist provided a supplementary report to the World Heritage Centre addressing the issues raised in the ISP review. The World Heritage Committee met in July 1999 and resolved not to inscribe Kakadu as 'World Heritage in danger'. After further investigations, the World Heritage Committee met in November 2000 and decided that the mine and mill proposal at Jabiluka does not threaten the natural values of Kakadu National Park.

**Table 37: The 20 most hazardous substances to the environment and humans, identified by the National Pollutant Inventory**

| |
|---|
| 1,3 Butadiene (vinyl ethylene) |
| 2-Ethoxyethanol |
| 2-Ethoxyethanol acetate |
| Arsenic and compounds |
| Benzene |
| Cadmium and compounds |
| Carbon monoxide |
| Chromium VI compounds |
| Dichloromethane |
| Glutaraldehyde |
| Lead and compounds |
| Oxides of nitrogen |
| Particulate matter |
| Polycyclic aromatic hydrocarbons |
| Sulfur dioxide |
| Sulfuric acid |
| Tetrachloroethylene |
| Total nitrogen (in solution) |
| Trichloroethylene |
| Xylenes (individual or mixed isomers) |

**Source:** Environment Australia.

## Research into the effects of pollution on biodiversity [BD Indicator 20]

*Persistent pollutants in frogs*

The disappearance (perhaps extinction) of frog species in eastern Australia and, indeed globally, is of serious concern. One explanation is the direct and indirect affects of airborne pollutants.

Mann and Bidwell (1999) reviewed environmental toxicology in Australian frogs and noted that few such studies have been carried out on native fauna. They reported that the single largest group of potential chemical pollutants that Australian frogs might encounter are the various pesticides used in agriculture and pest management. Much of the recent work examining the effects of pesticides on amphibians has concentrated on the newer generations of pesticides such as pyrethroids, carbamates and organophosphates, although there has been a resurgence of interest in the older organochlorine insecticides such as DDT because of their persistence in ecosystems and food chains. In particular areas, biological agents such as the chytrid fungi, iridoviruses or predation could also be involved in the decline of frog diversity.

*Persistent pollutants in crabs*

In coastal Queensland, Mortimer (1999) quantified the trace metals, metalloids and pesticide content in intertidal Burrowing Crabs (*Australoplax tridentata*) and the large Mud Crab (*Scylla serrata*). Estuaries between Cairns and Brisbane were sampled and residues of dieldrin were found at all locations, and heptachlor epoxide and DDT were recorded at most. Calculations of ambient exposures to organochlorines based on residues in crab tissues indicated that dieldrin exceeded national water quality guidelines for protection of aquatic ecosystems at all sampling locations, but exposure to DDT and its metabolites was below the threshold of concern. Use of DDT, dieldrin and heptachlor is banned in Australia.

The primary former uses of dieldrin included treating crops for the control of root fly larvae, locusts, crickets and grasshoppers; in building and industry to control termites; and to control disease vectors such as cockroaches, fleas and mosquito larvae. Use of dieldrin was progressively restricted from 1973 and banned in June 1994. Heptachlor was used as a soil treatment to control ants and grubs in sugar cane areas; the Banana Weevil Borer

**Table 38: Maximum acceptable concentrations of persistent organochlorines in crabs relative to ANZECC water quality guidelines**
Measured concentrations of dieldrin and heptachlore epoxide were above the acceptable limits in the Mud Crab (*Scylla serrata*) and the Burrowing Crab (*Australoplax tridentata*) in several sites between Cairns and Brisbane.

| Compound | ANZECC water quality (mg/L)[A] | Corresponding maximum acceptable concentration in crab tissues (mg/kg lipid) | Measured concentration (range of mean values) in tissues (mg/kg lipid) of the Mud Crab (MC) and Burrowing Crab (BC) |
|---|---|---|---|
| DDE | 14 | 59 | 0.029–2.8 (MC); 0.03–2.2 (BC)[B] |
| Dieldrin | 2 | 0.035 | 0.026–1.4 (MC); 0.043–5.5 (BC) |
| Heptachlor epoxide | 10 (parent compound) | 0.0037 | 0.018–0.62 (MC); 0.042–2.25 (BC) |

[A] Protection of aquatic ecosystems (marine waters); [B]Concentration of total DDTs, which are mostly the metabolite DDE.

**Source:** after Mortimer (1999).

(*Cosmopolites sordidus*) in banana plantations; and to control termites in buildings and other structures. Agricultural use of heptachlor ceased in 1987, but it was still used for termite control in Queensland until June 1995. DDT was used extensively in agriculture to control both crop and livestock pests. It was also used for domestic control of fleas, lice, mites and lawn grubs. Domestic uses were banned in 1973, and agricultural use was progressively restricted until it was banned in 1987. Dieldrin, heptachlor and DDT are extremely hazardous to humans and biodiversity (Table 38).

## Oil spills

More than 22 million tonnes of oil is shipped in Australian waters each year as tanker cargo, including many ships that pass through or near sensitive marine environments such as the Great Barrier Reef. Although Australia has experienced relatively few oil spills compared with elsewhere in the world, several major incidents during the 1990s (e.g. 1991: *Kirki*, 17 900 t of oil; 1995: *Iron Barron*, 325 t; 1999: *Laura D'Amato*, 80 t) are a reminder of the need for suitable monitoring of shipping standards and transits and the need for a high quality emergency capability. The probability of one or more major spills from tankers could be as high as 37% in any five-year period, and 84% in 20 years (Bureau of Transport and Communications Economics 1999).

## Ocean dumping

Since 1975, an international agreement known as the London Convention (formerly called the London Dumping Convention) has controlled sea dumping internationally. In order to ratify the London Convention, Australia enacted the *Environment Protection (Impact of Sea Dumping) Act 1981* which prevents the dumping of some wastes and provides for the regulated dumping of other substances in waters off Australia and its External Territories such, as the AAT, Heard Island and McDonald Islands, Macquarie Island, Norfolk Island, Cocos (Keeling) Islands and Christmas Island. Most permits issued are for the creation of artificial reefs or for disposal of uncontaminated dredge spoil.

**Container ship with a cargo of hazardous chemicals, stranded on the Great Barrier Reef.**

**Source:** A Rogers, The Courier-Mail.

## Exotic species and genetically modified organisms

This section reports on the following environmental indicators, which are defined in Saunders et al (1998).

| Environmental Indicator | |
|---|---|
| **BD 3.1** | Rate of extension of exotic species into IBRA |
| **BD 3.2** | Pest numbers |
| **BD 4.1** | Distribution and abundance of genetically modified organisms (GMOs) |
| **BD 19.1** | Number of management plans for exotic/alien/genetically modified organisms |
| **BD 19.2** | Number of research programs for exotic/alien/genetically modified organisms |
| **BD 19.3** | Funding for research and control of exotic/alien/genetically modified organisms |

### Alien or exotic species

#### Introduction

One of the objectives of the National Strategy for the Conservation of Australia's Biodiversity was to implement effective controls for at least one introduced mammal and at least three introduced plant species by the year 2000. The National Weeds Program and the National Feral Animal Control Program aim to provide a strategic framework for addressing such goals. The Commonwealth EPBC Act also includes provision for protecting Australia's environment from invasive species. However, as indicated below, the magnitude of the task is daunting.

#### Pest animal species [BD Indicator 3.1]

Australia's pest animals are species that cause severe damage to natural and agricultural systems (Olsen 1998). These pest animals are either domestic animals that have gone wild or those that were introduced for the control of pests or for recreation. Pest animals causing most public concern include the European Rabbit (*Oryctolagus cuniculus*), European Fox (*Vulpes vulpes*), cat (*Felis catus*), pig (*Sus scrofa*), goat (*Capra hirus*), donkey (*Equus asinus*), camel (*Camelus dromedarius*), Water Buffalo (*Bubalus arnee*), Mosquito Fish (*Gambusia holbrooki*), Northern Pacific Seastar (*Asterias amurensis*), European Carp (*Cyprinus carpio*) and Cane Toad (*Bufo marinus*). Pest animals may damage vegetation and soils, foul water or compete with native animals for habitat and food.

About 20 species of mammals, 25 species of birds, several amphibians and 19 species of freshwater fish make up the pest vertebrate populations of Australia. TAPs have been prepared under the National Feral Animal Control Program for four of these species: the European Fox, cat, rabbit and goat. These plans focus on strategic approaches to reducing, to an acceptable level, the effects of processes that threaten the long-term survival of native species and ecological communities.

Introduced species can have a major effect on offshore islands such as Lord Howe Island and Macquarie Island. The endangered Woodhen (*Tricholimnas sylvestris*), one of the world's rarest bird species, is found on Lord Howe Island. During the 1900s, the population of Woodhens has declined significantly in numbers as a result of disturbance by feral animals, hunting by humans and habitat loss. Thirty-four plant and animal species have been introduced on Macquarie Island, some deliberately for human consumption. The list ranges from domestic animals (which generally did not survive the harsh conditions) to insects such as the flea, which was probably introduced with the Black Rat. The greatest environmental damage on the Island has come from introduced mammals like cats and rats that eat ground-nesting seabirds, eggs and chicks or from rabbits, which eat the vegetation and contribute to soil erosion. More remote islands such as Heard and McDonald Islands are considered free from introduced species, although introductions of microorganisms could have occurred.

**Feral camels (*Camelus dromedarius)* eat a wide range of plants, especially shrubs and trees, including those not usually consumed by other herbivores.**

Populations may increase by as much as 15% in good seasons, such as 1999–2000 in central Australia.

**Source:** JE Williams.

Clarke et al. (2000) provided detailed descriptions of over 50 environmentally significant vertebrate and invertebrate pests in freshwater, terrestrial and marine environments (Table 39). Eight of the non-native pest animals were from freshwater habitats, over 30 from terrestrial habitats and at least 10 from marine habitats. Distribution maps have been produced for each species as well as total number of pest species per IBRA (Figure 36), drainage basin (Figure 37) and IMCRA region (Figure 38). These show that the highest numbers of pest species on both an IBRA, drainage basin and IMCRA basis occur in south-east Australia where the human population is highest.

*Invertebrate species and microorganisms*

About 500 introduced invertebrate species are thought to be changing the environment, including the European Honeybee (*Apis mellifera*) that may out-compete smaller, typically solitary Australian native bees (Paton 1996). The management of species such as the European Honeybee, which have been introduced for commercial purposes but have subsequent effects on native species, brings considerable challenges. This has also been observed with grasses introduced for pastoral purposes (see *Environmental weeds* on page 109). The potential for the introduction of microorganisms has not been systematically explored, but could have a significant effect on biodiversity. This could be of particular importance in remote environments such as Antarctica, where it is thought that the introduction of microorganisms is likely to have occurred.

New species continue to appear such as the recently discovered Black Striped Mussel (*Congeria sallei*), an invasive freshwater mussel from Central America, which was found in Darwin Harbour. Given the tolerance of this mussel to a range of temperature and salinity, it could potentially infest all Australian ports. A major program was put in place to eradicate the mussel, focusing on the application of large quantities of chlorine and copper sulfate. While the mussels are thought to be unable to survive this treatment, there is a strong chance that the species could become re-established and a national task force has been formed to combat the pest.

As so little is known about which marine species normally inhabit most ports and harbours, it is almost impossible to record the rate of introductions.

*When least expected*

Some introduced animals that have been around for decades can also become pests. For example, the Crazy Ant (*Anoplolepis gracilipes*) was introduced to Christmas Island in the 1930s, and only recently has become a major threat to biodiversity (see *The threat to biodiversity on Christmas Island from the Crazy Ant* box on page 110). Species introduced to control pest species can also become pests themselves. The introduction of the South American Cane Toad (*Bufo marinus*) into Queensland in 1935 from Hawaii to control two insect pests of sugar cane was a failure. The insects were later controlled using insecticides and other management practices. Meanwhile, the Cane Toad continues to thrive relying on a range of prey including native invertebrates and small vertebrate species, and they are also thought to

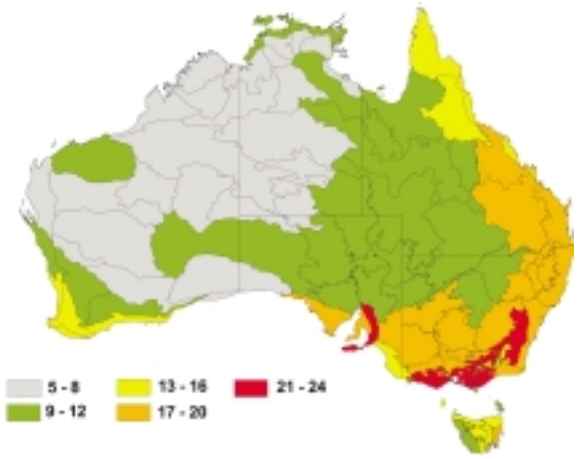



**Figure 36: Number of terrestrial non-indigenous vertebrate and invertebrate pest species per IBRA region based on a list of around 30 species considered to have a major impact in Australia (Table 39).**

**Source:** Clarke et al. (2000).

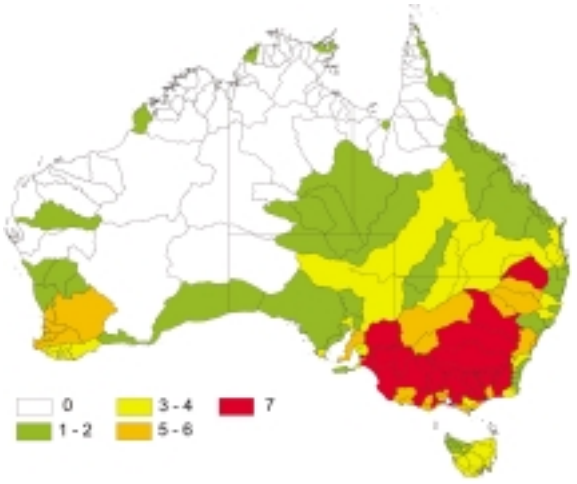



**Figure 37: Number of freshwater pest species per drainage basin including the endemic Yabbie (*Cherax destructor*).**

**Source:** Clarke et al. (2000).

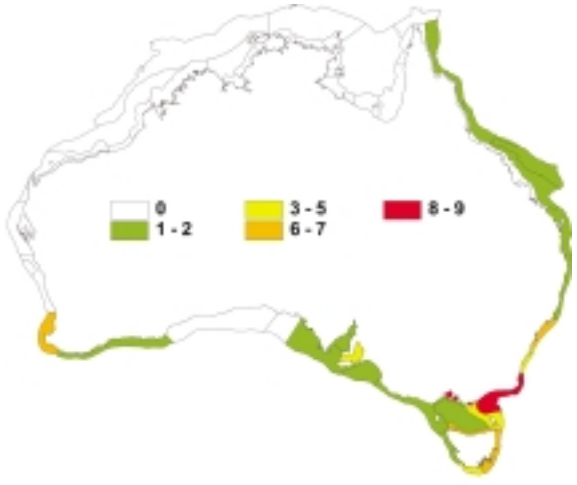



**Figure 38: Number of marine pest species per IMCRA region including the endemic Crown-of-thorns Starfish (*Acanthaster planci*).**

**Source:** Clarke et al. (2000).

**Table 39: Animal species listed in the SoE report on exotic pests (Clarke et al. 2000)**
The complete list is included. This list is used as the basis for Figures 36 to 38. Native species were not used to form the maps.

| No. | Common name | Species name |
|---|---|---|
| | **Freshwater species** | |
| 1 | Brown Trout | *Salmo trutta* |
| 2 | Rainbow Trout | *Oncorhynchus mykiss* |
| 3 | English Perch | *Perca fluviatilis* |
| 4 | European Carp | *Cyprinus carpio* |
| 5 | Goldfish | *Carrasius auratus* |
| 6 | Guppy | *Poecilia reticulata* |
| 7 | Mosquitofish | *Gambusia holbrooki* |
| 8 | Tilapia | *Oreochromis mossambicus* |
| | **Terrestrial vertebrate species** | |
| 9 | Cat | *Felis catus* |
| 10 | Fox | *Vulpes vulpes* |
| 11 | Pig[A] | *Sus scrofa* |
| 12 | Rabbit[A] | *Oryctolagus cuniculus* |
| 13 | Black Rat | *Rattus rattus* |
| 14 | Brown Rat | *Rattus norvegicus* |
| 15 | House Mouse[A] | *Mus musculus* |
| 16 | Goat[A] | *Capra hircus* |
| 17 | Brumby | *Equus caballus* |
| 18 | Deer | *Axis axis*<br>*Axis porcinus*<br>*Cervus elaphus*<br>*Cervus timoriensis*<br>*Cervus unicolor*<br>*Dama dama* |
| 19 | Cane Toad | *Bufo marinus* |
| 20 | Water Buffalo | *Bubalus bubalis* |
| 21 | Common Starling | *Sturnus vulgaris* |
| 22 | Common Myna | *Acridotheres tristis* |
| 23 | House Sparrow | *Passer domesticus* |
| 24 | Eurasian Blackbird | *Turdus merula* |
| 25 | Mallard | *Anas platyrhynchos* |
| 26 | Nutmeg Mannikin | *Lonchura punctulata* |
| 27 | Wild Dog | *Canis familiaris familiaris* |
| 28 | European Honeybee | *Apis mellifera* |
| 29 | European Wasp | *Vespula germanica* |
| 30 | Black Portuguese Millipede | *Ommatoiulus moreleti* |
| 31 | Western Flower Thrips | *Frankliniella occidentalis* |
| 32 | Bumble Bee | *Bombus terrestris* |
| 33 | Spiralling Whitefly | *Aleurodicus dispersus* |
| 34 | White Snails | *Theba pisana*<br>*Cernuella virgata* |
| 35 | Conical Snails | *Cochlicella acuta*<br>*Cochlicella barbara* |

**Table 39: Animal species listed in the SoE report on exotic pests (Clarke et al. 2000) *(continued)***
The complete list is included. This list is used as the basis for Figures 36 to 38. Native species were not used to form the maps.

| No. | Common name | Species name |
|---|---|---|
| 36 | Elm Bark Beetles | *Scolytus multistriatus*<br>*Pyrrhalta luteola* |
| 37 | Crazy Ant | *Anoplolepis gracilipes* |
| | **Marine species** | |
| 38 | Mediterranean Fanworm | *Sabella spallanzanii* |
| 39 | Northern Pacific Seastar | *Asterias amurensis* |
| 40 | European Shore Crab | *Carcinus maenas* |
| 41 | North Pacific Oyster | *Crassostrea gigas* |
| 42 | New Zealand Screw Shell | *Maoricolpus roseus* |
| 43 | Asian Date Mussel | *Musculista senhousia* |
| 44 | Japanese Kelp or Wakame | *Undaria pinnatifida* |
| 45 | Dead Man's Fingers or Broccoli Weed | *Codium fragile tomentosoides* |
| 46 | Caulerpa | *Caulerpa filiformis* |
| 47 | Toxic Dinoflagellates | *Gymnodinium catenatum*<br>*Alexandrium catenella*<br>*Alexandrium minutum* |
| 48 | Black Striped Zebra Mussel | *Mytilopsis sallei* |
| | **Endemic pest species** | |
| 49 | Laughing Kookaburra | *Dacelo novaeguineae* |
| 50 | Koala | *Phascolarctos cinereus* |
| 51 | Kangaroo[A] Western Grey<br>Eastern Grey<br>Red | *Macropus fuliginosus*<br>*Macropus giganteus*<br>*Macropus rufus* |
| 52 | Crown-of-Thorns Starfish | *Acanthaster planci* |
| 53 | Harvester Termites[A] | *Drepanotermes perniger*<br>*Drepanotermes rubriceps* |
| 54 | Yabbie | *Cherax destructor* |

[A] Indicates coverage includes both managed and natural ecosystems.

compete with native frogs and snakes for these foods. In addition, the toad has toxic skin secretions that are known to kill vertebrate predators such as goannas, quolls, skinks and snakes. The toads have been spreading, mainly to the north, since their introduction (Figure 39). In December 1998, they were noticed around 500 km south of Darwin. They have been found recently in as far north as the Koolatong River in east Arnhem Land to just inside the south-east corner of Kakadu National Park and throughout the Katherine River System.

## Environmental weeds [BD Indicator 3.2]

Environmental weeds are plants that invade natural ecosystems and can cause major modification to indigenous species and ecosystem function (as opposed to horticultural or agricultural weeds, although a species may be both). They are considered one of the greatest threats to nature conservation in Australia (Commonwealth of Australia 1999; Low 1999), having been implicated in the extinction of four plant species (Groves & Willis 1999). The most recent estimate of the number of environmental weeds in Australia is 1060 (Swarbrick & Skarrat 1994). Virtually all

**A Crazy Ant (*Anoplolepis gracilipes*) feeding on the honeydew produced by scale insects.**

The mutual relationship between these two species has been responsible for extensive canopy dieback on Christmas Island.

**Source:** Piper Films, Australia.

aquatic and terrestrial vegetation communities in Australia are affected by environmental weeds. There are, however, considerable differences in the level of invasion, both within and between vegetation types, with disturbance history and proximity to human development being key factors.

One species of great concern, the Rubber Vine (*Cryptostegia grandiflora*), entangles trees and other vegetation and eventually smothers them. The vine is spreading at an alarming rate through the river systems of southern Cape York, the Queensland part of the Gulf of Carpentaria and along the coast as far south as the Burnett River near Bundaberg, destroying the riverside vegetation in these regions.

For aquatic weeds, patterns of rainfall in particular have a major influence on their distribution and management. A network of people responsible for aquatic weed management is needed to gather information in order to assess the aquatic weed situation annually across Australia. Without this, it is impossible to describe the extent of effects at a national level, although several case studies for individual species are available.

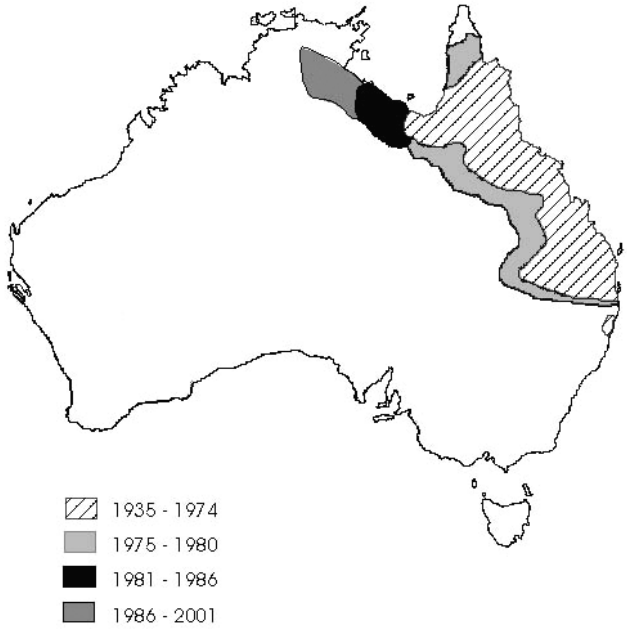



**Figure 39: Distribution and spread of Cane Toads (*Bufo marinus*) from 1935 to 2001.**

This is an indicative map only and does not record the complexity of the invaded areas. Recent information on the southward spread of the Cane Toad was not available for this report.

**Source:** Burgman and Lindenmayer (1998); van Dam et al. (2000).

*Indigenous species*

Not all environmental weeds are introduced from other countries. They can be indigenous species that have been deliberately planted for horticulture beyond their natural range or where altered disturbance regimes encourage their spread into areas where they did not grow previously. Despite being 'native' plants, weeds of indigenous origin can severely disrupt ecosystems. Examples are Coastal Tea-tree (*Leptospermum laevigatum*), Cootamundra Wattle (*Acacia baileyana*) and Sweet Pittosporum (*Pittosporum undulatum*) (Mullett 1996).

*Effects of environmental weeds*

Environmental weeds can have a range of effects on natural systems, although quantitative studies of these effects are uncommon (Adair & Groves 1998). Despite the paucity of studies, however, it is likely that major changes to ecosystem structure will cause consequent losses of biodiversity. This has been observed in New Zealand, where several species introduced deliberately for naturalisation in the wild have dispersed effectively from the locations in which they were planted, reducing the diversity of both plant and animal species in all cases (Williams & West 2000).

## The threat to biodiversity on Christmas Island from the Crazy Ant

The Crazy Ant (*Anoplolepis gracilipes*) has become a major threat to biodiversity on Christmas Island. It is a tropical species native to western Africa and was first found in Australia on Christmas Island in the 1930s. It has become a pest only recently there, but is already seen as a direct threat to as many as 20 animal species, including sea birds, land birds, mammals, reptiles and three species of crabs. Millions of the Red Crabs (*Gecariodea natalis*), for which Christmas Island is famous, have been killed by the Crazy Ant. The crab is critical to the dynamics of the unique rainforest communities on the island, so its elimination has a direct effect on forest structure and processes. The presence of Crazy Ants can also lead to canopy dieback due to the mutual relationship with scale insects that produce honeydew (scale insects cause a disease that can result in dieback; honeydew is a food source of the ant and the ants protect the scale insects from other predators). Several reasons underly the major threat imposed by these ants: their extremely broad diet, the formation of supercolonies with extraordinarily high and sustained densities, and they forage in three dimensions. Contact sprays, dusts and toxic baits have been successfully used to control the ant, and because there appears to be no native ant species on Christmas Island, biological control could be feasible long-term. Unless host specificity could be guaranteed, this method would not be suitable for mainland Australia, where the Crazy Ant has recently been recorded in the north-east of the Northern Territory.

**Source:** Clarke et al. (2000); Garnett and Crowley (2000).

The effects of environmental weeds are not always detrimental. For example, they can provide some native animals with additional food sources and shelter. In these cases, management strategies need to reflect the supply of alternative shelter and food sources. Equally important, management options need to include consideration of the control of native dispersal agents such as birds and mammals. Weeds can be spread widely by animals, as demonstrated for species such as the Brushtail Possum.

*Pasture plants*

Plants legally introduced into Australia for pasture production or horticulture have the potential to become environmental weeds. Lonsdale (1994) demonstrated that greater than 99% of species introduced between 1947 and 1985 that were considered useful for pasture production caused weed problems in both cropping and conservation areas in northern Australia. Only 5% became useful for pastoral use. Mitchell and Williams (2000) described two vigorous wetland grasses introduced for ponded pastures in Queensland in the 1980s which outcompeted native plants and have drastically altered the habitat for many waterfowl. Consequently, the net benefit for Australia of introducing such species needs to be seriously considered before similar species are introduced.

An introduced pasture species that is quickly becoming a major environmental weed in central Australia is Buffel Grass (*Cenchrus ciliaris*). This is a perennial grass, which has been shown to reduce the diversity and abundance of both native vascular plants and invertebrates (Pitts & Albrecht 2000). Seed of this species is spread by helicopter by some pastoralists and once established it is a difficult species to control. Burning is not an effective long-term solution as the grass recovers rapidly and completely, and suppresses the germination of native plant species.

*Sleeper weeds*

Many of the introduced plants already in Australia may become weeds given sufficient time or a change in conditions (e.g. disturbance, introduction of a pollinator and climate change). 'Sleeper weeds' (those species that have naturalised, but not yet exponentially expanded their populations) are a major concern. Groves (1999) identified two ecological factors that were useful in predicting sleeper weeds: time from naturalisation, and relocation to a more favourable site. Some progress has been made, with recent studies identifying 'potential environmental weeds' (non-native species only) that are amenable to eradication (Csurches & Edwards 1998). There is still, however, no effective response mechanisms in place to retrospectively apply weed risk assessment to naturalised species that can still be controlled.

*Nursery plants*

Another source of concern is garden plants that can become potential environmental weeds. In 1999, the Nursery Industry Association identified 860 invasive plants available through nurseries. To minimise the impact of this practice, the current emphasis is on education and raising awareness, with the government, nursery industry and horticultural media working together to find solutions (Blood 1999). Currently, 50 of the plants have been voluntarily withdrawn from sale. Control of this trade is made more difficult by the complex and inconsistent approach to noxious weed legislation in Australia (Thorp & Lynch 1999).

## Policies and programs for weed management [BD Indicator 19.1]

At the national level, the developing awareness during the 1990s of the threat of weed species to both production and conservation systems achieved formal recognition with the launch of the National Weeds Strategy in mid-1997.

A central component of the strategy was the identification of the most serious weed problems in Australia, which resulted in an official list of 20 Weeds of National Significance (WONS) (Table 40) (Thorp & Lynch 2000). This was developed on behalf of Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ), Australia and New Zealand Environment Conservation Council (ANZECC) and the Ministerial Council on Forestry, Fisheries and Aquaculture (MCFFA) and has been agreed with the states and territories of Australia after extensive consultation.

The final 20 species were selected from an original list of 71 species based on their invasiveness, economic, environmental and social effects, current distribution, potential for spread and effect in reducing the growth of desirable plants. Whereas all 20 species were identified as a threat to plant communities and endangered plant and animal species

**Table 40: The 20 Weeds of National Significance and their associated threats**

| Common name<br>Scientific name | Origin of weed | Threats to: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Human health & safety | Pastoral industries | Cropping industries | Forestry management | Water quality & supplies | Damage to infrastructure | Endangered species | Plant communities | Cultural values | Tourism | The community | Recreation and amenities |
| Alligator Weed<br>*Alternanthera philoxeroides* | North-east Argentina | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Athel Pine<br>*Tamarix aphylla* | Northern Africa; Iran; India; Arabian Peninsula | | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Bitou Bush/ Boneseed<br>*Chrysanthemoides monilifera* ssp. *rotundata/ molinifera* | South-west South Africa | | | | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Blackberry<br>*Rubus* sp. | Europe | | ✓ | | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Bridal Creeper<br>*Asparagus asparagoides* | South Africa | | | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Cabomba<br>*Cabomba caroliniana* | USA | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Chilean Needle Grass<br>*Nassella neesiana* | Southern America | | ✓ | | ✓ | | | ✓ | ✓ | | | ✓ | |
| Gorse<br>*Ulex europaeus* | Central & western Europe | ✓ | ✓ | | ✓ | | | ✓ | ✓ | | | ✓ | ✓ |
| Hymenachne<br>*Hymenachne amplexiculis* | South & central tropical America | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ |
| Lantana<br>*Lantana camara* | Central America | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Mesquite<br>*Prosopis* sp. | Northern South America; central America; southern USA | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Mimosa<br>*Mimosa pigra* | Tropical America | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Parkinsonia<br>*Parkinsonia aculeata* | Southern USA; Caribbean, Mexico; northern South America | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Parthenium Weed<br>*Parthenium hysterophorus* | Caribbean | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Pond Apple<br>*Annona glabra* | North, Central & South America; west coast of tropical Africa | | | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Prickly Acacia<br>*Acacia nilotica* ssp. *indica* | Africa; western Asia | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rubber Vine<br>*Cryptostegia grandiflora* | South-west Madagascar | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Salvinia<br>*Salvinia molesta* | South-east Brazil | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Serrated Tussock<br>*Nassella trichotoma* | Argentina; Peru; Chile; Uruguay | | ✓ | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Willows<br>*Salix* spp.[A] | Europe; America; Asia | | | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |

[A] Except Weeping Willows (*Salix babylonica*), Pussy Willows (*Salix calodendron*) and Sterile Pussy Willow (*Salix reichardtii*).

**Source:** after National Weeds Strategy Executive Committee (1999) http://www.weeds.org.au/natsig.htm.

(Table 40), six of the weed species were classified as primarily a threat to the environment, another five as primarily a threat to primary production systems, and nine weeds have both environmental and primary production effects. Maps of the current and predicted distribution of the 20 species have been produced (e.g. Figures 40 and 41) and a major publication on the WONS has been released (Thorp & Lynch 2000). While endorsement of the list is not accompanied by any specific form of guaranteed funding, it will assist the Commonwealth, states and territories in determining funding priorities as well as providing direction to research organisations, commercial partners, industry and community groups.

National coordination teams are being established for each of the weed species and individual management plans prepared. The implementation of the plans has been slower than expected due to the need to engage a range of stakeholders in their development. The intention of the plans is to focus on strategic management and on species that have national priority.

Considering the number of environmental weeds in Australia, and the potential threat posed by 'sleeper weeds', there is some concern that focusing resources on a small number of nationally significant species may not be the best approach. To help complement this strategy, an 'alert list' has been developed of 28 non-native plant species that are in the early stages of establishment and have the potential to become a significant threat to biodiversity if they are not managed. Funding priority for their management or control will be given to projects that promote the long-term protection of remnant vegetation, especially ecologically threatened communities, and that target isolated populations of the weeds to prevent further establishment and expansion of the weed.


**Figure 40: Current and potential distribution of Alligator Weed (*Alternanthera philoxeroides*), a weed of national significance.**

The potential distribution used is predicted from the climate-modelling program CLIMATE, plus the remainder of the current distribution, which was not included in the prediction.

**Source:** Thorp and Lynch (2000).

## Diseases

Introduced diseases pose a major threat to biodiversity in Australia, as shown by the effect of dieback disease, caused by the fungus *Phytophthora cinnamomi*. This species was introduced into Australia in the 1800s, probably accompanying plant material introduced for agriculture. Dieback disease can result in great changes in a broad range of ecosystems including heathlands, shrublands, woodlands and forests. About 20% of the 9000 vascular plants of south-west Western Australia may be at risk from dieback disease, including more than 80% of all Proteaceae which are particularly susceptible. At least 10% of the remaining jarrah forest in south-west Western Australia is infected with dieback disease, although this is considered an underestimate. Changes in vegetation communities associated with *Phytophthora* would affect fauna, especially for species such as the Honey Possum (*Tarsipes rostratus*), which rely on a specialised diet of pollen and nectar mainly from highly susceptible proteaceous plants.

*Phytophthora* is also a problem in eastern Australia, and has been found in the highlands of Tasmania. The flora of northern Australia is also considered susceptible to *Phytophthora*, so several hygiene measures have been put in place to stop its introduction via potted plants brought in for horticultural purposes or use in gardens.

The extent of the threat of *Phytophthora* to Australia's species and ecosystems is recognised in the 1996 *National Strategy for the Conservation of Australia's Biodiversity* where it is the only pathogenic taxon specifically cited. The Commonwealth EPBC Act also lists the disease caused by *Phytophthora* as a key threatening process. A nationally coordinated threat abatement process is being developed to manage the effect of *Phytophthora* dieback on Australian ecosystems. A draft plan was circulated in July 1999 which estimated that over $10 million would be needed to be spent over five years to implement the plan.

Disease has also been linked to the decline of some frog populations in Australia. There is strong evidence that a chytrid fungus is associated with the death of some frogs, but it is not known if it is the direct cause of mortality or an indication of other environmental stress. Other diseases already in Australia may become a threat, in much the same manner as 'sleeper weeds' and pests.

## Quarantine

Effective quarantine is a key factor in minimising the introduction of potential weeds, pests and diseases from both other countries and within Australia (see the *Land* Report). The recently introduced weed risk assessment was explicitly designed to detect weeds of both environmental and agricultural concern (Steinke & Walton 1999). This system has been endorsed by a wide range of client groups and is now used on all new plant imports whether they enter Australia as seeds, nursery stock or tissue culture, regardless of their use in Australia.

## Managing introduced species [BD Indicator 19.1]

*Integrated management*

Integrated management involves coordinated use of various control techniques, and integrating control with other activities. The major aims of integrated management for environmental weeds are to (Vranjic et al. 2000):

- effectively contain the spread of existing weeds
- manage the environment to prevent the incursion of new weeds
- rehabilitate the disturbed ecosystem as far as possible.

In natural systems, this involves a range of considerations such as the use of herbicides (and their potential effects on non-target species), the appropriate situations where fire can be used and the importance of passive and active revegetation.

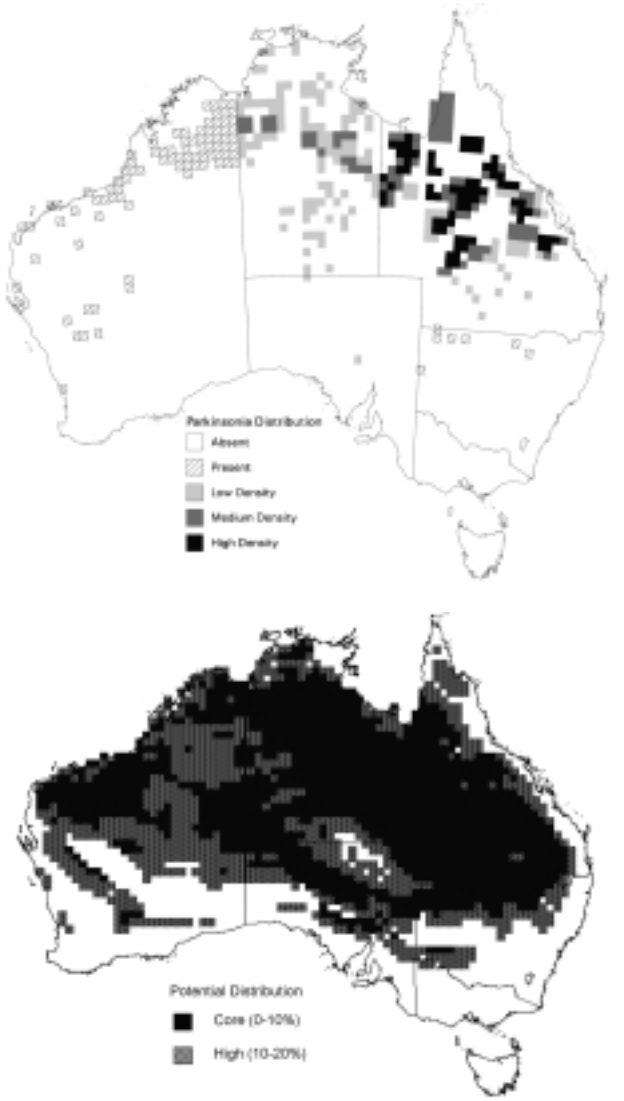



**Figure 41: Current and potential distribution of Parkinsonia (*Parkinsonia aculeata*), a weed of national significance.**

The potential distribution used is predicted from the climate-modelling program CLIMATE, plus the remainder of the current distribution, which was not included in the prediction.

**Source:** Thorp and Lynch (2000).

*Biological control*

Biological control is one of the tools used to manage a range of introduced organisms. The *Biological Control Act 1984* is the principal enabling legislation at the Commonwealth level. Biological control is not always the 'magic bullet', particularly for terrestrial weeds with large soil seed reserves (Briese 2000). Consequently, biological control is more frequently seen as part of an overall management strategy.

One of the critical tests for new organisms being considered as biological control agents is whether they will affect other non-target organisms. Stringent tests are now enforced to help ensure that biological control agents are effective and do not become pests themselves. However, the system is not fail-safe as illustrated by the untimely escape in 1995 of rabbit calicivirus (RCD) from Wardang Island in South Australia.

*Rabbit calicivirus and other management tools*

Agents such as RCD, and its precursor myxomatosis, are essential management tools, given the number and extent of rabbits in Australia. RCD is highly infectious to rabbits and can cause mortalities of up to 95% among adults, although regional variation in infection rates can be significant.

While an initial reduction in rabbit populations may be brought about by an effective outbreak of viruses such as RCD or by poisoning or drought, to keep populations low, follow-up techniques such as poisoning, warren ripping and fumigation are recommended. At another level, rabbit control may need to be integrated with the control of other pest species such as foxes and feral cats. There has been some concern that the reduction in rabbit numbers may lead to predators switching their prey to native animal species.

*Western Shield*

The Western Shield Program, managed by CALM in Western Australia, aims to bring at least 13 fauna species back from the brink of extinction by controlling foxes and feral cats, on almost five million hectares of land.

The main weapon in the fight against the fox and feral cat is use of the naturally occurring poison 1080, found in native plants called gastrolobiums ('poison peas'). Although native animals in south-west Australia have a high tolerance to the poison, introduced animals do not. In the south-west forests, scientific research and monitoring has shown that where fox numbers have been reduced by baiting with 1080, there has been a dramatic increase in native animal numbers.

Endangered native animals such as the Numbat (*Myrmecobius fasciatus*), Noisy Scrub-bird (*Atrichornis clamosus*) and Ring-Tailed Possum (*Petropseudes dahli*) are increasing in numbers after being reintroduced into forest inside and outside reserves. Already, three forest-dwelling mammals, the Woylie (*Bettongia pencillata*), Quenda or Southern Brown Bandicoot (*Isoodon obesulus*) and Tammar Wallaby (*Macropus eugenii*) have been removed from the State's Threatened Fauna List and the status of other species has been improved as a result of successful conservation management under the Western Shield Program.

*Community involvement*

The successful management of pests and weeds requires the informed and motivated participation of people throughout Australia. An important element of the success of the Western Shield Program described above is the cooperation and support of local communities. Many private landowners and Land Conservation District Committees have helped with fox baiting by laying baits on their own land where it is next to conservation reserves and state forests. As well as government funding, the baiting program is sponsored by Alcoa Australia, Cable Sands and Westralian Sands.

The Ballarat Region Gorse Task Force in Victoria is another example that involves a range of groups in the management of an environmental weed (see the *Ballarat Region gorse (*Ulex europaeus*) Task Force* box on page 116).

## Funding and research into exotic organisms [BD Indicator 19.2 and 19.3]

*Environmental weeds*

An indication of the nature of the research on environmental weeds can be gained through the annotated bibliography developed by Swarbrick and Timmins (1997). At the national level, the main focus of research has been through two CRCs: Tropical Pest Management in northern Australia and Weed Management Systems in southern Australia, established in 1995. The former CRC ceased operation in 1998, but individual organisations are still working on the ecology of environmental weeds in the north.

The Weed Management Systems CRC has worked on seven 'key' environmental weeds: Bitou Bush (*Chrysanthemoides monilifera* ssp. *rotundata*), Boneseed (*Chrysanthemoides monilifera* ssp. *monilifera*), Bridal Creeper (*Asparagus asparagoides*), Broom (*Cytisus scoparius*), Blackberry (*Rubus fruticosus*), Horehound (*Marrubium vulgare*) and St John's Wort (*Hypericum perforatum*).

In 2001, the CRC for Weed Management Systems was granted a further seven years of funding. This new CRC for Australian Weed Management has two programs of relevance to environmental weeds. The 'Landscape Management' Program will focus on the management of key habitats to control weeds, the management of model weed types and enhanced biocontrol strategies. A 'Weed Incursion and Risk Management' Program is also being developed that will examine risk assessment (see the *Risk assessment and management approaches to biodiversity* box on page 92) and management of sleeper weeds.

At the national level, the main source of funding for environmental weeds is through the National Weeds Program. From 1996 to 2002, a sum of $28.5 million has been allocated to this Program (see *Natural Heritage Trust expenditure* on page 161). In May 2001, the Commonwealth government announced funding through this Program for onground projects related to the management of established weeds that could pose a significant threat to biodiversity (as identified in the 'Alert list' of 28 species).

*Pest Animals*

The CRC for Biological Control of Pest Animals started in 1999 and builds on the work of the CRC for Vertebrate Biocontrol. The research focus of the CRC is to develop ways to

## Ballarat Region Gorse (*Ulex europaeus*) Task Force

Gorse (*Ulex europaeus*) is a serious environmental and agricultural weed in south-east Australia because of its invasiveness and the difficulty and expense involved in conventional control. It invades bushland, reducing access and conservation values and threatening the survival of rare and endangered plants. On pastoral land, gorse significantly reduces pasture and animal productivity. Gorse also provides habitat and shelter for vertebrate pests such as rabbits and foxes, and increases fire hazards. In Victoria, gorse is common in the central highlands, the south-west and parts of Gippsland.

The Gorse Task Force Area is centred on Ballarat and covers some 800 000 ha of urban, farming and forested land in the central highlands of Victoria.

The Ballarat Region Gorse Task Force represents 43 Landcare groups across the central highlands of Victoria. The Task Force has prepared a Gorse Control Strategy which targets infestations along roadsides and waterways where the greatest potential for spread exists, and where there is a demonstrated public benefit associated with control.

The Task Force approach is based on a model with strong partnerships between landholders and Landcare groups, local government, catchment management authorities and the Department of Natural Resources and Environment (DNRE). The model empowers community groups to lead and coordinate the implementation of agreed community-based weed control strategies. The role of DNRE is to support these strategies through providing community education, extension and enforcement programs to ensure that a lack of action by a minority does not jeopardise the good work of most of the community.

The Gorse Task Force has secured funding for implementation of the Gorse Control Strategy, including the employment of facilitators and provision of incentives for onground control where there is a demonstrated public benefit. DNRE have provided compliance officers, funded through their 'Enhanced Enforcement' program. The Strategy identifies facilitation as the key to raising community awareness of the problems caused by gorse, for coordinating strategic programs for long-term management, and most importantly, for creating community acceptance of responsibility for gorse control.

**Source:** DNRE, Victoria.

control populations of the rabbit, fox and introduced house mouse through using vaccines that cause sterility. Before sterilisation for these animals becomes a reality, many ecological hurdles will need to be identified and overcome.

The total resources involved in the CRC for biological control is estimated to be around $57 million over seven years. The Centre has 20 postgraduate students and the equivalent of 51 full-time research staff. At the national level, $18.9 million was allocated to the National Feral Animals Control Program between 1996 and 2002 (see *Natural Heritage Trust expenditure* on page 161).

### Genetically modified organisms

#### Distribution and abundance of genetically modified organisms [BD Indicator 4.1]

A GMO is any organism with genetic material that has been altered by genetic engineering. GMO research programs have much in common with traditional plant and animal breeding programs whose intention is to produce individuals with new genetic composition, better adapted to the needs of agriculture, medicine or some other productive use. GMOs are novel because the tools of molecular biology allow genes to be introduced into species that would be difficult or impossible using traditional breeding techniques. There are potential ecological benefits from genetically modified (GM) plants and animals, including the prospect of plant varieties to rehabilitate salt-affected areas or soils contaminated by heavy metals. Some potential benefits are indirect and difficult to predict, such as reductions in the use of pesticides (Barnes 2000).

Like other introduced organisms, there is also the potential for ecological costs. With the proliferation of GM products and the almost exponential growth of land use for GM crops (AAS 1999), there is growing interest in the estimation of the risks to the environment of exposure to such products. The major potential hazards for biodiversity posed by GM species may be summarised under four headings (Levin 1992):

1 transgenic leakage into related wild populations may occur by hybridisation, where genes from the GM species move by cross-pollination into wild relatives of the same or different but closely related species
2 GM populations may become invasive of natural habitats, competing most intensely with wild relatives

3 GM species may be a direct hazard to non-target species, where the specific properties of GMOs (e.g. insect resistance in crop plants) may make them allergenic or toxic to a range of species that are part of the ecosystem shared by the GM species
4 GM species may have indirect effects through changes in agricultural practice, including establishment of crops and livestock in areas considered marginal for agriculture, made possible by the novel properties of GMOs.

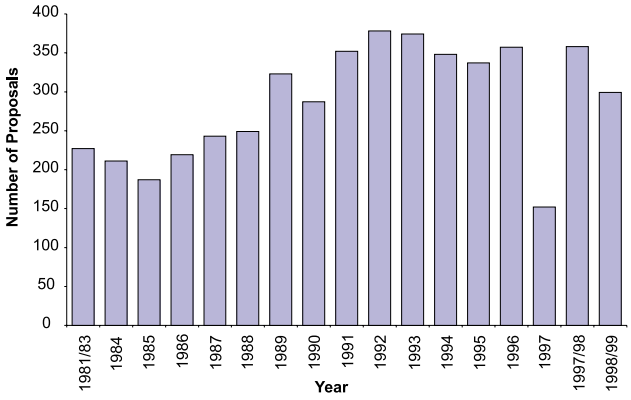



**Figure 42: Total of small-scale proposals (for laboratory, glasshouse or clinical applications of recombinant DNA under contained conditions) assessed by the Genetic Manipulation Advisory Committee (GMAC) between 1981 and 30 June 1999.**

**Source:** GMAC Annual Report 1997–98 (GMAC 1997) and 1998–99 (GMAC 1999).

The introduction and spread of GMOs in Australia is regulated by the Interim Office of the Gene Technology Regulator and its Genetic Manipulation Advisory Committee (GMAC). Institutional Biosafety Committees (IBCs) operate in institutions where GMO research is undertaken. They oversee the development of new proposals and the conduct of research, acting as a first filter before new ideas are forwarded to GMAC for their consideration. General releases of GMOs are controlled by the Commonwealth Minister for Health and Aged Care under interim arrangements announced by the Commonwealth in August 1999. A national system of statutory regulation will be in place by July 2001.

Because of the prospect of the spread of genes from GM crops to adjacent non-GM crops, or between related species by hybridisation, buffers between field trials and adjacent wild and non-transgenic crop populations are used. The extent and utility of these buffers has been the focus of some research, with quantification of some aspects of genetic systems, dispersal and gene introgression (di Giovanni & Beckett 1990; Adler et al. 1993; Timmons et al. 1996; Giddings et al. 1997; Hokanson et al. 1997; Moyes & Dale 1999). However, there has been little work on comprehensive, quantitative modelling of ecological risks of GMOs (Timmons et al. 1996; Hails 2000) in Australia or elsewhere.

Small-scale proposals include laboratory, glasshouse or clinical applications of recombinant DNA under contained conditions. They do not involve the release or cultivation of individuals under field conditions. A total of 4811 small-scale proposals were assessed by GMAC between 1981 and June 1999 (Figure 42). In June 1999, there were 1681 active, small-scale, contained projects.

Deliberate releases of GMOs involve trials under field conditions and range from areas smaller than 1 ha up to many thousands of hectares, and numbers of individuals ranging from fewer than 50 to many millions. In June 1999, there were 13 large-scale projects and 109 deliberate releases underway, the latter an increase from June 1998 of 69 projects (Table 41). Most deliberate releases are for commercial crops. Cotton (*Gossypium* spp.) and Canola (*Brassica* spp.) have been the subjects of most attention and make up the bulk of field trials, although more than 30 different kinds of GM species had been trialed up to June 1999 (Table 42). GMOs have been trialed in all Australian states (Table 43). A general release implies that the product is commercially available. There were two general releases in Australia before March 2001, for cotton and carnations.

GMAC assessed almost all proposals as acceptable, after modification and with different levels of protection being required. Two proposals were rejected, both relating to a project focused on the development of bacteria in the guts of ruminant animals that would allow them to tolerate fluoroacetate poisons that naturally occur in native plant species. One of the concerns was the potential for the bacterium to find its way into the guts of non-target species, perhaps resulting in increased effects on natural vegetation from feral animals. In addition, i is

**Table 41: The number of projects on GMOs current in June 1998 and June 1999 and the number of Institutional Biosafety Committees (IBCs) responsible for them**

| Year | Small-scale contained work | Large-scale contained work | Deliberate releases | Projects with the potential for unintended release | IBCs |
|---|---|---|---|---|---|
| 1997–98 | 1 818 | 18 | 40 | 0 | 85 |
| 1998–99 | 1 681 | 13 | 109 | 2 | 89 |

**Source:** GMAC Annual Report (1997–98) and 1998–99 (see http://www.health.gov.au/ogtr/index.htm).

**Table 42: Proposals for deliberate release of GMOs considered by the Genetic Manipulation Advisory Committee (GMAC) between 1981 and March 2000**

| Target species | Number of projects | Objective of project |
|---|---|---|
| *Agrobacterium radiobacter* | 1 | Control of crown gall disease |
| Apples | 2 | Kanamycin resistance |
| Baker's Yeast | 1 | Commercial evaluation of melibiose |
| Barley | 4 | Barley yellow dwarf virus resistance; expression of marker genes |
| Canola | 32 | Protoplast fusion breeding lines; new hybridisation systems; seed increase; glufosinate ammonium tolerance; glyphosate herbicide tolerance; fungal disease resistance; photoperiod insensitivity; reduced glucosinolate content; dwarfed cultivars; reduced pod-shatter |
| Carnation | 8 | Modified colour, enhanced vase life; fungal resistance |
| Cattle | 5 | Bovine rhinotracheitis vaccine; salmonella vaccine in lactating dairy cows; release of bovine herpes virus for vaccination |
| Chrysanthemum | 1 | Glasshouse trial of transgenics |
| Cotton | 90 | Insect resistance (Bt); seed increase; glycophosate tolerance; 2,4-D resistance; bromoxynil resistance; yield and fibre tests; climate response assessment; integrated pest management & ecological assessment; progeny selection; Verticillium wilt tolerance; waterlogging tolerance |
| Field Pea | 11 | Enhanced grain sulfur levels; pea weevil (*Bruchus pisorum*) resistance; resistance to Ascochyta blight; resistance to Liberty |
| Grapevine | 1 | Evaluation of transgenes |
| *Helicoverpa armigera* | 4 | Transgenics for monitoring frequency of Bt resistance in field; dispersal, stability and transmission of a genetically marked *Helicoverpa armigera* singly-enveloped nucleopolyhedrovirus in cotton |
| Lentils | 1 | Resistance to Basta |
| Lettuce | 1 | Virus resistance |
| Lupins | 10 | Herbicide resistance (*Lupinus angustifolius*); virus resistance; sunflower seed albumin |
| Oilseed Poppy | 3 | Field trial and release |
| Papaya | 2 | Virus resistance; superior post-harvest fruit quality |
| Pigs | 1 | No details |
| Pineapple | 1 | Control of flowering and ripening |
| Potatoes | 9 | Resistance to potato leafroll virus and potato virus Y; seed tuber production; viral resistance; low browning properties |
| Poultry | 2 | Salmonella vaccine; evaluation of fowlpox virus vaccine |
| *Pseudomonas* spp. | 4 | Test of microbial tracking system; non-chemical control of bacterial wilt (*Pseudomonas solanacearum*); colonisation ability of modified Pseudomonas biological control bacteria on wheat roots in soil |
| *Rhizobium* spp. | 2 | Field release of strain containing a plasmid marked with a transposon |
| Rose | 3 | Colour modification; kanamycin or chlorsulfuron resistance |
| Rumen bacteria | 2 | Detoxification of fluoroacetate in domestic animals |
| Sheep | 2 | Salmonella vaccine to prevent death during live sheep export |
| Subterranean Clover | 9 | Bromoxynil-tolerance; sunflower seed albumin |
| Sugar Cane | 5 | Resistance to leaf scald disease; resistance to sugarcane mosaic virus; modified sucrose metabolism and juice colour |
| Tomato | 4 | Insect resistance (Bt); seed increase |
| Wheat | 5 | Evaluation of gene flow using a herbicide-resistant marker gene; altered starch composition; modified grain qualities; Basta tolerance; production of a glutenin protein |
| White Clover | 3 | Resistance to alfalfa mosaic virus |
| Unknown | 1 | Fruit ripening and flavour development |
| **Total** | **230** | |

**Source:** GMAC Annual Report 1997–98 and 1998–99 (see http://www.health.gov.au/ogtr/publications/index.htm).

**Table 43: The locations by state and territory of deliberate releases of GMOs in Australia to 30 June 1999**

Australia-wide (general release): *Agrobacterium,* no gall pesticide; carnation, improved vase life and altered flower colour; cotton, insect-resistant (restricted to parts of Qld and NSW).

| ACT | New South Wales | Queensland | Victoria |
|---|---|---|---|
| Barley | Baker's Yeast | Apple | Canola |
| Clover | Canola | Bovine Herpes Virus 1 | Carnation |
| Field Pea | Clover | Canola | Clover |
| Potato | Cotton | Cotton | Field Pea |
| *Pseudomonas* | Field Pea | Papaya | Grapevine |
| Rhizobium | Fowlpox Virus | Pineapple | Indian Mustard |
| Wheat | *Helicoverpa armigera* singly-enveloped nucleopolyhedrovirus<br>Indian Mustard<br>Potato<br>Tobacco | Potato<br>*Pseudomonas*<br>Sugar Cane<br>Tomato | Potato<br>Rose<br>Tomato<br>*Salmonella* |
| **Northern Territory** | **South Australia** | **Tasmania** | **Western Australia** |
| Cotton | Barley<br>Canola<br>Field Pea<br>Indian Mustard<br>Potato<br>*Pseudomonas*<br>Wheat | Canola<br>Indian Mustard<br>Poppy<br>Potato | Canola<br>Clover<br>Cotton<br>Field Pea<br>Lentil<br>Lupin<br>*Salmonella* |

**Source:** GMAC, Canberra.

possible that the effect of 1080 bait used in the Western Shield Project in Western Australia (see *Managing introduced species* on page 114) could be reduced if feral animals developed tolerance to these poisons.

There are several crop genera where Australian native species are found in the same genus (Table 44). Of the species listed, GM varieties of potatoes, tomatoes and cotton have been trialed in the field. Many other crop species have the potential to hybridise with native species outside their genus. For example, there are many Australian species in the family Brassicaceae that could hybridise with crops of Canola and Indian Mustard (genus *Brassica*). The native species are important in their own right, and represent important reservoirs for genetic

**Table 44: Genetically modified crop genera with related Australian native plant species**

| Field crops | | Vegetables | | Oils, fruits, nuts, spices | |
|---|---|---|---|---|---|
| **Latin name** | **Common name** | **Latin name** | **Common name** | **Latin name** | **Common name** |
| *Amaranthus* | Pigweed, Chinese Spinach | *Abelmoschus* | Okra | *Brassica* | |
| *Chenopodium* | Australian Spinach | *Alocasia* | Taro | *Cinnamomum* | Cinnamon |
| *Cajanus* | Dahl | *Apium* | Celery | *Citrus* | Orange, Lemon |
| *Corchorus* | Jute | *Cucumis* | Cucumber | *Eucalyptus* | |
| *Glycine* | Soybean | *Dioscorea* | Yam | *Ficus* | Fig |
| *Gossypium* | Cotton | *Ipomoea* | Sweet Potato | *Macadamia* | |
| *Linum* | Flax | *Solanum* | Potato, Tomato | *Melaleuca* | Tea-tree |
| *Nicotiana* | Tobacco | | | *Musa* | Banana |
| *Oryza* | Rice | | | *Myristica* | Nutmeg |
| *Sorghum* | | | | *Olea* | Olive |
| *Vigna* | Cow pea, Black-eyed Pea | | | *Piper* | Pepper (white, black etc.) |
| | | | | *Prunus* | Almond, Peach, Cherry) |
| | | | | *Rubus* | Blackberry |
| | | | | *Syzygium* | Bush Cherry |

**Source:** after Brown and Brubaker (2000).

resources for crop improvement. These species may be at risk from unwanted hybridisation, both from genetically modified variants and from stock developed by more traditional means. The risk of hybridisation depends on many factors including pollen size and mode of dispersal, seed dispersal mechanisms, timing of flowering, wind direction, water flows, outcrossing rates and the spatial proximity of populations.

## Protecting biodiversity

This section reports on the following environmental indicators, which are defined in Saunders et al. (1998).

| Environmental Indicator | |
|---|---|
| **BD 9.1** | Number of subspecific taxa |
| **BD 9.2** | Population size; numbers; and physical isolation |
| **BD 9.3** | Environmental amplitude of populations |
| **BD 9.4** | Genetic diversity at marker loci |
| **BD 10.1** | Number of species |
| **BD 10.2** | Estimated number of species |
| **BD 10.3** | Number of species formally described |
| **BD 10.4** | Percentage of number of species described |
| **BD 10.5** | Number of subspecies as a percentage of species |
| **BD 10.6** | Number of endemic species |
| **BD 10.7** | Conservation status of species |
| **BD 10.8** | Economic importance of species |
| **BD 10.9** | Percentage of species changing in distribution |
| **BD 10.10** | Number distribution and abundance of migratory species |
| **BD 10.11** | Demographic characteristics of target taxa |
| **BD 11.1** | Ecosystem diversity |
| **BD 11.2** | Number and extent of ecological communities of high conservation potential |
| **BD 15.1** | Number of recovery plans |
| **BD 15.2** | Amount of funding for recovery plans |
| **BD 16.1** | Number of ex situ research programs |
| **BD 16.2** | Number of releases to the wild from ex situ breeding |

### Genetic diversity

Conserving genes and genetic diversity in populations may be achieved through the maintenance of genetic structure within and among subpopulations, or among sets of populations with common evolutionary histories. This strategy improves the ability of populations to adapt to novel environmental conditions and avoids the potentially negative effects of inbreeding (Frankham et al. 2001). Genetic information may also be used to guide the management of captive populations, to set conservation priorities by identifying unique populations (see the *Conserving quantitative genetic variation* box on page 120), to provide information on population dynamics and mating systems that would otherwise be unobtainable, and to understand the consequences of historical events, such as range expansions, fragmentation and bottlenecks (Moritz 1995).

#### Number of subspecific taxa [BD Indicator 9.1]

Information to report on this indicator is unavailable.

#### Population size, numbers and physical isolation [BD Indicator 9.2]

There are insufficient data for this indicator to be a reliable reflection of any general or specific trends in the distribution of genetic variation as a response to changes in the environment.

## Conserving quantitative genetic variation

Monitoring the potential for adaptation to environmental change might be well served by an explicit focus on monitoring changes in quantitative environmental variation, particularly the component that is available for evolution, namely, heritable genetic variation.

However, studies that measure overall levels of genetic variation within and among populations do not provide any information on genetic variation of fitness traits that are under selection in the field. The focus on maintaining variability among such populations raises the real threat that the adaptive potential of larger but less distinct populations is being minimised. A rapidly changing environment where the maximisation of genetic variation for traits associated with stress and disease resistance will be critical for long-term persistence.

Alternate approaches for maintaining appropriate genetic variation in populations have been advocated. These include shifting the focus to phenotypic variation of traits associated with stress and disease resistance that will have the effect of selection of favourable genes at many loci (Woods et al. 1999). Another approach is to concentrate on populations that persist at ecological margins as these will have been selected for environmental stress resistance and are likely to have higher frequencies of stress resistance genes than population inhabiting more favourable environments (Hoffman & Parsons 1997). Marginal populations may have evolved generalised stress resistance mechanisms that will allow them greater resistance in stress environments other than those in which they have been selected.

Management strategies should aim to conserve species across a broad range of climatic regions and to conserve all races, variants and subspecies. This will ensure that any genotypes fixed because of local adaptation will be conserved and available to counter future climatic changes.

### Environmental amplitude of populations [BD Indicator 9.3]

The data for this indicator are unavailable.

### Genetic diversity at marker loci [BD Indicator 9.4]

It is not possible to report in any detail on this indicator.

### Challenges associated with genetic indicators

The entire genome of an individual cannot be measured. The closest science has come to achieving this goal is the Human Genome Project. This involved enormous human and financial resources, sequenced various parts of different humans, not of one individual alone, and was a one-off project. Even if it were possible to measure an entire genome, we would not know which parts of the genome had adaptive significance. The kinds of genetic data that may be acquired reflect the different regions of the genome from which they are sampled. Different regions have different characteristics and the data taken from them may have different applications.

Overall, the recommendations on genetic indicators by Brown et al. (1997) and Saunders et al. (1998) may generate some useful statistics for monitoring species but most current genetic studies of Australian species do not provide sufficient information for the relevant variables to be calculated.

Allelic richness and gene diversity measure the basic raw material available for evolution: allelic richness is more sensitive a measure, but is more susceptible to sampling artefacts. The observed heterozygosity per individual ($H_o$) is a good indicator of processes such as mating systems, and may predict fitness. It is also possible to estimate levels of inbreeding from patterns of heterozygosity. The concepts of allelic richness, gene diversity and observed heterozygosity are explained in greater detail (see the *Measuring genetic variation* box on page 123).

Interspecific and intraspecific comparisons of allelic richness are compromised, however, because of biases in the selection of markers. For example, comparisons between taxa and between times will be affected by the choice of markers, because different marker systems produce different estimates of genetic diversity (Moran et al. 2000).

Brown et al. (1997) recommended identifying a set of species for detailed monitoring, providing baselines for assessing future changes in genetic diversity. Their recommendations depend on the identification of indicator taxa, and resampling of species genomes to ensure sufficient sample sizes to reliably detect trends in the distribution and amount of genetic variation. Table 45 reflects the current uneven availability of genetic data required for biodiversity monitoring. There is considerable effort expended on measuring and reporting genetic variation within and between populations using several markers. These data would be

**Table 45: Genetic variation of some representative taxa reflecting the uneven availability of genetic data required for biodiversity monitoring**
Diversity values are averages calculated across all polymorphic loci.

| Taxon | Total (expected) diversity ($H_e$) | Observed diversity ($H_o$) | Mean number of alleles per locus ($A$) | Proportion of variable loci ($P$) | Marker |
|---|---|---|---|---|---|
| All mammals[A] | 0.104 | | | | Isozymes |
| Marsupials[B] | 0.052 | | | | Isozymes |
| All mammals[C] | | 0.041 (0.035) | | 0.19 (0.14) | Isozymes |
| Birds[D] | | 0.051 (0.029) | | 0.30 (0.14) | Isozymes |
| Reptiles[E] | | 0.083 (0.119) | | 0.26 (0.15) | Isozymes |
| Amphibians[F] | | 0.067 (0.058) | | 0.25 (0.15) | Isozymes |
| Fish[G] | | 0.051 (0.035) | | 0.21 (0.14) | Isozymes |
| Invertebrates[H] | | 0.100 (0.091) | | 0.38 (0.22) | Isozymes |
| *Cherax quadricarinatus*[I] | 0.688 | 0.420 | | | Microsatellite |
| *Ctenophorus ornatus*[J] | 0.630 | 0.642 | | | Microsatellite |
| All plants[K] | 0.230 | | | | Isozymes |
| All plants[L] | | 0.075 (0.069) | | 0.30 (0.25) | Isozymes |
| *Grevillea scapigera*[M] | 0.356 | | | | RAPDs |
| *Eucalyptus lateritica*[N] | 0.318 | | | | Isozymes |
| *Eucalyptus johnsonii*[N] | 0.139 | | | | Isozymes |
| *Lambertia orbifolia*[O] | 0.11 (0.01) | 0.06 (0.01) | 1.5 (0.05) | | Isozymes |

[A] Average of two summaries (Sherwin & Murray 1990); [B]Average of three studies including 18 species (Sherwin & Murray 1990); [C]Average of 184 species for *H* and 181 species for *P* (Nevo et al. 1984); [D]Average of 46 species for *H* and 56 species for *P* (Nevo et al. 1984); [E]Average of 75 species for *H* and 84 species for *P* (Nevo et al. 1984); [F]Average of 61 species for *H* and 73 species for *P* (Nevo et al. 1984); [G]Average of 183 species for *H* and 200 species for *P* (Nevo et al. 1984); [H]Average of 361 species for *H* and 371 species for *P* (Nevo et al. 1984); [I]Baker et al. (2000); [J]Lebas & Spencer (2000); [K]Summarised by Hamrick and Godt (1989; 1996) from 400 studies; [L]Average of 56 species for *H* and 75 species for *P* (Nevo et al. 1984); [M]Rossetto et al. (1995); [N]Moran and Hopper (1987); [O]Coates and Hamley (1999).

**Source:** after Moran and Hopper (1987); Sherwin and Murray (1990); Sydes (1995).

considerably more useful for biodiversity monitoring if collection and reporting reflected the procedures used by Coates and Hamley (1999) (see the *Monitoring Round-leaf Honeysuckle (*Lambertia orbifolia*)* box on page 123).

## Species diversity

### Species richness [BD Indicators 10.1, 10.2, 10.3 and 10.4]

The most recent estimate of global species richness (Lawton & May 1995) puts the total number between five and seven million species globally, with an upper limit of perhaps 15 million species. Estimates of the total number of species in Australia vary considerably. SoE (1996) reported around one million species, whereas Horwitz et al. (1999) believe that it is likely to exceed ten million. These figures demonstrate the large gaps in knowledge about even the number of species found in Australia.

The ABRS provided the most recent summary of our knowledge of species diversity in Australia (summarised in Table 46). Only a few vertebrate groups are thought to be fully described: frogs, birds, lizards, snakes, birds, mammals and lancelets. Consequently there are very few examples where the number of species is believed to be the final total. Table 46 also provides the most recent estimate of the number of species formally described.

For most groups, particularly the invertebrates, there are still large gaps in our knowledge. This makes it difficult to estimate the total number of species and, therefore, the percentage of number of species described in each group. Based on the figures provided in Table 46, however, for many groups it is estimated that more than 50% of species remain to be described. Estimates of the number of some marine species is thought to be out by three-fold to five-fold. For example, in 1974 there were over 1300 sponge species recorded in Australia but there could be up to 5000 (Chris Battershill, pers. comm.). With the advent of molecular taxonomic techniques, the figure is also likely to be an underestimate. For some groups such as cryptograms, there is not even agreement on what the accepted species are, and hence no list is available of the number of species that have been described.

## Measuring genetic variation for State of the Environment reporting

**Allelic richness:** Allelic richness is defined as the number of alleles in a sample, standardised for sample size. Two statistics are relevant to allelic richness, the percentage of polymorphic loci (*P*), and the average number of alleles per locus (*A*). To compare allelic richness between species, or to compare samples from the same species at different times, it would be necessary to sample the same markers on each occasion, or to take a random sample of all possible markers. But methodological conventions are to survey available markers and to select informative ones for analysis and reporting. Selection is often haphazard but is rarely random (Glaubitz et al. 1999). In addition, loci are treated as polymorphic only if the frequency of the most frequent allele is less than 0.95, or sometimes less than 0.99 or 0.90. Typically, the number and identity of monomorphic markers are not published, sometimes by editorial policy, if not by convention.

It is also possible to estimate the number of alleles per polymorphic locus, which may be readily compared across studies. In addition, planned and coordinated monitoring strategies could overcome biases through appropriate marker choice.

**Gene diversity:** Gene diversity, $H_e$, is the expected level of heterozygosity in a randomly mating population, given observed allelic frequencies. In species with subdivisions (populations), the diversity may be partitioned into within-population ($H_s$) and between-population ($G_{ST}$) components. This information may be used to examine patterns of population structure and differentiation and non-random mating.

The level and type of information obtained from genetic studies depends on the markers chosen. Gene diversity is directly available in studies that use codominant markers (including restriction fragment length polymorphisms, RFLPs, isozymes and microsatellites). Studies using dominant markers (e.g. polymerase chain reaction-based markers including amplified fragment length polymorphisms and random amplified polymorphic DNA, RAPD) or haploid markers (e.g. mitochondrial DNA) usually report genetic distances. These studies do not provide any direct measure of gene frequencies. Mitochondrial DNA gives a measure of diversity equivalent to $H_e$ (haplotype diversity) but no measure of inbreeding. This occurs because the various methods used to score genetic markers detect different proportions of the total variation in DNA base sequences. Moreover, the rates of mutation vary widely between different classes of marker. For example, isozymes and RFLPs have low mutation rates and microsatellites have very high mutation rates (Ennos 1996).

**Observed heterozygosity:** Observed heterozygosity, $H_o$, is the proportion of heterozygotes in a population, averaged over all loci, and is theoretically available in all studies that use codominant markers. However, this statistic is rarely reported in the literature. Most studies are concerned primarily with differentiation between populations in a single study, so that comparisons between times and between species are rarely considered. Microsatellite studies contrast with studies that use other codominant markers. Most microsatellite studies report both $H_o$ and $H_e$, allowing computation of inbreeding coefficients (e.g. Baker et al. 2000; Lebas & Spencer 2000; Miwa et al. 2000).

## Monitoring Round-leaf Honeysuckle (*Lambertia orbifolia*)

Coates and Hamley (1999) measured the genetic variation within and between populations of *Lambertia orbifolia*, a large woody shrub restricted to seven populations in Western Australia. They found 12 out of 19 isozyme loci were polymorphic. Levels of genetic variation were roughly comparable with other long-lived woody shrub species endemic to the region. Genetic divergence between population groups was very high, with 44% of variation in genetic diversity being composed of between population differences. They estimated rates of gene flow between the populations to be very low and found consistently low levels of outcrossing. Coates and Hamley (1999) recommended that one population be recognised as a separate conservation unit, on the basis of the degree of genetic differentiation. They reported *A*, *P*, $H_e$ and $H_o$, together with standard errors for each statistic, for each of the populations, making it possible to resample these populations in future years, to measure trends in diversity.

**Table 46: The estimated total number and percentage of species described in Australia and the percentage of endemic species for various taxa**

| Taxonomic group | Estimated number of species described [BD Indicator 10.3] | Estimated total number of species [BD Indicators 10.1 and 10.2] | Estimated percentage described (as at 2000) [BD Indicator 10.4] | Endemic (%) |
|---|---|---|---|---|
| **Prokaryota (Bacteria)** | | | | |
| | Unknown | Unknown | Unknown | Unknown |
| **Protoctistae (Unicellular organisms)** | | | | |
| | Unknown | Unknown | Unknown | Unknown |
| **Fungi** | | | | |
| Fungi (other than lichens) | ~12 500 | ~250 000 | ~5 | 90 |
| Lichens | 2 877 | ~5 000 | ~60 | Unknown |
| **Plantae (Plants)** | | | | |
| Vascular plants (flowering plants, cycads, conifers, ferns and fern allies) | 15 638 | 20 000 to 25 000 | ~70 | 85 |
| Algae | 5 000 | 10 000 to 12 000 | ~45 | Unknown |
| Bryophyta (mosses and allies) | 1 500 | ~2 500 | ~60 | Unknown |
| **Total Australian flora (plants and fungi)** | **~25 000** | ~290 000 | ~9 | — |
| **Animalia (Animals)** | | | | |
| **Invertebrates** | | | | |
| Porifera (sponges) | 1 416 | ~3 500 | ~40 | Unknown |
| Cnidaria (corals, anemonies, jellyfish) | 1 270 | ~1 760 | ~70 | Unknown |
| Platyhelminthes (flatworms, parasites) | 1 506 | ~10 800 | ~14 | Unknown |
| Acanthocephala (thorny-headed worms) | 57 | ~160 | ~35 | Unknown |
| Nematoda (roundworms, threadworms) | 2 060 | 30 000 | ~7 | Unknown |
| Mollusca (squid, octopus, mussels, clams, snails) | 9 336 | ~12 250 | ~75 | 90 |
| Annelida (ringed worms, earthworms) | 2 125 | ~4 230 | ~50 | Unknown |
| Onychophora (velvet worms) | 56 | ~56 | ~100 | Unknown |
| Crustacea (crayfish, crabs, prawns etc.) | 6 426 | ~9 500 | ~70 | Unknown |
| Arachnida (spiders, mites etc.) | 5 666 | ~27 960 | ~20 | Unknown |
| Insecta (insects) | 58 532 | ~83 860 | ~70 | 90 |
| Echinodermata (starfish, echinoderms etc.) | 1 206 | ~1 400 | ~85 | Unknown |
| Other invertebrates | 2 929 | ~7 230 | ~35 | Unknown |
| **Chordates** | | | | |
| Tunicata (sea squirts, doliolids, salps) | 536 | ~735 | ~70 | Unknown |
| Cephalochordata (lancelets) | 8 | ~8 | ~100 | Unknown |
| Agnatha (lampreys, hagfishes, slime eels) | 5 | ~10 | ~50 | Unknown |
| Pisces (fish) | 4 150 | ~5 250 | ~80 | 90 |
| Amphibia (frogs) | 176 | ~176 | ~100 | 93 |
| Reptilia (snakes, lizards) | 633 | ~633 | ~100 | 89 |
| Aves (birds) | 825 | ~825 | ~100 | 45 |
| Mammalia (mammals) | 369 | ~369 | ~100 | 83 |
| **Total Australian fauna** | 99 287 | ~200 000 | ~50% | — |

**Source:** Data on species numbers, collected by the ABRS. Data on endemic species compiled from: Office of the Chief Scientist (1992); Anderson (1994); Mummery & Hardy (1995); Scott et al. (1997); Burgman & Lindenmayer (1998); WCMC (2000); T. May (pers. comm.).

Of the groups that are described, certain taxa in Australia contain a globally significant number of species (e.g. reptiles, ants, lichens), as do certain regions (e.g. Great Barrier Reef, wet tropics, south-west corner). Australia has a rich and unique assemblage of vertebrates and vascular plants. By world standards, the number of freshwater fish species in Australia is low (Table 47), reflecting the small amount of freshwater habitat.

**Table 47: A global comparison of the number of freshwater fish species**

| Continent | No. of freshwater fish species |
|---|---|
| South America | 2 200 |
| Africa | 1 800 |
| Asia | 1 500 |
| North America | 950 |
| Central America | 354 |
| Europe | 250 |
| **Australia** | **170** |
| New Zealand | 27 |

The value for Asia is probably an underestimate because of relatively little taxonomy and few surveys.

**Source:** Banister (1992).

The importance and dominance of invertebrates as a component of biodiversity, and their role in ecosystem functioning is well documented (Ponder & Lunney 1999). The overwhelming number of species and the lack of fundamental taxonomic activity is regarded as being the major impediment to effective invertebrate conservation in Australia and throughout the world. Estimates of total numbers of invertebrate species are inherently unreliable because of the lack of relatively complete taxonomies for the most species-rich taxa. Recher and Majer (1996) (based on a study where they sampled 1600 invertebrate species on four different species of eucalypt) estimated that around 250 000 species of just one group of terrestrial invertebrates would be found in association with the genus *Eucalyptus*. In contrast, Yen and Butcher (1997) estimated that in total there were around 300 000 species of non-marine invertebrates, of which less than 100 000 are described. Whatever the number, invertebrates make a major contribution to species diversity in Australia (Ponder & Lunney 1999). With the exception of a few charismatic groups, most notably the butterflies, there is very little biological or ecological knowledge of these species.

Microorganisms (see *The fascinating world of microbial biodiversity* box on page 126), are also an important component of species richness in Australia and can have utilitarian and indirect values in both marine and terrestrial systems. Very little is known about these organisms, although estimates have been made of the species richness and endemism of fungi (Table 46), based largely on their visible fruiting bodies. To illustrate their diversity, May and Simpson (1997) estimated that the approximately 700 species of eucalypts in Australia are likely to have about 7000 species of associated fungi.

Even less is known about other microorganisms. For example, so little is known about bacterial diversity in Australia that even an estimate of the total number is unavailable. However, recent studies are starting to shed some light: Gordon and Fitzgibbon (1999) identified 90 species of bacteria in 20 genera in the gastrointestinal tract of Australian mammals. As with invertebrates, these and other microorganisms are poorly studied and are usually underrepresented in species lists and biological surveys. The number of plant species present at a site can also be

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

**Source:** JJ Bruhl, University of New England.

## The fascinating world of microbial biodiversity

The microbial world encompasses a large proportion of life forms, broadly including any organism that spends all or most of its life in microscopic form. Microorganisms therefore include viruses, single-celled algae, bacteria, archaea (a specialised form of bacteria that are important in decay processes, especially in wetlands), protozoa and fungi, and in the broadest sense, microscopic invertebrates such as nematodes and mites. During the 1990s, it has become increasingly apparent that our knowledge of biodiversity in the microbial world is largely inadequate. More than 99% of microorganisms are yet to be discovered or described (Amman et al. 1995; Head et al. 1998; Hugenholtz et al. 1998). Understanding the roles of these unknown organisms is likely to be essential to understanding and monitoring biodiversity, since they occupy key positions in all ecosystems. The prokaryotes (bacteria and archaea) as a group contain roughly equivalent quantities of organic carbon as plants, and may hold up to 10 times more phosphorus and nitrogen than do plants (Whitman et al. 1998). Similarly, in terrestrial ecosystems, the biomass of fungi exceeds all other groups except vascular plants (Lal 1995). Microorganisms perform key ecosystem services such as nitrogen fixation, carbon cycling and the regulation of atmospheric gases. A recent attempt to value the world's ecosystem services arrived at a value of US$33 trillion per year (Costanza et al. 1997). Categories of these services that are mainly, or partly provided by microorganisms (nutrient cycling, waste treatment/degradation, atmospheric gas regulation, erosion control, soil formation, biological control and food production) amount to over 70% of this total value.

A further area where we lack adequate understanding of microbial biodiversity is in the associations between microbial life and larger organisms. Almost all macroorganisms depend on microbial symbioses to some extent. Microorganisms contribute significantly to the conservation and production of nutrients in the vertebrate gastrointestinal tract (reviewed in Stevens & Hume 1998). Investigations of the microbiota associated with native Australian animals are only just beginning. Around 75% of vascular plants form mutualistic associations with mycorrhizal fungi. Although the composition and type of plant species in a terrestrial ecosystem is a primary determinant of ecosystem productivity and sustainability (Tilman et al. 1996; Hooper and Vitousek 1997), plant biodiversity may in turn be primarily regulated by the diversity of mycorrhizal fungi (Read 1998; van der Heijden et al. 1998). Consequently, fungal diversity may indirectly control both ecosystem productivity and variability (Read 1998; van der Heijden et al. 1998). Fungal endophytes also occur in the leaves and stems of vascular plants, and the extent and importance of this form of mutualism is receiving more attention. In Australia, 95% of ectomycorrhizal fungi are novel, with some 22 genera and 3 families being endemic (Castellano & Bougher 1994). Thus, Australian fungi are likely to be as unique as our animal and plant species. A similar situation occurs in the mutualistic association between nitrogen-fixing soil bacteria and legumes, which in Australia represent about 10% of plant species. A survey of native shrubby legumes recovered 21 genomic rhizobial species, only one of which corresponded to a known species (Lafay & Burdon 1998).

Because of their large biomass, extraordinary genetic diversity and their central roles in many ecosystem processes, the characterisation of microbial biodiversity should be a consideration in any biodiversity assessment. However, the systematic investigation of microbial diversity in Australia has been the subject of few studies, and methods for rapid assessment of the distribution and abundance of microorganisms are still being developed (Liesack & Stackebrandt 1992; Holmes et al. 2000). The conservation of microbial diversity has not yet received the attention given to larger organisms, and indeed there is only one mention of the word 'microorganism' in the body of the CBD (Davison et al. 1999).

**Source:** Mike Gilling, Macquarie University.

underrepresented if surveys of the soil seed bank are not undertaken. For example, a recent study in the wheat belt of Western Australia found that at some sites over 50% of native plant species were detected only as seeds in the soil.

### Number of subspecies as a percentage of species [BD Indicator 10.5]

Information to report on this indicator is unavailable.

### Endemism [BD Indicator 10.6]

A taxon (e.g. a species) is considered endemic to a particular area if it occurs only in that area. The proportion of vertebrate taxa in Australia that are endemic is particularly high compared to other countries, with the richness of vertebrate species being largely as a result of a remarkable variety of reptiles. Because of its size, age and geological and evolutionary isolation, over 80% of mammal, reptile and flowering plant species in Australia are also endemic (Table 46). The degree of endemism in fungi, molluscs and insects is also estimated to be over 80%, and as such, the Australian continent is recognised as a centre of endemism of global

significance (Major 1988). While the level of endemism of many taxonomic groups is still unknown, it is likely to be high because of Australia's evolutionary and geological history.

Since the concept of endemism is tied to particular areas, the identification of centres of endemism is dependent on scale (Crisp et al. 2001). At a global level, high levels of species richness and endemism are consistent across most taxonomic groups in Australia and in most environments (e.g. reef and coral fishes; Table 48). Areas of high endemism also occur within regions in the Australian continent. For example, about 5% of Australia's flora occurs in the Stirling Ranges of south-west Australia, an isolated mountain range with some unique ecological characteristics. The high level of vascular plant endemism in this region is evident also at the global level. In a worldwide study, Myers (1988, 1990) identified 18 relatively small areas that are rich in endemic vascular plant species and that are experiencing relatively rapid rates of habitat modification or loss (Table 49). The only region in Australia on this list is the south-west of the continent. These 18 sites contain about 50 000 endemic plant species (20% of the world's total) in about 750 000 square kilometres (0.5% of the earth's surface area).

**Table 48: A global comparison of the number of fish and coral species associated with coral reefs**

| Coral reef | No. of fish species | No. of coral species |
|---|---|---|
| **Great Barrier Reef** | **2 000** | **500** |
| New Caledonia | 1 000 | 300 |
| French Polynesia | 800 | 168 |
| **Heron Island (Great Barrier Reef)** | **750** | **139** |
| Society Islands | 633 | 120 |
| Toliara (Madagascar) | 552 | 147 |
| Aqaba | 400 | 150 |
| Moorea (Society Islands) | 280 | 48 |
| St Gilles (Réunion) | 258 | 120 |
| Tutia Reef (Tanzania) | 192 | 52 |
| Tadjoura (Djibouti) | 180 | 65 |
| Baie Possession (Réunion) | 109 | 54 |
| Kuwait | 85 | 23 |
| Hermitage (Réunion) | 81 | 30 |

**Source:** after Harmelin-Vivien (1989), in Banister (1992).

Several different patterns of endemism have been observed within the Australian biota. Cracraft (1991) identified 14 recognisable areas in Australia with a unique assemblage of bird species (see figure 4.16 of SoE 1996). Crisp et al. (2001) analysed the distribution patterns of around 8500 vascular plant species. Twelve centres of endemism, which were all near coastal, were identified. The lack of centres of endemism in inland Australia was attributed to the selective extinction of narrow endemics driven by extreme climates during the last glacial maximum.

Major centres of both plant endemism and diversity were also examined by Crisp et al. (2001). The regions that met both these criteria were south-west Australia, the Border Ranges between New South Wales and Queensland; the Wet Tropics near Cairns; Tasmania; and the Iron-McIlwraith Range of eastern Cape York Peninsula. The last centre appears to be more significant than recognised previously, and the Adelaide–Kangaroo Island region, which was also identified as important, has previously been overlooked altogether. It is important to have identified areas where high concentrations of species occur, so that they can be sympathetically managed.

Levels of endemism are also high for marine groups such as macroalgae, with southern Australia being of major significance (Zann 1995). Levels of endemism of other marine groups are described (see *The conservation status of marine species* on page 131). The 5500 km coastline from south-west Western Australia to the border between New South Wales and Victoria is particularly rich in brown algae and red algae. Of these two groups, around 57 and 75% of species are endemic to southern Australia. Recent studies of cave biota in Australia have also discovered high levels of endemism (see Wilkens et al. 2000).

**Table 49: Numbers of endemic plant species in 18 regions exhibiting high levels of plant species richness and endemism**
Of the total, 14 regions may be classified as tropical rainforest, and four (italic) have Mediterranean type climates. Of these, the only region in Australia is found in the south-west of the continent.

| Region | Numbers of endemic vascular plant species |
|---|---|
| *Cape region (South Africa)* | 6 000 |
| Upland west Amazonia | 5 000 |
| Atlantic coastal Brazil | 5 000 |
| Madagascar | 4 900 |
| Philippines | 3 700 |
| North Borneo | 3 500 |
| Eastern Himalaya | 3 500 |
| ***South-west Australia*** | **2 830** |
| Western Ecuador | 2 500 |
| Colombian Chocó | 2 500 |
| Malaysian Peninsula | 2 400 |
| *California* | 2 140 |
| Western Ghats (India) | 1 600 |
| *Central Chile* | 1 450 |
| New Caledonia | 1 400 |
| Eastern Arc Mountains (Tanzania) | 535 |
| South-west Sri Lanka | 500 |
| South-west Côte d'Ivoire | 200 |

**Source:** after Myers (1988, 1990) and Burgman and Lindenmayer (1998).

Another measure of the uniqueness of Australia's biodiversity is the high level of variation in species richness among communities, and the variation in commonness and rarity among species, termed mosaic diversity. High values indicate complex landscapes with many environmental gradients, and many species with roughly equal abundance. Using this measure, the diversity of species and terrestrial ecosystems in Australia exceeds that of any other continent.

## Vulnerable, endangered, threatened or extinct species [BD Indicator 10.7]

The differences between taxa in the percentages of threatened and extinct species reflect the biases in taxonomic and conservation focus (Table 50). Vertebrates (especially birds and mammals) and in general vascular plants receive much more attention than do invertebrates, non-vascular plants and fungi. This bias also appears in the records of other countries (Lawton & May 1995).

It appears that the number of nationally endangered and vulnerable species has increased in several groups over the last seven years (Table 50). In some instances, the numbers of species in these categories may change over time because there have been changes in the abundance or distribution of species. But in many cases, the changes are due to taxonomic revisions resulting in either the creation or loss of new species.

The status of species may also change based on new information without any underlying change in the number or distribution of individuals or in the processes affecting them. New observations result in a reassessment of area of occupancy, extent of occurrence, population size, threat status, trends in population size or other factors contributing to assessment of conservation status.

### *Plants*

The most important change has been an increase in the number of endangered vascular plants. There were 226 endangered species on the official list in 1993, and 517 in 2001. Most of this is because the work on assessing threatened flora is continuing. Most additions are species that have never been assessed before, including some recently described taxa with very restricted distributions. However, there are some that are facing higher levels of threat than they were in

**Table 50: Total number of endangered (EN), vulnerable (VU) and presumed extinct (PEX) species in 1993 and 2001**
Species listed in 1993 are those under the *Endangered Species Protection Act 1992* and in 2001, under the EPBC Act. Total number of threatened species, 1993, 1027; Endangered and Vulnerable, 2001, 1478

| Taxon | EN (1993) | EN (2001) | VU (1993) | VU (2001) | PEX (1993) | PEX (2001) |
|---|---|---|---|---|---|---|
| Ecological communities | — | 27 | — | — | — | — |
| Fish | 7 | 13 | 6 | 17 | — | — |
| Amphibians | 7 | 15 | 2 | 12 | — | 4 |
| Invertebrates | — | — | — | 4 | — | — |
| Reptiles | 6 | 11 | 15 | 38 | — | — |
| Birds | 26 | 33 | 25 | 61 | 20 | 23 |
| Mammals | 28 | 29 | 18 | 45 | 21 | 27 |
| Non-vascular Plants | — | 1 | — | 1 | — | — |
| Vascular plants | 226 | 517 | 661 | 654 | 74 | 63 |
| Fungi | — | — | — | — | — | — |
| **Total species** | **300** | **646** | **727** | **832** | **115** | **117** |

1993. The most important cause of changes in threat status that are not the result of new work or taxonomic revision over the last five years has been land clearance for urban and agricultural development.

As many as 123 species vascular plant species were presumed extinct in 1988 but the number was revised downwards subsequently, largely as a result of new information, survey work and taxonomic revision (Figure 43). A total of 227 vascular plant species have been considered at some time to be extinct. The first two Rare or Threatened Australian Plants (ROTAP database) lists share relatively few species with one another, or with any of the subsequent lists. The turnover in species on the list of presumed extinct plants has been substantial, varying by 10 to 40% of their constituent species, even during the 1990s when the total number of species presumed to be extinct did not change greatly. Most of the changes are due to taxonomic revision and survey work. Few reflect actual changes in status.

The number of presumed extinct vascular plants at the national level has fallen from 74 to 63 during 1993 to 2001 (Table 50). This has occurred as a result of taxonomic revision and rediscovery. Additional survey work is often prompted by the inclusion of species on the 'presumed extinct' list. There may be some further reduction over the next five years. There may be new additions as new species are described, data on plant abundances are revised, and surveys are conducted for rare and endangered flora (Figures 44 and 45).

*Birds*

The 2000 Action Plan for Australian Birds (Garnett & Crowley 2000) listed 25 bird taxa (reporting to the subspecies level) as extinct, 32 as critically endangered, 41 as endangered, 82 as vulnerable and 81 as near threatened. The remaining 1114 taxa are deemed to be least concern, including 28 introduced taxa and 95 vagrants. Of those taxa known to have been present or to have occurred regularly in Australia when Europeans settled in 1788, 1.9% are reported as extinct and a further 11.5% are considered threatened. Some 6.0% are near threatened. Since the last

**Button Wrinklewort (*Rutidosis leptorhynchoides*) is listed as a nationally endangered species within Australia (gazetted by ANZECC in 1999).**

Once plentiful in the lowland grassy plains of Victoria, this species is now restricted mainly to railway reserves and is threatened by disturbances such as soil excavation, dumping and ploughing.

**Source:** Murray Fagg, Australian National Botanic Gardens.

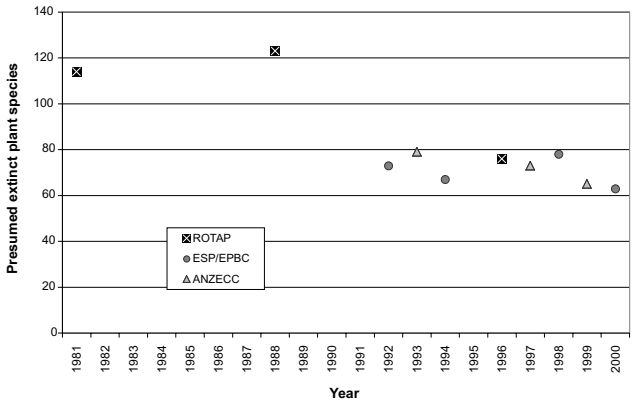



**Figure 43: Changes in the number of presumed extinct vascular plant species in Australia between 1981 and 2000.**

The first list was compiled in 1981. ROTAP—Rare or Threatened Australian Plants database; ESP—*Endangered Species Protection Act 1992*; EPBC—*Environmental Protection and Biodiversity Conservation Act 1999*; ANZECC—Australian and New Zealand Environment Conservation Council.

**Source:** ANZECC (1993, 1995, 1999); Leigh et al. (1981); Briggs and Leigh (1988, 1996); *Endangered Species Protection Act 1992, 1994, 1998* (Cwlth); EPBC Act; Leigh and Briggs (1992).

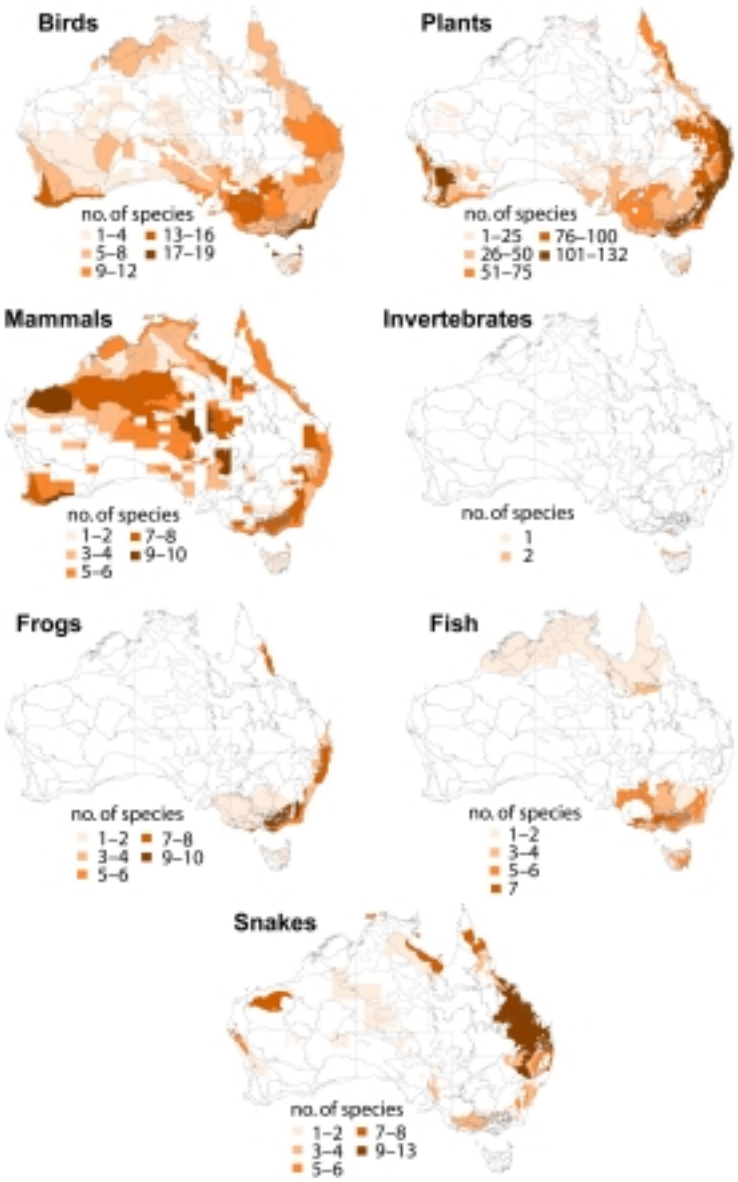



**Figure 44: Number of nationally rare and threatened species in 2000 per IBRA region.**

Mammal species have been particularly affected in the arid regions of Australia, whereas broad-scale clearance of woodland vegetation has had a major and ongoing affect on birds.

**Source:** Environmental Information Resources Network.

Action Plan in 1992, research and surveys have shown that seven taxa are less threatened than was thought but a further 56 taxa should have been listed. Other differences between the 1992 Action Plan and Garnett and Crowley (2000) are accounted for by changes to taxonomy (19 taxa), to more rigorous IUCN criteria, which better define the different categories (138 taxa) or both (11 taxa).

Using current knowledge, taxonomy and IUCN criteria, there has been a change in the status of 25 bird taxa (2.0%) over the eight years since the 1992 Bird Action Plan. For seven taxa, the conservation status can be downgraded as a result of effective conservation management: two from critically endangered to endangered, four from endangered to vulnerable and one from vulnerable to near threatened. However, the status of 18 taxa should be upgraded. Although no taxon has become extinct in the last decade, there has been a net increase of eight critically

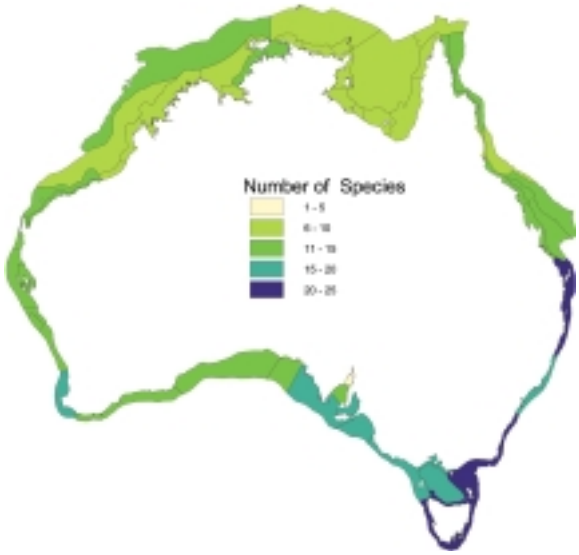


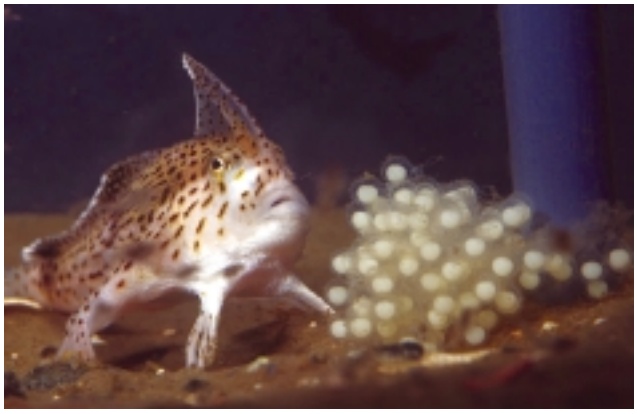

**Figure 45: Number of nationally rare and threatened species in 2000 per IMCRA region.**

**Source:** Environmental Information Resources Network.

endangered taxa, with six fewer vulnerable and one more near threatened species.

*Invertebrates*

There are 281 species of Australian invertebrates listed on the 1996 IUCN Red List of Threatened Animals (IUCN 1996), representing fewer than 0.5% of known taxa. However, only four species are listed nationally in the EPBC Act. The first attempt to appraise an invertebrate group in Australia comprehensively is underway for butterflies. At a broader level, the draft Action Plan for Invertebrates aims to objectively assess the conservation status of invertebrates in Australia by using 25 species to illustrate the range of needs for this diverse group.



**The Spotted Handfish (*Brachionichthys hirsutus*), endemic to the lower Derwent River estuary in Tasmania, 'walks' on its fins instead of swimming.**

**Source:** M Green, CSIRO Marine Research.

## The conservation status of marine species

[BD Indicator 10.7]

Knowledge of the conservation status of most of Australia's marine species is very limited. Australia's first endangered marine fish, the Spotted Handfish (*Brachionichthys hirsutus*), is endemic to the lower Derwent River estuary in Tasmania. The decline in Spotted Handfish numbers has been linked to decline in suitable spawning substrate due to overall deterioration in the health of the Derwent system and the effect of the introduced Northern Pacific Seastar (*Asterias amurensis*).

Scientific interest has largely centred on the higher vertebrates such as turtles, seabirds, seals, Dugongs and whales. Microorganisms, algae, invertebrates and fish have been generally neglected. Australia is very rich in macroalgae or seaweeds. Southern Australia has over 1150 species (Zann 1995). This is greater than 50% more than any comparable region in the world (see also *Coasts and Oceans* Report).

*Fish species*

Australia has an estimated 4000 to 4500 species of fish, of which around 3600 have been described (Zann 1995). About one-quarter of the species are endemic, most of which are found in the south. Although regulations governing many of the fished species have long existed in Australia, marine fish conservation is a relatively new field and the conservation status of most species is poorly known. Potentially vulnerable fish include sharks, which are slow growing, have a low reproduction rate, are highly migratory and form schools during the mating season. Threats are commercial and sports fisheries, and shark meshing of surfing beaches. Fish species with restricted distributions are also vulnerable, particularly from loss of habitat. Broad-scale studies of the distribution of coral reef fishes, conducted by the Australian Institute of Marine Science (AIMS), show that overfishing can rapidly deplete the stocks of coral reef fishes. Surveys of the density of Coral Trout on Bramble Reef during and after the reef was closed to fishing found that the population of legal size Coral Trout fell by 57% in just two months when the reef was reopened for fishing (Wachenfeld et al. 1998).

*Sea snakes*

Australia has about 30 of the total number of 50 species, about half of which are endemic (Zann 1995). The family of aipysurids live in coral reef waters and the family of hydrophiids live in the interreef waters of Australia's tropics. Sea snakes bear live young and have a relatively short lifespan; they reach sexual maturity in around three years, and live for some 10 years. The greatest human impact is from prawn trawling. Between 10 and 40% of sea snakes taken in trawls die once released (Barratt et al. 2001). For the past 20 years, trawled sea snakes have been used in a small leather industry. Licences limit the take of sea snakes for leather to 20 000 per year (Barratt et al. 2001).

*Turtles*

Unlike seasnakes, turtles are a long-lived group of reptiles that are slow to reach maturity. They may breed only around five times in their lives, making them extremely vulnerable to overexploitation and habitat destruction or modification (Zann 1995). Breeding migrations may cover hundreds to thousands of kilometres and many turtles breeding in Australia may live around the islands of Papua New Guinea, the south-west Pacific Islands and Indonesia

(Figure 46), making habitat management and enforcement difficult. The main human effects that occur while turtles are in Australian waters are: mortality of subadults and adults in prawn trawls, shark nets, drumlines and gill nets, and in collisions with high speed vessels; hunting by Indigenous communities; habitat degradation; and predation on eggs by feral animals. The effects of disease and parasites are unknown.

Monitoring of turtles is essential to ensure that management practices are suitable to minimise or eliminate habitat degradation (Figures 47 and 48). In the Great Barrier Reef World Heritage Area most scientific studies of turtle populations have concentrated on Green and Loggerhead Turtles (*Chelonia mydes and Caretta caretta* respectively) (Wachenfeld et al. 1998). The Loggerhead is of specific concern as the number of nesting females has steadily declined since surveys began in the late 1970s. The east Australian population of Loggerhead Turtles used to represent the bulk of the South Pacific stock. If this population disappears, it will represent a highly significant loss (Wachenfeld et al. 1998). Because female turtles nest in the area where they were hatched, it is highly unlikely that a stock that has died out would be colonised naturally by Loggerhead Turtles elsewhere in the world.

**Figure 46: Distribution of nesting turtles, for all six species occurring within Australian waters.**

Large dots denotes thousands of nesting females per year, medium denotes 10 to 100 females per year and the smallest dots are <10 per year. There is a gap in knowledge for Arnhem Land and data for Western Australia has been pooled at the regional level.

**Source:** QPWS, Marine Turtle Database.

*Seabirds*

About 142 species of seabirds belonging to 12 families are found in Australia and its external territories (Zann 1995). Of these, 76 species breed and spend their entire lives in the region, and 34 species are regular or occasional visitors. Problems for sea birds include illegal poaching of adults, chicks and eggs; mortality from bushfires and feral animals; incidental capture of albatrosses and other seabirds by longline fishing; clearing of habitats; decline in prey due to overfishing; and disturbances of nesting colonies by humans and low-flying aircraft (e.g. Wachenfeld et al. 1998; Barratt et al. 2001). Possibly half of Australia's nesting islands are subject to one or more of these direct human threats.

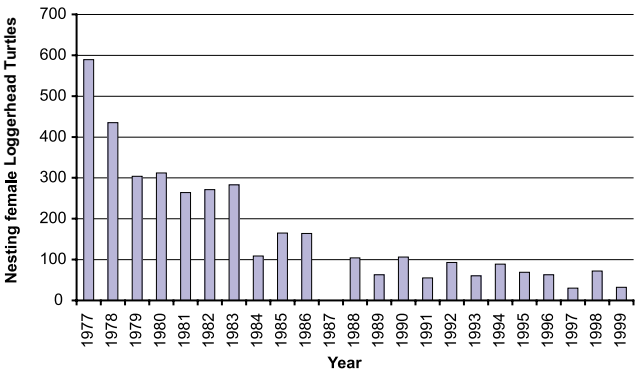



**Figure 47: Decline in the number of nesting female Loggerhead Turtles (*Caretta caretta*) at Wreck Island.**

Since 1977, a census has been conducted each year during the peak breeding season in the last two weeks of December.

**Source:** QPWS, Marine Turtle Database.

*Dugongs*

The tropical Dugong (*Dugong dugon*) is the only fully herbivorous marine mammal and the only Sirenian (sea cow) to occur in Australia (Zann 1995). It is extinct or near extinct in most of its former range which extended from East Africa to South-East Asia and the Western Pacific. Northern Australia has the last significant populations (estimated to be over 80 000) in the world. Large, long-lived mammals, Dugongs become sexually mature at around nine to17 years and calve every three to seven years, making them vulnerable to excessive mortality. Management concerns include the potential for overhunting of some Torres Strait populations, death of individuals that are accidentally caught in fish gillnets and shark nets, and loss of seagrass habitat (Zann 1995; Wachenfeld et al. 1998).

Surveys of Dugongs have been undertaken across Queensland since the early 1980s. Surveys south of Cooktown have documented a distinct decline in population with the 1994 estimate being only 48% of that for 1986 to 1987. A major mortality of animals occurred in

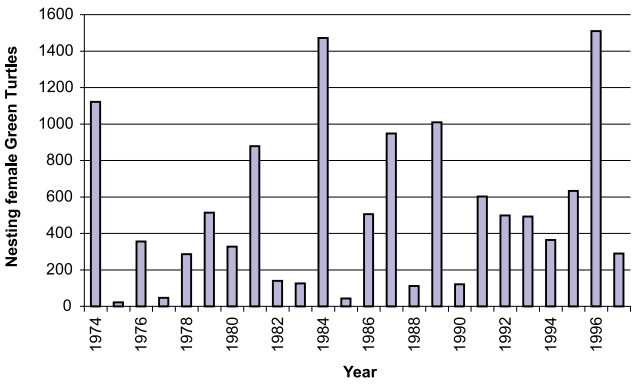



**Figure 48: Number of nesting female Green Turtles (*Chelonia mydes*) tagged on Heron Island between 1974 and 1996 for the entire breeding season.**

The extreme variability in population numbers is caused by regional climatic cycles.

**Source:** QPWS, Marine Turtle Database.

Hervey Bay (Qld) in 1992 following the die-off of seagrasses. The Dugong is listed by the IUCN as 'vulnerable to extinction' and is a listed marine species under the EPBC Act. A population of around 10 000 animals at Shark Bay in Western Australia is considered of major significance for the species.

*Seals*

Australia's seals were overhunted in the 1800s. They are now fully protected and some populations appear to be increasing, although marked long-term declines have been reported for other populations such as the Southern Elephant Seal (*Mirounga leonina*) on Macquarie Island which have been monitored for the last 50 years. In this instance, the cause of the decrease is unknown, although it is likely to be related to increased competition for food supplies.

An Action Plan has also been developed to encourage the long-term viability of seals. Major human threats include entanglement in fishing nets and ocean litter, oil pollution and disturbances by visitors. Fur seals are still occasionally illegally killed for lobster bait, and around fish farms for 'stealing' fish. Development of predator-resistant cages has reduced the latter problem. Entanglement in nets and plastic box straps remains a major threat. About 2% of seals at haul out or resting sites in Tasmania are entangled in net fragments and other plastic litter at any time (Barratt et al. 2001). A significant number of more badly tangled seals drown before reaching haul out sites. In 1990, an oil spill in Western Australia affected a number of New Zealand Fur Seal pups (Zann 1995).

*Whales and dolphins*

Gillnets, shark nets set off bathing beaches, discarded fishing nets, bioaccumulation of toxins and ingestion of plastic litter are considered threats to cetaceans (whales and dolphins) within Australia (Zann 1995). During the 1980s, almost 14 000 dolphins were drowned in Taiwanese shark gillnets off northern Australia but this fishery is now closed. The use of long driftnets (sometimes referred to as the 'walls of death'), which caused substantial mortalities of cetaceans, is now banned under the Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific and the United Nations global moratorium on their use. However, many cetaceans are still caught in protective shark nets off bathing beaches. For example, around 520 dolphins were caught in shark nets off the coast of Queensland between 1967 and 1988 (Zann 1995).

During the period of industrial whaling (1948–1962), the estimated numbers of Humpback Whales (*Megaptera novaeangliae*) fell dramatically. Whaling has been replaced by the new industry of whale watching, which can bring significant incomes to local economies. For example, in Victoria, Warrnambool's land-based whale-watching industry is estimated to contribute $17 million annually to the region. Because of concerns that boats, aircraft and divers may affect whale behaviour, regulations govern the distances that observers may approach whales. Increases in the estimated number of whale species such as the Humpback Whale in eastern Australian waters suggest that habitat conditions are sound (Figure 49 and 52). Numbers have shown a steady increase since regular monitoring began in 1981.

## Recovery plans: Securing species and communities in the wild [BD Indicators 15.1 and 15.2]

Recovery plans set out the actions thought necessary to support the recovery of threatened species or ecological communities to maximise their chances of long-term survival in the wild.

There were 1451 species and 27 ecological communities listed under the EPBC Act in February 2001, as either endangered or vulnerable at the national level. The categories 'critically endangered', 'conservation dependant' and 'extinct in the wild' have been added to the previous categories of endangered, vulnerable and extinct for threatened species and 'critically endangered' and 'vulnerable' have been added to the previous category of endangered for ecological communities. When approved by government Ministers, recovery plans become statutory

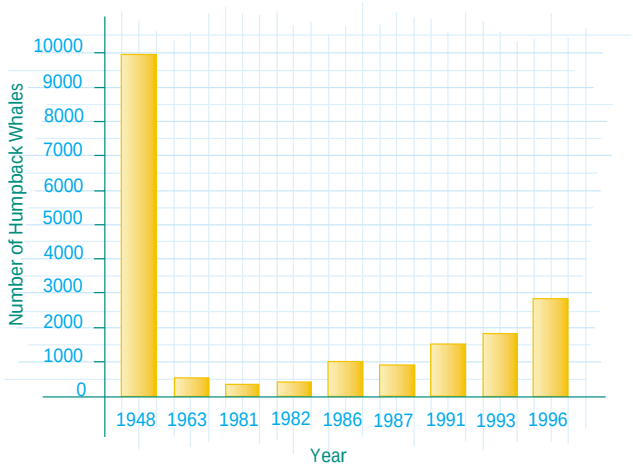



**Figure 49: Number of Humpback Whales (*Megaptera novaeangliae*) off Australia's east coast between 1948 and 1996.**

**Source:** Bryden et al. (1996).

**Table 51: The number of recovery plans for species and ecological communities threatened with extinction**
Species and communities are those listed under the EPBC Act as either endangered or vulnerable compared with the number of species and communities so classified, as at May 2000.

| Species group | No. of adopted recovery plans for listed threatened species | No. of species/ ecological communities covered by the recovery plans | No. of species/ ecological communities in each group classified as threatened | Threatened species in each group covered by a Recovery Plan (%) |
|---|---|---|---|---|
| Fish | 2 | 5 | 30 | 16.7 |
| Amphibians | 1 | 2 | 27 | 7.4 |
| Invertebrates | — | — | — | — |
| Reptiles | 2 | 2 | 49 | 4.0 |
| Birds | 12 | 12 | 94 | 12.8 |
| Mammals | 5 | 5 | 74 | 6.7 |
| Non-vascular plants | — | — | 2 | 0 |
| Vascular plants | 15 | 18 | 1165 | 1.5 |
| **Total species** | **37** | **44** | **1441** | **3** |
| **Ecological communities** | **—** | **23** | **23** | **100** |

**Source:** Regional Wildlife Programs, Wildlife Branch, Environment Australia.

documents. Furthermore, the EPBC Act prohibits Commonwealth agencies from undertaking activities that are inconsistent with a recovery plan.

As of May 2000, there were 37 adopted recovery plans in place under the EPBC Act (Table 51) covering 44 species, 18 of which are plants. This means that around 3% of nationally listed species and communities have recovery plans. In early 2001, another 100 recovery plans, covering in excess of 130 species were being considered for adoption by the Threatened Species Scientific Committee. State and territory governments also prepare recovery plans under their legislation, but documenting these plans was beyond the scope of this report.

There are many more plans in preparation, many without any funding support from the ESP. The amount of funding provided for the implementation of recovery plans, compared with the amount specified in the plans for full implementation, is provided in Table 52 for the Commonwealth level. This information relates to recovery plans funded through the ESP for species listed in the (now repealed) *Endangered Species Act 1992*. The total cost of implementation of the adopted plans from all sponsors comes to $25 015 105, of which the ESP provided $8 832 275, about 35% of the total cost. In order to be recognised under the EPBC Act, recovery plans have to be resubmitted.

## Looking after species away from their homes [BD Indicators 16.1 and 16.2]

As part of the recovery process for threatened species, zoos and herbaria have been refining the processes through which they manage captive populations. Although managing species in the wild is preferred, sometimes it is necessary to manage them *ex situ* (away from their homes). Usually this is required to increase the number of individuals by breeding them in captivity and releasing them into the wild when conditions are suitable. Considerable human and financial resources have been expended on *ex situ* conservation for threatened species (e.g. see the *Mala recovery programs and Mala dreaming* box on page 136).

Table 53 lists threatened species under the EPBC Act that are subject to *ex situ* programs of the major botanical gardens and zoos, and wildlife parks in Australia. Many of these programs involve research aimed at maintaining, breeding and propagating populations in the zoos and botanic gardens for release back into the wild. *Ex situ* research is defined as research using captive animals that aims to assist with sustaining and establishing the captive population. *Ex situ* programs were recorded for 86 species.

Craig et al. (1998) provided some material on the release of captive-bred animals from zoo programs. Of the 19 programs that explicitly recognised the process by which zoos cooperate with wildlife agencies as part of an overall recovery plan, captive breeding for release into the wild is an explicit goal of 16 recovery programs. The recovery program for the Mala, an endangered species with particular importance for Indigenous people in central Australia (see the *Mala recovery programs and Mala Dreaming* box above), illustrates the complex nature

**Table 52: The amount of funding provided for the implementation of recovery plans under the (repealed) *Endangered Species Act 1992* (Cwlth) compared with the amount specified in the plans for full implementation**

There are donor sources that supply funding for the implementation of recovery plans (Commonwealth, state & local governments, NGOs, local community, and others). Endangered Species Program (ESP) $ does not include funding provided under the Threatened Species Network Community Grants Program. Figures are extracted from Program Administrator database and are subject to the accuracy of the information included in the database.

| Adopted recovery plans (37 plans covering 44 species) | Period of plan | Total cost of implementation of adopted plan (all sponsors) ($) | ESP $ provided for species | Period of ESP funding |
|---|---|---|---|---|
| **Animals** | | | | |
| Abbott's Booby | 1998–2002 | 140 000 | 57 000 | 1993–94 to 1995–96 |
| Black-eared Miner | 1997–2001 | 2 089 200 | 219 000 | 1991–92 to 1999–00 |
| Central Rock-rat | 2000–2001 | 608 900 | 181 646 | 1989–90 to 1999–00 |
| Christmas Island Shrew | 1997–2002 | 129 000 | 22 700 | 1996–97 to 1998–99 |
| Chuditch | 1992–2001 | 1 452 400 | 682 800 | 1991–92 to 1998–99 |
| Forty-spotted Pardalote | 1991–1996 | 322 500 | 271 650 | 1991–92 to 1995–96 |
| Glossy Black Cockatoo (SA spp.) | 1999–2003 | 1 192 300 | 648 800 | 1992–93 to 1999–00 |
| Golden-shouldered Parrot | 1999–2002 | 256 000 | 200 800 | 1993–94 to 1997–98 |
| Gouldian Finch | 1998–2002 | 1 065 600 | 770 000 | 1992–93 to 1999–00 |
| Helmeted Honeyeater | 1999–2003 | 1 675 600 | 495 000 | 1992–93 to 1999–00 |
| Leadbeaters Possum | 1997–2001 | 1 211 000 | 329 500 | 1993–94 to 1999–00 |
| Noisy Scrub Bird | 1993–2002 | 2 540 400 | 405 940 | 1992–93 to 1999–00 |
| Northern Hairy-nosed Wombat | 1998–2002 | 1 789 600 | 819 422 | 1991–92 to 1999–00 |
| Orange-bellied Parrot | 1991–1996 | 496 300 | 752 630 | 1989–90 to 1999–00 |
| Regent Honeyeater | 1999–2003 | 2 116 000 | 635 900 | 1993–94 to 1999–00 |
| Spotted Handfish | 1999–2001 | 1 086 300 | 358 291 | 1995–96 to 1999–00 |
| Striped Legless Lizard | 1999–2003 | 1 119 800 | — | — |
| Swift Parrot | 1997–1999 | 620 700 | 486 636 | 1991–92 to 1998–99 |
| Tasmanian Galaxiid Species (4 species) | 1997–2002 | 711 300 | 422 610 | 1989–90 to 1999–00 |
| Wedge-tailed Eagle (Tas. spp.) | 1998–2003 | 465 900 | 238 726 | 1991–92 to 1999–00 |
| Western Swamp Tortoise | 1998–2002 | 968 600 | 450 470 | 1989–90 to 1999–00 |
| White and Orange Bellied Frog | 1992–2001 | 343 100 | 224 700 | 1991–92 to 1995–96 |
| **Plants** | | | | |
| *Acacia pharangites* | 1999–2002 | 65 500 | — | — |
| *Alectryon ramiflorus* | 1998–2001 | 265 000 | 48 614 | 1994–95 to 1998–99 |
| *Banksia cuneata* | 1992–2001 | 253 000 | 170 200 | 1992–93 to 1998–99 |
| *Barbarea australis* | 1998–2002 | 202 449 | 15 548 | 1992–93 to 1998–99 |
| *Cyphanthera odgersii* ssp. *occidentalis* | 1999–2002 | 109 550 | — | — |
| *Eucalyptus rhodantha* | 1992–2001 | 356 800 | 175 900 | 1991–92 to 1998–99 |
| *Persoonia nutans* | 1997–2002 | 21 995 | 21 400 | 1992–93 to 1995–96 |
| *Pimelia spicata* | 1993–1997 | 141 560 | 108 130 | 1992–93 to 1996–97 |
| *Ranunculus prasinus* | 1992–2000 | 8 766 | 7 595 | 1991–92 to 1995–96 |
| *Rutidosis leptorrhynchoides* | 1993–2000 | 437 700 | 33 000 | 1992–93 to 1993–94 |
| *Spyridium obcordatum* | 1991–1993 | 20 885 | — | — |
| *Stylidium coroniforme* | 1992–2001 | 125 000 | 63 500 | 1991–92 to 1996–97 |
| Tasmanian Lowland *Euphrasia* species (4 species) | 1997–2001 | 172 800 | 140 967 | 1993–94 to 1998–99 |
| *Wollemia nobilis* | 1997–2001 | 398 600 | — | — |
| *Zieria prostrata* | 1998–2001 | 35 000 | 22 000 | 1991–92 to 1996–97 |

**Source:** Regional Wildlife Programs, Wildlife Branch, Environment Australia. Data currency: May 2000.

## Mala recovery programs and Mala Dreaming

The Mala or Rufous Hare-Wallaby (*Lagorchestes hirsutus*) once occupied about 25% of the continent and was common across the spinifex deserts of the Northern Territory and north-west South Australia, to the temperate woodlands and grasslands of Western Australia's wheat belt. The species was an important food source to Indigenous peoples throughout its geographical range, and the Mala remains of great cultural significance to the people of the central deserts. Since European settlement, the population of Mala has declined to the brink of extinction, suffering a similar fate as many small to medium-sized mammals in arid Australia. It is now listed as a nationally endangered species.

By 1980, there were only two known populations of the species on the continent, comprising a total of about 50 individuals. These populations were situated close together in the Tanami Desert in country owned by the Warlpiri. In 1980, a captive breeding program for the species was commenced in Alice Springs. By 1986, as a consequence of successful breeding, scientists from the Northern Territory's PWC were able to translocate progeny of this population into an electric-fenced enclosure on the floodplain of the Lander River, near the Indigenous community at Willowra in the Tanami Desert.

Despite numerous efforts to reintroduce Mala from the enclosure into adjacent spinifex grassland, a wild population could not be established mainly because of predation by the cat and fox. The captive breeding program at the Alice Springs Desert Wildlife Park continues under the direction of the PWC. Translocations of some animals bred in central Australia have been made to habitats previously occupied by the species in Western Australia, including an enclosure in Dryandra forest south-east of Perth, and to breeding compounds in François Peron National Park. Another group of Mala have been successfully established in the wild on Trimouille Island off the Pilbara coast. Recently Mala from the Tanami Desert captive colony were translocated to a large new enclosure in Watarrka National Park to the south-west of Alice Springs.

The Mala occupies an important role in the cultural lives of the Warlpiri and other Indigenous peoples who are traditional owners of the land the species once occupied. The Mala features prominently in the creation stories and ceremonies of many of these peoples, and the Warlpiri felt a considerable responsibility for the disappearance of the species as they relate its decline to a decline in traditional Mala ceremonies.

Mala (Wallaby) Dreaming was the first painting by Kumantjayi Tjupurrula, who is now recognised as one of Australia's greatest contemporary artists. The dreaming or story of the painting was recorded by Geoffrey Bardon AO, when it was created at Papunya (NT) in early 1971. He noted (G Bardon 1999, *Summary of story associated with painting*):

> The central pattern of the work shows ceremonial men sitting at a series of fireplaces. On both sides are wallaby tracks from the Wallaby Spirit Men as they travel too and from a sit-down place, which are indicated by the concentric circles. The repetition and looping between concentric circles in the central motif, represents a dancing and singing ceremony. This ceremony is held in turn at a sit-down place that is part of the Wallaby Dreaming.

of these activities. Predation by feral cats and foxes pose a major threat to species when they are released into the wild and major programs such as the Western Shield (see *Managing introduced species* on page 114) aim to reduce their numbers before native species are released into the wild.

### Species of economic importance [BD Indicator 10.8]

The values of biodiversity discussed at the beginning of this report included economic values. The economic value of some native species or suites of species is well enough known, as there are recognised economic activities and products traded in markets. These include major industries such as fisheries and forestry, which are based largely on wild populations. The wildflower, bushfood and cut foliage industries involve numerous native species (Table 54). Perhaps less obvious is the use of spiders and snakes for their venom and the harvesting of sea cucumbers—an animal that is considered a delicacy in Asian countries. Seahorses are also harvested from the wild, being primarily used as Chinese medicines, aphrodisiacs and food, although the market for curios and aquarium fish is growing steadily. Tropical species of seahorse are endangered as a result of wild

**Members of the Warlpiri community have been closely involved in the recovery program for the endangered Mala (*Lagorchestes hirsutus*), which occupies an important role in the cultural lives of these traditional owners of land the species once occupied.**

**Source:** D Langford, Parks and Wildlife Commission of the Northern Territory.

**Table 53: Threatened species (listed under the *Environment Protection and Biodiversity Conservation Act 1999*) for which there are *ex situ* programs in Australian zoos and botanical gardens to breed populations in captivity**

| Common name | Species name | Institution[A] | No. in captivity | Release[B] | *Ex situ* research | National Threat Status[C] |
|---|---|---|---|---|---|---|
| | | **Fauna** | | | | |
| Black-eared Miner | *Manorina melanotis* | AZ<br>ZPGB-V | UN[D]<br>UN | UN<br>0 | Yes<br>Yes | EN |
| Black-flanked Rock-wallaby | *Petrogale lateralis lateralis* | ZPGB-V | UN | 0 | Yes | VU |
| Bridled Nailtail Wallaby | *Onychogalea fraenata* | QPWS<br>ES | UN<br>UN | Yes<br>UN | Yes<br>No | EN |
| Broad-headed Snake | *Hoplocephalus bungaroides* | ARP | c. 8 | 0 | No | VU |
| Brush-tailed Rock-wallaby | *Petrogale penicillata* | AZ<br>ZPGB-V | UN<br>UN | Yes<br>0 | No<br>Yes | VU |
| Burrowing Bettong | *Bettongia lesueur* | ES | UN | UN | No | VU |
| Carpentarian Rock Rat | *Zyzomys palatalis* | TWP | UN | 0 | No | EN |
| Chuditch | *Dasyurus geoffroii* | PZ | UN | 302[E] | Yes | VU |
| Dibbler | *Parantechinus apicalis* | PZ | UN | 86[F] | Yes | EN |
| Eastern Barred Bandicoot | *Perameles gunnii* | ZPGB-V | UN | 400 | Yes | EN |
| False Water Rat | *Xeromys myoides* | TWP | UN | 0 | No | VU |
| Fleay's Barred Frog | *Mixophyes fleayi* | QPWS | UN | 0 | Yes | EN |
| Giant Burrowing Frog | *Heleioporus australiacus* | ARP | 2 | 0 | No | VU |
| Golden-backed Tree Rat | *Mesembriomys macruus* | TWP | UN | 0 | No | VU |
| Golden Bandicoot | *Isoodon auratus arnhemensis* | TWP | UN | 0 | No | VU |
| Greater Bilby | *Macrotis lagotis* | ES<br>MZP<br>QPWS<br>TWP | UN<br>UN<br>UN<br>UN | UN<br>Yes<br>0<br>Yes | No<br>No<br>No<br>No | VU |
| Greater Stick-nest Rat | *Leporillus conditor* | PZ<br>ES<br>MZP | UN<br>UN<br>UN | 0<br>UN<br>0[G] | Yes<br>No<br>No | VU |
| Green and Golden Bell Frog | *Litorea aurea* | ARP | c. 20 | 0 | Yes | VU |
| Helmeted Honeyeater | *Lichenostomus melanops cassidix* | ZPGB-V | UN | 34 | Yes | EN |
| Julia Creek Dunnart | *Sminthopsis douglasi* | QPWS | UN | 0 | Yes | EN |
| Lancelin Island Skinks | *Ctenotus lancelini* | PZ | UN | 0 | Yes | VU |
| Leadbeaters Possum | *Gymnobelideus leadbeateri* | ZPGB-V | UN | 0 | Yes | EN |
| Long-footed Potoroo | *Potorous longipes* | ZPGB-V | UN | 0 | Yes | EN |
| Long-nosed Potoroo | *Potorous tridactylus tridactylus* | ES | UN | UN | No | VU |
| Mala | *Lagorchestes hirsutus* | MZP | UN | 0 | No | EN |
| Mallee Fowl | *Leipoa ocellata* | AZ, MZP | UN | 0 | No | VU |
| Mountain Pygmy Possum | *Burramys parvus* | ZPGB-V | UN | 0 | Yes | EN |
| Mulgara | *Dasycercus cristicauda* | TWP | UN | 0 | No | VU |
| Northern Bettong | *Bettongia tropica* | QPWS | UN | 0 | Yes | EN |
| Numbat | *Myrmecobius fasciatus* | ES<br>PZ | UN<br>UN | UN<br>42[H] | No<br>Yes | VU |
| Orange Bellied Parrot | *Neophema chrysogaster* | AZ<br>ZPGB-V | 2 breeding pairs<br>UN | 0<br>28 | No<br>Yes | EN |
| Partridge Pigeon (eastern) | *Genophaps smithii smithii* | TWP | UN | 0 | No | VU |
| Plains Rat | *Pseudomys australis* | ES | UN | UN | No | VU |

**Table 53: Threatened species (listed under the *Environment Protection and Biodiversity Conservation Act 1999*) for which there are *ex situ* programs in Australian zoos and botanical gardens to breed populations in captivity *(continued)***

| Common name | Species name | Institution[A] | No. in captivity | Release[B] | *Ex situ* research | National Threat Status[C] |
|---|---|---|---|---|---|---|
| Proserpine Rock-wallaby | *Petrogale persephone* | QPWS | UN | Yes | Yes | EN |
| Regent Honeyeater | *Xanthomyza phrygia* | AZ, GWP | UN | 0 | | EN |
| Southern Brown Bandicoot | *Isoodon obesulus* | ES | UN | UN | No | VU |
| Striped Legless Lizard | *Delma impar* | ZPGB-V | UN | UN | Yes | VU |
| Stuttering Frog | *Mixophyes balbus* | ARP | 2 | 0 | Yes | VU |
| Tammar Wallaby | *Macropus eugenii eugenii* | AZ<br>ES | UN<br>UN | 0<br>UN | No<br>No | EX (SA) |
| Western Swamp Tortoise | *Pseudemydura umbrina* | PZ | >150 | 247[E] | Yes | EN |
| Yellow-footed Rock-wallaby | *Petrogale xanthopus* | ES<br>AZ, MZP | UN<br>48 | UN<br>Yes | No<br>Yes | VU |
| **Total fauna: 41 species out of a total of 332 threatened species (EX, VU or EN) = 12.4 %** | | | | | | |
| | | **Flora** | | | | |
| — | *Allocasuarina portuensis* | RBGS | UN | Yes | Yes | EN |
| — | *Eucalyptus copulans* | RBGS | UN | 0 | Yes | EN |
| Adamson's Blown-grass | *Agrostis adamsonii* | RMBG | UN | c. 100 | Yes | EN |
| Anglesea Grevillea | *Grevillea infecunda* | RMBG | UN | 0 | No | VU |
| Basalt Diuris Orchid | *Diuris basaltica* | RMBG | UN | 0 | Yes | EN |
| Border heath | *Epacris limbata* | TDPIWE | 10 | 0 | No | VU |
| Concave Pomaderris | *Pomaderris subplicata* | RMBG | UN | c. 80 | Yes | VU |
| Cotoneaster Pomaderris | *Pomaderris cotoneaster* | RMBG | UN | 0 | No | EN |
| Davies' Wax-flower | *Phebalium daviesii* | TDPIWE | UN | Yes | No | EN |
| Drapetes | *Kelleria laxa* | RMBG | UN | 0 | No | VU |
| Dwarf Kerrawang | *Rulingia prostrata* | RMBG | UN | 0 | Yes | EN |
| Echidna Wattle | *Acacia cretacea* | PBC | UN | UN | Yes | EN |
| Elegant Spider-orchid | *Caladenia formosa* | RMBG | UN | 0 | No | VU |
| Glandular Phebalium | *Phebalium glandulosum* | PBC | UN | UN | Yes | VU |
| Glenelg Pomaderris | *Pomaderris halmaturina* | PBC | UN | UN | Yes | VU |
| Gorae Leek Orchid | *Prasophyllum diversiflorum* | RMBG | UN | 0 | No | EN |
| Grampians Pincushion-lily | *Borya mirabilis* | RMBG | UN | 0 | | EN |
| Kings Lomatia | *Lomatia tasmanica* | TDPIWE | 2 | 0 | Yes | EN |
| Lowan Phebalium | *Phebalium lowanense* | RMBG | UN | 0 | Yes | VU |
| Marble Daisy-bush | *Olearia astroloba* | RMBG | UN | 0 | No | VU |
| Menzels Wattle | *Acacia pinguifolia* | PBC | UN | UN | Yes | EN |
| Monarto Mintbush | *Prostanthera eurybioides* | PBC | UN | UN | Yes | EN |
| Moresby Range Drummondita | *Dodonaea subglandulifera* | PBC | UN | UN | Yes | EN |
| Mountain Correa | *Correa lawrenciana var. genoensis* | RMBG | UN | 10 | Yes | EN |
| Mt William Grevillea | *Grevillea williamsonii* | RMBG | UN | 0 | Yes | EN |
| Mueller Daisy | *Brachyscome muelleri* | PBC | UN | UN | Yes | EN |
| Prickly Raspwort | *Haloragis eyreana* | PBC | UN | UN | Yes | EN |
| Rigid Spider-orchid | *Caladenia tensa* | RMBG | UN | 0 | No | EN |
| Rosella Spider-orchid | *Caladenia rosella* | RMBG | UN | 0 | Yes | EN |

**Table 53: Threatened species (listed under the *Environment Protection and Biodiversity Conservation Act 1999*) for which there are *ex situ* programs in Australian zoos and botanical gardens to breed populations in captivity *(continued)***

| Common name | Species name | Institution[A] | No. in captivity | Release[B] | *Ex situ* research | National Threat Status[C] |
|---|---|---|---|---|---|---|
| Saltbush | *Ballantinia antipoda* | RMBG | UN | 0 | No | EN |
| Sandhill Greenhood | *Pterostylis arenicola* | PBC | UN | UN | Yes | VU |
| Small Scurf-pea | *Cullen parvum* | RMBG | UN | 0 | No | EN |
| Small-flowered Daisy-bush | *Olearia microdisca* | PBC | UN | UN | Yes | EN |
| Somersby Mintbush | *Prostanthera junonis* | RBGS | UN | 0 | Yes | EN |
| Spreading Phebalium | *Phebalium brachyphyllum* | PBC | UN | UN | Yes | EN |
| Stiff Groundsel | *Senecio behrianus* | RMBG | UN | 0 | No | EN |
| Stuart's Heath | *Epacris stuartii* | TDPIWE | 400 | Yes | No | EN |
| Sunshine Diuris Orchid | *Diuris fragrantissima* | RMBG | UN | Yes | Yes | EN |
| Superb Greenhood | *Pterostylis cucullata* | RMBG | UN | 0 | No | VU |
| Tall Astelia | *Astelia australiana* | RMBG | UN | 0 | No | VU |
| Trailing Willow-herb | *Epacris barbata* | TDPIWE | 10 | 0 | No | EN |
| Tufted Bush-pea | *Pultenaea trichophylla* | PBC | UN | UN | Yes | VU |
| Whibley Wattle | *Acacia whibleyana* | PBC | UN | UN | Yes | EN |
| Whipstick Westringia | *Westringia crassifolia* | RMBG | UN | 0 | Yes | EN |
| Wollemi Pine | *Wollemia nobilis* | RBGS | UN | 0 | Yes | EN |
| **Total Flora: 45 species out of a total of 1236 threatened species (EX, VU or EN) = 3.6 %** | | | | | | |

[A]AZ, Adelaide Zoo; ZPGB-V, Zoological Parks and Gardens Board, Victoria (includes Melbourne Zoo, Healesville Sanctuary and Victoria's Open Range Zoo, Werribee); QPWS, Queensland Parks and Wildlife Service; ES, Earth Sanctuaries; ARP, Australian Reptile Park; TWP, Territory Wildlife Park; PZ, Perth Zoo; 1990–2000; 1997–2000; No longer released since overall recovery objectives achieved; WPZ-D, Western Plains Zoo (Dubbo); 1993–2000; GWP, Gorge Wildlife Park; UN, unknown;RBGS, Royal Botanic Gardens Sydney (includes Mount Annan Botanic Gardens); RMBG, Royal Melbourne Botanic Gardens; TDPIWE, Tasmania Department of Primary Industries, Wildlife and Environment; PBC, Plant Biodiversity Centre, South Australian Department of Environment and Heritage; [B]Release back to wild or to predator controlled sites, 1990–2000 (unless otherwise stated) and number released where provided by institution; [C]National Threat Status (see *Table 50*); [D]UN, unknown; [E]1990–2000; [F]1997–2000; [G]No longer released since overall recovery objectives achieved;[H]1993–2000.

harvesting. A company in Tasmania is planning to supply this market by farming temperate species. The species used is proving suitable for aquaculture and the venture is on the point of commercial production.

Any attempt to assess the economic significance of biodiversity is complicated by two factors. First, many values of biodiversity are not traded in markets. Thus, new and often contested valuation methods must be used to estimate the financial value of biodiversity. This difficulty is encapsulated by the example of a valuation of use of an Australian national park, where one critic claimed the original estimate was four times too large and another claimed it was six times too small (Beal 1998). Second, many biodiversity-based industries are recent and small and thus often do not have well-developed information systems. Third, biodiversity is the classic 'cross-sectoral' issue, so that expenditure or economic activity across a wide range of commercial sectors and policy portfolios affects or is affected by biodiversity.

**Painting of Mala (*Lagorchestes hirsutus*) Dreaming by Kumantjayi Tjupurrula (1971).**

**Source:** TW Norton.

*Assigning a dollar value to biodiversity*

Although there is considerable and increasing activity that gains economic benefits from native species, few empirical data are available. Consequently, the following examples are indicative only. To give at least a lower estimate of the dollar value of biodiversity, these examples are also summarised in Table 55.

**Table 54: Permits issued to pick or sell native flora in New South Wales, 1998 to1999**
Also includes some species listed in the permit data.

| Species | No. of stems licensed to pick or sell |
|---|---|
| *Actinotus helianthi* | 14 320 |
| *Adiantum spp.* | 778 |
| *Archontophoenix cunninghamiana* | 1 000 |
| *Asplenium nidus* | 10 925 |
| *Asplenium flactum* | 50 |
| *Blandfordia* spp. | 1 160 |
| *Boronia* spp. | 220 |
| *Bulbophyllum* spp. | 190 |
| *Calanthe triplicata* | 25 |
| *Casuarina cunninghamiana* | <5kg seed |
| *Caustis* spp. | 400[A] |
| *Cyathea* spp. | 10 328 |
| *Cymbidium* spp. | 20 |
| *Davallia pyxidata* | 28 |
| *Dendrobium* spp. | 6 464 |
| *Dicksonia* spp. | 2 968 |
| *Dipodium* spp. | 20 |
| *Doryanthes* spp. | 665 |
| *Eriostemon* spp. | 1 210 |
| *Galeola* spp. | 20 |
| *Geodorum pictum* | 20 |
| *Liparis* spp. | 20 |
| *Livistona australis* | 4 550 |
| *Lomatia silaifolia* | 250 |
| *Oberonia* spp. | 20 |
| *Papillilabium beckleri* | 20 |
| *Parasarcochilus* spp. | 20 |
| *Peristeranthus hillii* | 20 |
| *Persoonia pinifolia* | 80 |
| *Phreatia* spp. | 20 |
| *Platycerium* spp. | 7 675 |
| *Restio tetraphyllus* | 450 |
| *Rhinerrhiza divitiflora* | 70 |
| *Sarcochilus* spp. | 753 |
| *Taeniophyllum* spp. | 20 |
| *Telopea* spp. | 31 150 |
| **Unspecified numbers of:** | |
| *Ceratopetalum gummiferum* | |
| *Crowea* spp. | |
| *Lycopodium deuterodensum* | |
| *Sprengelia incarnata* | |
| *Todea barbara* | |
| *Xylomelum* spp. | |

[A] Bunches.

**Table 55: The dollar value of biodiversity: A selection of species of economic importance that are referred to in the text, excluding fish**
Dollars values ($A) are in millions, except for the value of individual pets.

| Category of use | Species common name | Scientific name | Details | Estimated value in A$ million (national turnover of industry, unless otherwise stated) |
|---|---|---|---|---|
| | | **Animal products** | | |
| Meat/skin/hide/ feathers | | | | |
| | Kangaroo | Including: *Macropus rufus, M. giganteus, M. robustus,* and *M. fuliginosus* | Skins, leather, game meat and pet food | 445 (1998) |
| | Emu | *Dromaius novaehollandiae* | Oil, feathers, skin, meat | 7 (1998) |
| | Freshwater Eel | *Anguilla* spp. | Meat | 5 (2000) |
| | Brushtail Possum | *Trichosurus vulpecula* | Harvested commercially for skins and meat only in Tas. where they are larger and have denser fur | 5 (1998) |
| | Crocodile | *Crocodylus porosus* and *Crocodylus johnstoni* | Meat, leather | 3 (1998) |
| | Yabbies | *Cherax* spp. | | 2.1 (1997) |
| | Bennett's Wallaby | *Macropus rufogriseus* | Primarily sold as pet food in Tasmania | 0.75 (1999) |
| | Muttonbird/Short-tailed Shearwater | *Puffinus tenuirostris* | Oil, feathers, skin, meat | 0.43 (1998) |
| Dried food product | | | | |
| | Jellyfish | *Catoctylus mosaicus* | | Unknown |
| | Sea cucumber, bêche-de-mer | Family Holothuroidea | | Unknown |
| | Seahorse | *Hippocampus* spp. | Food and Chinese medicines | Unknown |
| Venom | | | Venom, purified toxins, antibodies to toxins, and blood snake serums | Unknown |
| | Redback Spider | *Latrodectus hasselti* | | |
| | Snake | *Serpentes* spp. | | |
| | Sydney Funnel Web Spider | *Atrax robustus* | | |
| | White-tailed Spider | *Lampona cylindrata* | | |
| | | **Plant products** | | |
| Essential oils | | | | 20 (1998) |
| | Blue Mallee | *Eucalyptus polybractea* | Eucalyptus oil used as a food flavouring, perfume, inhalent and solvent. | |
| | Boronia | *Boronia megastigma* | Boronia oil used as a fragrance | |
| | Tasmanian Mountain Pepper | *Tasmania lanceolata* | Oil exported to Japan for use in chocolates, toothpaste and chewing gum | |
| | Tea-tree | *Melaleuca alternifolia* | Tea-tree oil used for its antiseptic and antifungal properties | |
| Alkaloid extracts | | | | |
| | Corkwood | *Duboisia* spp. | Used for a number of medical purposes, including as a muscle relaxant and as a depressant | 3.8 (gross value of industry, 1991–92) |
| Tannins | | | | |
| | Black Wattle | *Acacia mearnsii* | Tanning agent in leather manufacture | Unknown |

**Table 55: The dollar value of biodiversity: A selection of species of economic importance that are referred to in the text, excluding fish *(continued)***
Dollars values ($A) are in millions, except for the value of individual pets.

| Category of use | Species common name | Scientific name | Details | Estimated value in A$ million (national turnover of industry, unless otherwise stated) |
|---|---|---|---|---|
| Wildflowers | Kangaroo Paw, Wax Flowers & Grampians Thryptomene | *Anigozanthus* spp *Chamelaucium* spp. and *Thryptomene calycina* | Listed are the three top export species (see Table 6.20 for native species harvested in WA) | 30 (1998) |
| Bushfoods | Bush Tomato | *Solanum centrale* | Fruit | 14 (1998) |
| | Lemon Aspera | *Acronychia acidula* | Fruit | |
| | Lemon Myrtle | *Backhousia citriodora* | Leaf and oil | |
| | Tasmanian Mountain Pepper | *Tasmannia lanceolata* | Leaves and berries | |
| | Muntries | *Kunzea pomifera* | Fruit | |
| | Quandong | *Santalum acuminatum* | Fruit | |
| | Warrigal Greens | *Tetragonia tetragonoides* | Salad vegetable | |
| | Wattle | *Acacia* spp. | Flavouring in desserts, ground wattleseed used in pastries and breads | |
| Agricultural production | Macadamia | *Macadamia integrifolia* and *M. tetraphylla*. | Nuts and oil | 26.6 (gross value of industry, 1991–92) |
| Building material and fibre | Broombush | *Melaleuca uncinata* | Brush fencing | Unknown |
| | Seagrass | *Zostera* spp. | Beach cast material is used as house insulation and garden mulch | Unknown |
| | Sphagnum Moss | *Sphagnum* spp. | Potting mix | Unknown |
| Kelp derived products | Kelp | *Phaeophyta* spp. | Human food, food and cosmetic manufacture (thickeners and emulsifiers), agriculture (fertilisers and growth promoters) and biomedicines. | Unknown |
| **Ornamental** | | | | |
| Pearls | Giant Australian Oyster | *Pinctada maxima* | | 200 (1998) |
| Shells | | | Specimen collections. Only a few mollusc species, of the total of 12 000, are exempt from collection | Unknown |
| **Other** | | | | |
| Tourism | Koala | *Phascolarctos cinereus* | 'Koala industry' includes visiting zoos and wildlife parks, accommodation, photographs | 336 (1998) |
| | Fairy Penguin | *Eudyptula minor* | Penguin Parade at Phillip Island, Vic. | 96.5 (for Victoria, 1998) |
| | Whale | Cetaceans | Whale watching | 17 (Victoria, 2001) |
| | Crocodile | *Crocodylus porosus* | Crocodile cruises on Adelaide River, NT | 2 (1998) |
| Hunting | Duck and Quail | | | 36 (1998) |

**Table 55: The dollar value of biodiversity: A selection of species of economic importance that are referred to in the text, excluding fish *(continued)***
Dollars values ($A) are in millions, except for the value of individual pets.

| Category of use | Species common name | Scientific name | Details | Estimated value in A$ million (national turnover of industry, unless otherwise stated) |
|---|---|---|---|---|
| | | **Whole plants** | | |
| Native nursery plants | | | Some 1 600 native species available in the nursery trade | Unknown |
| | Soft Tree Fern | *Dicksonia antarctica* | Plantation and legally harvested plants sold by nurseries and retail outlets for landscaping | 1 (estimated value of export market, 2000) |
| Fodder crops | | | | |
| | Golden Wreath Wattle | *Acacia saligna* | | Unknown |
| | Old Man Saltbush and River Saltbush | *Atriplex nummularia* and *A. amnicola* | | Unknown |
| | | **Live animals** | | |
| | | | | The following prices are for individual animals sold in Australia (1997) |
| Pet birds | | | | |
| | Red-tail Black Cockatoo | *Calyptorhynchus magnificus* | | 1 750 |
| | Gang-gang Cockatoo | *Callocephalon fimbriatum* | | 500 |
| | Major Mitchell Cockatoo | *Cacatua leadbeateri* | | 350 |
| | Cloncurry Parrot | *Barnardius barnardius macgillivrayi* | | 175 |
| | Sulphur-crested Cockatoo | *Cacatua galerita* | | 60 |
| | Hooded Parrot | *Psephotus dissimilis* | | 50 |
| | Princess Parrot | *Polytelis alexandrae* | | 50 |
| | Eastern Rosella | *Platycercus eximius* | | 30 |
| | Galah | *Cacatua roseicapilla* | | 30 |
| | Turquoise Parrot | *Neophema pulchella* | | 15 |
| | Red-rumped Parrot | *Psephotus haematonotus* | | 12 |
| | Cockatiel | *Nymphicus hollandicus* | | 10 |
| Pet reptiles | | | | |
| | Green Tree Phython | *Chondropython viridis* | | 2 300 |
| | Spiny-tailed Monitor | *Varanus acanthurus* | | 550 |
| | Goulds Monitor | *Varanus gouldii* | | 450 |
| | Carpet Python | *Morelia spilota variegata* | | 200 |
| | Cunninghams Skink | *Egernia cunninghami* | | 80 |
| | Blue Tongue Lizard | *Tiliqua scincoides* | | 40 |
| | Long-necked Tortoise | *Chelodina longicollis* | | 40 |
| | Bearded Dragon | *Pogona vitticeps* | | 35 |

**Table 55: The dollar value of biodiversity: A selection of species of economic importance that are referred to in the text, excluding fish *(continued)***
Dollars values ($A) are in millions, except for the value of individual pets.

| Category of use | Species common name | Scientific name | Details | Estimated value in A$ million (national turnover of industry, unless otherwise stated) |
|---|---|---|---|---|
| Earth sanctuaries | | | Threatened species are protected and bred within feral-proof sanctuaries. The sanctuaries provide for ecotourism | 1.1 Total market and economic value, 1999 |
| | Bilby | *Macrotis lagotis* | | |
| | Boodie | *Bettongia lesueur* | | |
| | Bridled Nailtail Wallaby | *Onychogalea fraenata* | | |
| | Eastern Quoll | *Dasyurus viverrinus* | | |
| | Long-nosed Potoroo | *Potorous tridactylus tridactylus* | | |
| | Numbat | *Myrmecobius fasciatus* | | |
| | Platypus | *Ornithorhynchus anatinus* | | |
| | Red-necked Pademelon | *Thylogale thetis* | | |
| | Rufous Bettong | *Aepyprymnus rufescens* | | |
| | Southern Brown Bandicoot | *Isoodon obesulus* | | |
| | Southern Hairy nosed Wombat | *Lasiorhinus latifrons* | | |
| | Sticknest Rat | *Leporillus conditor* | | |
| | Tammar Wallaby | *Macropus eugenii* | | |
| | Woylie/Brush-tailed Bettong | *Bettongia penicillata ogilbyi* | | |
| | Yellow-footed Rock-wallaby | *Petrogale xanthopus* | | |

**Source:** Australian Senate (1998); Tasmanian Parks and Wildlife Service (1998); Tasmania, DPIWE (1999); Parliament of Victoria (2000).

*Commercial fisheries*

Commercial fisheries in Australia depend largely on wild caught species, supported an estimated production value of $1.8 billion in 1998–99 (ABARE 1999). The oyster industry, based on the Giant Australian Oyster (*Pinctada maxima*) produces exports of some $200 million per year. There is major scope for commercial production of some native fish species for human consumption, such as Silver Perch (*Bidyanus bidyanus*), Murray Cod (*Maccullochella peelii*), Snapper (*Chrysophrys auratus*), Barramundi (*Lates calcarifer*) and Mulloway (*Johnius antarctica*). Freshwater eels (*Anguilla* spp.), which have a poorly understood breeding migration to offshore waters (possibly in the Coral Sea), support an industry of about $5 million per year and are increasingly 'ranched', with harvested young raised in captivity. It is likely that the total economic value of recreational fisheries, again largely based on native species, exceeds that of commercial fisheries when ancillary activity (e.g. boats, fuel, accommodation) is accounted for.

*Forests and fodder*

Woodchips from native forests had a value in 1998–99 of $590 million. While this is only one category of forestry production in economic terms, it is a particularly significant one and known to be sourced from native forests rather than exotic plantations. Significant pastoral industries in drier areas in Australia depend on pasture provided by native shrub, grass and forb species. For example, 7% of Australia's beef cattle are found in the Northern Territory, and these depend largely on native pastures. To give some estimate of this value, between 1983 and 1984, the value of native pasture support industries in Queensland was calculated as

$1125 million per year. There are increasing efforts to re-establish useful native shrub species for fodder and land degradation control (e.g. Old Man Saltbush, *Atriplex nummularia*, in western New South Wales).

*Growing and harvesting native plant species*

The ABS (ABS 1999a) used the annual service costs of maintaining a garden with native plants as the basis for estimating households' expenditure towards 'protection of biodiversity and landscape'. The result was an estimate of $169 million in 1996–97, which reflects a growing use of native species for ornamental purposes. Australian wildflower exports in 1997 were valued at $30 million and the 'bushfood' industry was expected to grow from $14 million in 1996 to over $100 million in 2000. There are no data on the value of the native species component of the nursery industry, but some 1600 species are grown and traded (Parliament of Victoria 2000).

*Native animal species (meat, skin and hides)*

Duck and quail hunting (recreational) in Victoria is estimated to involve over $30 million expenditure each year. The kangaroo industry is estimated to support 4000 jobs in rural areas, and the value of the industry is about $245 million per year; the emerging Emu (*Dromaius novaehollandiae*) industry is smaller at $6–8 million per year. In Tasmania, the Brushtail Possum (*Trichosurus vulpecula*) harvest has an annual value of $400 000, the Muttonbird (*Puffinus* spp.) harvest $425 000 and Bennett's Wallaby *(Macropus rufogriseus*), $750 000 (DPIWE 1999). An increasing number of possums are exported for human consumption in China as a 'warming meat'.

In many such industries, there is considered to be scope for greater economic value through increased processing, niche products, expansion of cultivation rather than harvesting, or greater use for human consumption (e.g. much kangaroo meat is used for pet food, and much leather remains unused). Again, different values will define different attitudes to the expansion of such industries. Some biodiversity-based industries now coordinated by industry organisations are more organised towards both sustainable practices and value-adding and export. These include the Kangaroo Industry Association and the Southern Bushfoods Association.

*Live animal species*

Another indication of the economic value of Australian species is the prices paid for single specimens for companion animals. Red-tailed Black Cockatoos (*Calyptorhynchus magnificus*), one of the few bird species subject to a managed harvest for export (from NT), can fetch $8000 to $9000 per animal, the same as a Gang-Gang Cockatoo (*Callocephalon fimbriatum*). Sulfur-crested Cockatoos (*Cacatua galerita*) and Galahs (*Cacatua roseicapilla*) can fetch over $1000 each, as can a native Green Tree Python (*Chondropython viridis*) or a Spiny-tailed Monitor (*Varanus acanthurus*) in other countries. This trade is small, and beset with problems of legality and whether this is an acceptable or appropriate use of biodiversity.

Some argue that if wild populations have a commercial value, landholders are encouraged to improve the resources they depend on and that a carefully regulated industry could increase the distribution and numbers of wild species. Earth Sanctuaries Limited has put an 'economic value' on a range of vertebrate species and includes $3.8 million for Australian fauna on its balance sheet. For example, the 130 individuals of Numbat owned and managed by the company are valued at $650 000. The Productivity Commission has recently undertaken a study of creating markets for biodiversity resources and services that focuses on Earth Sanctuaries.

In Western Australia, Fund for Wild Australia, a privately owned non-profit organisation, is also developing a series of wildlife exclosures to protect endangered mammal species, although this enterprise is not listed on the stock exchange. The World Wildlife Fund for Nature argues that while well-managed predator exclosures can contribute to the conservation of certain species, their benefits should not be exaggerated. They should be seen as just one of the tools available to help protect endangered animal species.

*Tourism*

Other species are clearly of economic significance but this is more difficult to estimate. Tourism provides an example. Hundloe and Hamilton (1997) estimated that the koala is worth $1.1 billion per year through its iconic role in attracting international tourists to

Australia, and that in the absence of Australia's unique wildlife, there would have been a loss of $1.8 billion in tourism revenue in 1996 (rising to $2.5 billion in 2000). Surveys of international tourists indicate that a major proportion identify nature-based factors such as wildlife and national parks as a motivation for their visit. Many remote communities are increasingly dependent on income from small-scale 'ecotourism' ventures.

Although the contribution of particular elements of biodiversity to the attractiveness or allure of, say, a national park is difficult to measure precisely, it is fundamental. Valuations reported in Bennett et al. (1996) provided some idea of the local and regional benefits of protected areas. The annual economic value of Dorrigo and Gibraltar Range National Parks in New South Wales was $5.4 million and $800 000, respectively. Such figures and associated employment can be highly significant in rural areas. Biodiversity in protected areas is obviously crucial to the tourism industry, both domestic and international. Some indicative economic values from Victoria are: nature-based tourism in the Grampians region, $100 million annually; and the Penguin Parade Reserve, $96.5 million in 1995–96 and over 1000 jobs (Parliament of Victoria 2000). Visitation to national parks and reserves in Victoria grew from 8 to 25 million per year between the late 1980s and late 1990s.

*Bioprospecting*

Bioprospecting (the chemical prospecting for pharmaceuticals in natural organisms) is a growing industry in Australia, with potential in both terrestrial and aquatic environments (see the *Bioprospecting* box on page 147). If managed appropriately, bioprospecting has the potential to have minimal impact, as modern screening methodologies and analytical instruments permit the identification of biologically active compounds from fairly small samples (Benkendorff 2001). Another area of clear future significance is the potential economic value of native genetic resources. The ability to capture new biotechnological benefits will rely on maintaining biodiversity in its natural environment because the exploitation of metabolites usually depends on observing the interactions between organisms in their natural environment (Battershill & EvansIllidge 2000).

*Ecosystem services*

Such estimates of particular economic contributions from biodiversity only go some way towards providing measurement of the total value of biodiversity. For example, although the $300 million-plus Australian honey industry is based on introduced bees, these bees depend greatly on native plant species for pollen and nectar. The value to agriculture of 'pollination services' by native insects as well as honeybees is likely to be worth significantly more than this.

The actual economic and social value of 'ecosystem services' (indirect utilitarian values) is often difficult to calculate. For example, the role of soil organisms in maintaining agricultural production is both poorly known and of obvious economic significance. However, the service values of ecosystems can be highlighted when they become degraded to the point that the economics of restoration are measured in dollar terms. In the mid-1990s the treatment of land degradation in Australia, for example, had direct costs of more than $400 million per year, including treatment for waterlogging, salinity and erosion. More recent estimates by the Australian Conservation Foundation (ACF) and National Farmers Federation have put the annual cost of degradation in rural landscapes at a minimum of $2 billion, which is predicted to increase to over $6 billion annually by 2020 if no action is taken (Madden et al. 2000). The recently released report *Coordinating Catchment Management* (from the bipartisan House of Representatives Standing Committee on Environment and Heritage) recommended that a National Environment Levy be put in place for the next 25 years to help fund programs to address these issues.

Carbon and biodiversity credits, while still in their infancy, propose to calculate specific dollar values on elements of biodiversity so they can be traded on domestic and international markets. Interest has increased in valuation of non-traded ecological services and assets, especially in the wake of a global study that estimated the economic value of 17 ecosystem services across 16 biomes as between US$16 to 54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year (Costanza et al. 1997). This valuation was, in turn, used to estimate an average value in 1997 for terrestrial Australian ecosystems of US$245 billion per year and for marine ecosystems of US$640 billion per year (Jones & Pittock 1997). Whether such valuations will, first, develop widely accepted methodologies and, second, ever become used routinely in decision making and biodiversity policy, will only become clear with time. It may be that the main use of broad ecosystem service valuations will influence public perceptions

## Bioprospecting: Chemical prospecting in natural organisms

Bioprospecting—the chemical prospecting for pharmaceuticals in natural organisms—has been promoted as a means for discovering new medicines, an instrument for economic development and an incentive for conservation. Certainly most of both the drugs in commercial use, and those being developed, are of natural origin. The most well-known and celebrated example of a pharmaceutical company channelling money towards the preservation of biodiversity is the collaboration between Merck and the Costa Rica National Biodiversity Institute (INBio). Merck negotiated an up-front fee of US$1 million for the opportunity to explore Costa Rica's biodiversity for novel drugs. If a useful drug is discovered, INBio will receive a share of the royalties. As part of the deal, 10% of the up-front money and 50% of the royalties must go directly towards conservation.

A major program at AIMS is examining the benefits from marine biotechnology. The aim is to use specimens of macro and microorganisms to discover novel biomolecules with strong biocidal and anti-infective activities as well as developing and commercialising technology for seafood diagnostic kits.

Benkendorff (2001) identifies conservation benefits and problems associated with bioprospecting in the marine environment. Comprehensive surveys undertaken as part of her studies recorded a much higher species diversity than previously recognised, identified an important breeding site and hotspot of molluscan species richness, recorded new distributions for three species and found an unidentified Polycerid nudibranch. Following the surveys, her research focused on the marine mollusc, *Dicathais orbita*. Several potential resources are produced by both the adults and egg masses of *Dicathais orbita*, including pharmaceuticals.

Several ethical issues have also been identified such as the potential environmental effects of extraction, the need for the fair and equitable sharing of results and benefits, and the need to protect intellectual property rights when traditional or other knowledge about the natural biota is shared with bioprospectors.

Benefit sharing and intellectual property rights, and to a lesser extent the environmental effects of bioprospecting, have been described in several national and international declarations, resolutions and other publications. These include the recent public inquiry into access to biological resources in Commonwealth areas (Voumard 2000). The final report from this inquiry recommended that bioprospecting should be considered as a 'matter of significance' under s23 and s26 of the EPBC Act when assessing applications for access to biodiversity on Commonwealth land or in Commonwealth marine areas. State governments are also developing policies on the access and benefit sharing of biodiversity resources. The Commonwealth House of Representatives Standing Committee on Primary Industries and Regional Services is also examining the development of high technology industries in regional Australia based on bioprospecting. At the international level, bioprospecting is a major topic being examined through the CBD, with Australia being strongly involved in the development of a policy on access and benefit sharing. Given this level of activity, it is likely that the level of bioprospecting in Australia will increase, despite the financial risks and potential difficulties associated with synthesising large quantities of the extracted compounds.

rather than, say, feeding into cost-benefit analysis at a project approval level. In Australia, the CSIRO, supported by the Myer Foundation, has commenced a major research project into the valuation of ecosystem services.

Some native species may be considered to have negative economic value, as a result of reduction in productive capacity of the land. An example is the increase in 'woody weeds' in central and western New South Wales and Queensland (e.g. *Senna* and *Eremophila* spp.), although in such cases there may be counterbalancing benefits such as protection of wildlife habitat and soil.

*The use of native species by Indigenous communities*

Some small-scale biodiversity-based industries are significant to small or remote settlements and to Indigenous communities (Australian Senate 1998). The kangaroo industry is one example, as is the Tasmanian Muttonbird (*Puffinus tenuirostris*) harvest that is carried out largely by Tasmanian Indigenous peoples and is considered to be sustainable. Crocodile 'ranching', where wild young are harvested and then grown in captivity is important to some Indigenous communities in northern Australia, and crocodile 'cruises' for tourists was generating some $2 million of economic activity per year in the mid-1990s. Increased breeding and stocking in recent decades of native fish species, especially Golden Perch (*Macuaria ambigua*) and Murray Cod (*Maccullochella peelii*), has established several inland empoundment fisheries of considerable local economic importance in mainland eastern

Australia. The genetic implications for wild populations of the widespread distribution of these stocks may be an issue.

Access to biological resources has been the subject of a recent major public inquiry (Voumard 2000). This inquiry gave advice on an access scheme that could be implemented under the EPBC Act. The scheme centred on a benefit-sharing contract which included protection for and valuing of Indigenous knowledge and environmental benefits in the areas from which the resource was obtained. Although the inquiry focused on Commonwealth areas, it recommended that a nationally consistent scheme be developed across all jurisdictions.

**Magpie geese (*Anseranas semipalmata*) foraging among Rice Grass (*Oryza* sp.) and Spike Rush (*Eleocharis* sp.) at Fogg Dam, NT.**

Migrating up to hundreds of kilometres to visit perennial swamps in the dry season, the magpie goose once extended to south-west Victoria, but is now restricted to northern Australia.

**Source:** K Benkendorff, University of Wollongong.

## Species known to be changing significantly in distribution [BD Indicator 10.9]

The Australian environment has undergone, and is still undergoing, significant and often detrimental changes. Threatening processes such as broad-scale land clearance, overharvesting and altered fire regimes would be expected to significantly change the distribution of native species. For example, loss of habitat in southern Australia is associated with a reduction in the range of the Magpie Goose (*Anseranas semipalmata*).

At a national scale, the most comprehensive database available on the distribution and relative abundance of native species is on birds (Barrett 2000b). Between 1977 and 1981, 90 000 bird surveys, collected by 3000 volunteers, were entered into computer by hand—and thus the first continental-scale Bird Atlas (referred to as the Field Atlas) was created (Figure 50). Saunders et al. (1998) recommended that a repeat survey be initiated to reflect changes over 20 years. This is underway, and like the Field Atlas, the current version (referred to as the New Atlas) is an Australia-wide, community-based survey being conducted over several years.

The two data sets were used to analyse whether there had been significant changes in the distribution of bird species at the national level over 20 years. Although the New Atlas survey is yet to be completed, preliminary analysis (see *Analysing changes in bird distribution using data from the Field Atlas (1977–1981) and New Atlas (1998–2000)* box on page 150) has shown changes in the distribution of bird species in southern and eastern Australia. The analysis was confined to these areas as differences in sampling meant that northern Australia has been undersampled in the second Atlas, at least at this point. Other biases include sampling along roads in the more remote parts of Australia (Figure 50) and a bias towards recording common open country birds in the Field Atlas due to differences in sampling techniques used.

The analysis detected a total of 65 species that appear to display reductions in range between the Field Atlas (1997–81) and the New Atlas (1998–2000). These differences are sufficiently large that they are likely to be biologically important. Of these species, 13 show a substantial and systematic difference between the Field Atlas and the New Atlas surveys (Table 56; Figure 51). The list includes birds of prey, ground birds and water birds, illustrating that a range of changes could be responsible for the major reductions in range.

To try to understand why these 13 species appeared to show major declines in range in the last 20 years, opinions were sought from five specialists from around Australia.

There was consensus among four specialists that at the national scale the following species (Table 56) had genuinely contracted in their range due to human-related threats: the Brush-turkey (habitat loss and degradation/predation), Australian Bustard (habitat loss and degradation/hunting) (Figure 51), Black-chinned Honeyeater (loss of habitat, especially mature trees), Fuscous Honeyeater (loss of habitat) and the Wedge-tailed Eagle (loss of food, rabbits, due to the calicivirus). Changes in the range of the Black Kite were thought to be related to differences in rainfall between the two Atlas periods. Below

**Figure 50: A map of the distribution of 87 595 bird surveys observed at 12 200 unique locations during the Field Atlas (1977–81).**

Sampling along roadways in remote areas is evident during this survey.

**Source:** Birds Australia. Compiled by Acromap, Melbourne.

**Table 56: Bird species that appear to have decreased their range between the Field Atlas (1977–1981) and the New Atlas (1998–2000) surveys**
See also Figure 50 and *Analysing changes in bird distribution (1977–1981) and the New Atlas (1998–2000)* box on page 150.

| Common name | Latin name |
|---|---|
| Brush-turkey (Australian) | *Alectura lathami* |
| Australian Bustard | *Ardeotis australis* |
| Black Kite | *Milvus migrans* |
| Black-chinned Honeyeater | *Melithreptus gularis* |
| Black Swan | *Cygnus atratus* |
| European Goldfinch | *Carduelis carduelis* |
| Fuscous Honeyeater | *Lichenostomus fuscus* |
| Great Cormorant | *Phalacrocorax carbo* |
| Australian Pipit | *Anthus novaeseelandiae* |
| Wedge-tailed Eagle | *Aquila audax* |
| White-necked Heron | *Ardea pacifica* |
| White-throated Needletail | *Hirundapus caudacutus* |
| Yellow-billed Spoonbill | *Platalea flavipes* |

average rainfall was recorded over the period of the first survey. During such dry climatic periods, there can be a considerable expansion in the range of bird species in the search for water and prey.

Three specialists commented on species in southern Australia. Of these, two thought that the decline of the European Goldfinch could be related to the intensification of agriculture and the decline in preferred weed seeds. Changes in agricultural practice were also associated with the Australian Pipit, although one commentator felt that it might be returning to its pre-European range. The raw data for the White-throated Needletail, with the range analysis, picked up a significant decline. One specialist felt that this was an artefact of the differences in sampling between the two Bird Atlases, another that the decline was related to pressures on its habitat in South-East Asia and one-third gave no explanation for the observed pattern. These responses demonstrate that even when there appears to be a major decline in the range of a species, informed opinion about the reasons underlying the change can vary.

Some introduced species such as the Common Myna (*Arcdotheris trisis*), Common Blackbird (*Turdus merula*), Mallard (*Anas platyrhynchos*) and Spotted Turtle-dove (*Streptopelia chinensis*) as well as native species able to exploit urban environments such as the Eastern Rosella (*Platycercus eximius*) and Red Wattlebird (*Anthochaera carunculata*) appear to have expanded their range since 1981. While the results on the species that are increasing could be an artefact of the analysis, other sources of information support the results.

As noted earlier, the analysis undertaken for this report of the Bird Atlas data focused on species in southern Australia. In a separate study, Franklin (1999) used historical data on the distribution of birds to assess change in groups of grain-eating birds in the tropical and subtropical savannas of northern Australia. Twelve of the 49 native and mostly resident species had declined, and three others had increased. One species was thought to be extinct (the Paradise Parrot, *Psephotus pulcherrimus*), and two taxa

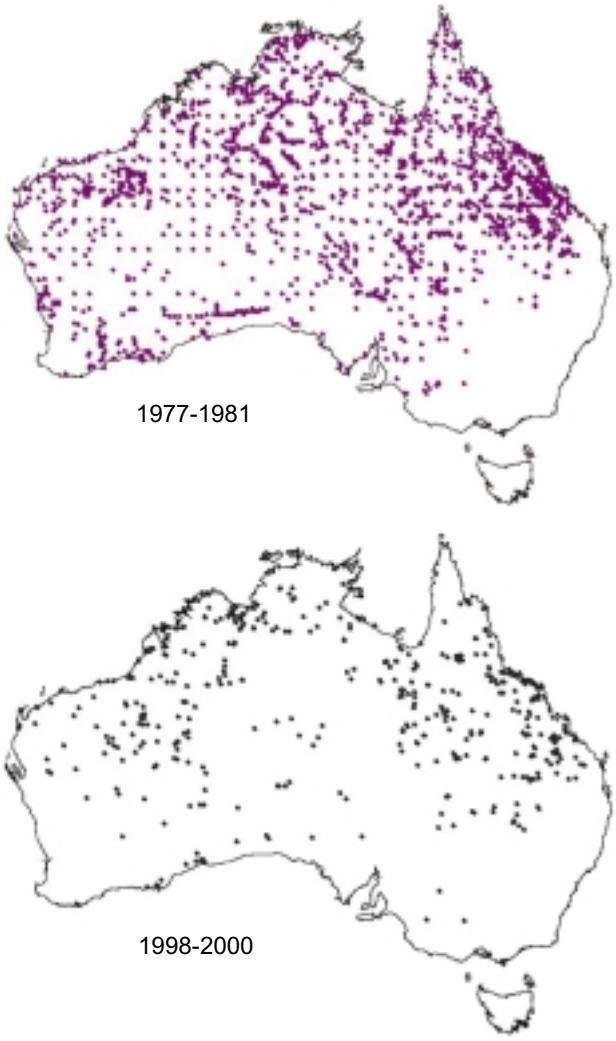



**Figure 51: Distribution of the Australian Bustard (*Ardeotis australis*), during the Field Atlas (1977–1981) and the New Atlas (1998–2000) showing a decrease in range.**
**Source:** Birds Australia. Compiled by RMIT University.

## Analysing changes in bird distribution using data from the Field Atlas (1977–1981) and the New Atlas (1998–2000)

Bird atlas data were supplied by Birds Australia to analyse changes in the distribution of bird species over 20 years. Two sets of Atlas data were supplied; the first Field Atlas spanned from 26 December 1972 to 30 June 1986, but data used in this analysis were restricted to 1 January 1977 and 31 December 1981. The data set was cleaned of obvious errors. For example, 313 survey sheets plotting at least 30 km offshore were deleted. A total of 87 595 sheets observed at 12 200 unique locations were accepted resulting in 2 649 449 species observations.

The New Atlas data span the period from 1 January 1998 to 3 July 2000 (data collection is ongoing). A total of 138 surveys plotted more than 30 km offshore of Australia were deleted from the database. Taxonomic variations in the New Atlas were corrected to be consistent with the Field Atlas. Species groupings and species not recognised within Australia were removed from the database. A total of 91 983 New Atlas survey sheets remained, at 50 350 unique locations recording 1 688 204 species observations. The relatively high number of unique locations reflects the higher precision (seconds instead of minutes) of most of the coordinates of the New Atlas surveys. Geographical Positioning System (GPS) was used to position about 60% of New Atlas surveys, whereas none of the Field Atlas records were GPS-based. The distinct sampling patterns along roads in central and northern Australia can be detected in the figures from both Atlases.

Taxonomic revisions result in some confounding of data between the two observation periods. Species split into two or more species were grouped under a single atlas number. Similarly, subspecies in the Field Atlas more recently revised to full species status were relegated to their original atlas number because the original records were not resolved. There were sufficient data from the two survey periods to include 492 bird species in the analysis out of the approximate total of 750 species recorded. The subset of species was located principally in southern and eastern Australia because areas in northern and inland Australia had considerably lower numbers of surveys in the New Atlas compared with the original Field Atlas. The most likely cause is because at the time of the analysis, data were available only for 2.5 years for the New Atlas compared with five years for the first Atlas. Consequently, comparing species in these undersampled areas would result in apparent changes in distribution that were an artefact of the data collection.

were critically endangered. Even though human settlements are sparse in these areas and the intensity of pastoralism is relatively low, these changes demonstrate the potential effect of altered fire and grazing regimes in these northern woodlands.

Information is becoming increasingly available on changes in distribution of plants and animals at a local and regional level. A relevant example is a recent study on reptiles in central-western New South Wales that showed that two species have vanished from the agricultural landscape. Up to a further nine species were in decline, and may be facing the same fate. Extensive land clearing appears to be the reason for the reduction in the range of these reptiles, with inadequate native vegetation remaining to satisfy their need for food and shelter.

### Number, distribution and abundance of migratory species [BD Indicator 10.10]

Several Australian animals migrate on a seasonal basis both within Australia and to areas outside the country. These groups include marine mammals such as whales (Figures 52 and 53), turtles, many bird and fish species and eels (see page 4–42 of SoE 1996).

Perhaps the most impressive migrants that journey to Australia are the shore birds, which are found in shallow water in both coastal and inland wetlands. These birds, which include sandpipers, curlew, snipe and plovers, may fly 2500 km annually as they migrate between the southern and northern hemispheres. Of the 50 species of wading or shore birds that regularly occur in Australia, 33 breed outside Australia in central Asia, Siberia or the Arctic zone of North America (Blakers et al. 1984). One of the important routes that is travelled by these birds is the East Asian–Australasian Flyway, which extends from the Arctic Circle through South-East Asia to Australia and New Zealand.

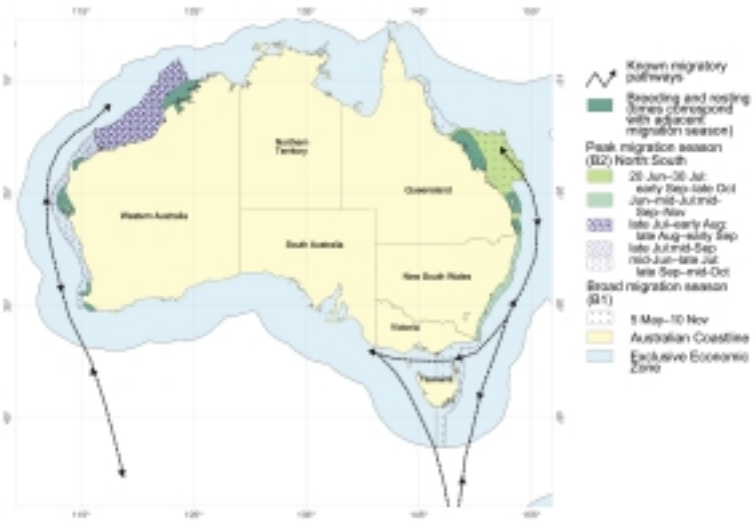



**Figure 52: Distribution, migration and recognised aggregation areas of the Humpback Whale (*Megaptera novaeangliae*).**

**Source:** Environmental Information Resources Network.

This Flyway has a series of wetlands that the shorebirds visit to rest and feed before they undertake the next stage of the journey.

When other bird groups are also considered, over 300 species are known to migrate between Australia and other countries (Birds Australia, pers. comm. 2000). This number includes species that have been recorded outside their normal range (vagrant species), as well as species that are strict migrants, moving regularly from one country to another, often from breeding to non-breeding areas.

Because the actions of humans in other parts of the world can affect these species, several agreements have been negotiated between the Commonwealth government and the countries where the species migrate. These include the Japan and Australia Migratory Bird Agreement and the China and Australia Migratory Bird Agreement. At the multilateral level, Australia is involved in the United Nations Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention) where they are taking the lead negotiating a regional albatross conservation agreement (see the *Albatross and bycatch policy* box on page 43).

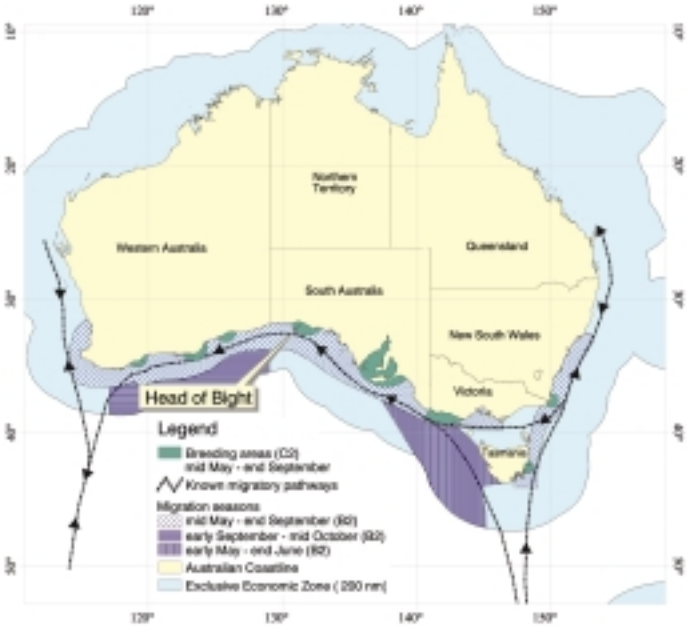



**Figure 53: Distribution, migration and recognised aggregation areas of the Southern Right Whale (*Eubalaena australis*).**

**Source:** Environmental Information Resources Network.

Some bird species also migrate within Australia. The Swift Parrot (*Lathamus discolor*) is an endangered bird species that only breeds in Tasmania, but migrates to the mainland for autumn–winter (March–August). This is a telling example of the threats posed to migratory species. In Tasmania, the birds are almost always associated with Blue Gum (*Eucalyptus globulus*) or Swamp Gum (*Eucalyptus ovata*) (Garnett & Crowley 2000). Both of these habitats have been reduced as a result of clearing for agriculture, residential development and intensive forestry practices. The Sharmans of Spreyton in Tasmania led community tree-planting programs to reverse the loss of habitat trees and sources of food for the Swift Parrot. On the mainland, clearance for agriculture and residential development have destroyed over 70% of the bird's habitat (Garnett & Crowley 2000). Climate change also poses a further threat to this species (see Figure 30).

### Demographic characteristics of target taxa [BD Indicator 10.11]

This indicator was not reported on.

## Ecosystem diversity

### Ecosystems: What do they provide?

Ecosystems provide the ecological functions and processes on which consumptive and productive values depend (see *A classification and examples of ecosystem services* box on page 152). These functions include photosynthetic fixation, pollination, gene flow, predation, competition, maintenance of water cycles, provision of nurseries for commercial fish species (in mangroves and coral reefs in particular), regulation of climate and carbon sequestration, soil production and protection, support of symbiotic fungi essential for plant growth, storage and cycling of essential nutrients, and the absorption, breakdown and dispersal of organic wastes, pesticides, air pollutants and water pollutants, and control of crop and livestock pests through predation.

Ecosystems provide many products that do not pass through a market, termed consumptive values. The most important direct uses are food, medicine, fuel and building materials. Consumptive values are usually more diverse and depend on a much wider spectrum of the available biota than do market-based patterns of use. Many people, particularly those who live in traditional ways such as some Australian Indigenous peoples, depend directly on the natural environment for live game, firewood, edible plants, medicines, building materials, materials for weapons and transport, cultural and spiritual items, raw materials for

**The Sharmans of Spreyton in Tasmania led community tree-planting programs to reverse the loss of habitat trees and sources of food for the endangered Swift Parrot (*Lathamus discolor*). Mrs Sharman is recently deceased.**

**Source:** TW Norton.

## A classification and examples of ecosystem services

### Production of goods

*Food:* Terrestrial animal and plant products, forage, seafood, spice
*Pharmaceuticals:* Medicines, precursors to synthetic drugs
*Durable materials:* Natural fibre, timber
*Energy:* Biomass fuels, low-sediment water for hydropower
*Industrial products:* Waxes, oils, fragrances, dyes, latex, rubber, precursors to many synthetic products
*Genetic resources:* The basis for the production of other goods

### Regeneration processes

*Cycling and filtration processes:* Detoxification and decomposition of wastes, renewal of soil fertility, purification of air and water
*Translocation processes:* Dispersal of seeds necessary for revegetation, pollination of crops and native vegetation

### Stabilising processes

Coastal and river channel stability, compensation and substitution of one species for another when environments vary, control of most potential pest species, moderation of weather extremes (e.g. temperature and wind), partial stabilisation of climate, regulation of the hydrological cycle (mitigation of floods, droughts and salinity).

### Life-fulfilling functions

Aesthetic beauty, cultural, intellectual, and spiritual inspiration, existence value, scientific discovery, serenity.

### Preservation of options

Maintenance of ecological components and systems needed for the future, supply of goods and services awaiting discovery.

**Source:** after Daily (1999) by Cork and Shelton (2000).

other technology and trade goods. Natural ecosystems also provide opportunities for aesthetic, recreational and tourist use, founded on the accessibility, composition and appearance of Australian species, ecosystems and landscapes. Tourist use of natural environments is part of Australia's largest export-earning industry (see also *Species of economic importance* on page 136).

Ecosystems provide services that are more difficult to quantify and explain than those outlined above. They include cultural, spiritual, experiential and existence values. Natural environments in Australia include sites of religious, spiritual and cultural significance, especially for Indigenous people. In its submission to the Resources Assessment Commission, the Australian Heritage Commission (AHC) defined cultural heritage values as: 'features which are sacred to Aboriginal people, prehistoric archaeological sites going back to as far as 30 000 years, and material remains of historic activity since European settlement'.

Since 1998, several projects have started on the role of ecosystem services. Cork and Shelton (2000) reported that the Myer Foundation has provided seed funding for a project on ecosystem services, The Nature and Value of Australia's Ecosystem Services, involving CSIRO, land managers, community groups, scientists and economists.

## Ecosystem diversity [BD Indicator 11.1]

Ecosystems can be defined in several ways. Typically, and for convenience, ecosystems may be defined by different vegetation types and marine and freshwater habitat types. These types of ecosystems can be quantified at a continental scale, regional scale or landscape level. Compared with many other parts of the world, ecosystem diversity in Australia is high. In Queensland, for example, there are 13 terrestrial bioregions and 1085 regional vegetation ecosystems (Sattler & Williams 1999). These include rainforests of the wet tropics, vine thickets of the Brigalow Belt and coastal wetlands, a number of which may occur on offshore islands. A comparable level of marine ecosystem diversity is yet to be undertaken in Queensland, but the diversity of marine habitat types may be higher given the presence of the Great Barrier Reef ecosystem and the range in water depths, sea currents and other environmental gradients encompassed.

When completed, the National Vegetation Information System (NVIS) will provide a national overview of terrestrial vegetation types at the bioregional scale. NVIS is being developed by the NLWRA in collaboration with Agriculture, Fisheries and Forests Australia and the states and territories. For the first time, a consistent, nationally agreed vegetation classification will be produced, along with a set of core vegetation attributes. Monitoring the condition of rangeland systems is the most advanced, with both production and conservation values being addressed. Reporting on marine habitats will be further down the track as many aquatic and marine ecosystems remain relatively unexplored, as well as some terrestrial ecosystems such as cliff faces (see *Unexplored ecosystems: Seamounts and terrestrial cliffs* on page 66).

**Table 57: Threatened ecological communities listed in 2001, under the *Environment Protection and Biodiversity Conservation Act 1999***
The Scientific Committee's advice to the Minister regarding the listing of each of these ecological communities is also available.

| |
|---|
| Aquatic Root Mat Community 1 in Caves of the Leeuwin Naturaliste Ridge |
| Aquatic Root Mat Community 2 in Caves of the Leeuwin Naturaliste Ridge |
| Aquatic Root Mat Community 3 in Caves of the Leeuwin Naturaliste Ridge |
| Aquatic Root Mat Community 4 in Caves of the Leeuwin Naturaliste Ridge |
| Aquatic Root Mat Community in Caves of the Swan Coastal Plain |
| Assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the Swan Coastal Plain |
| Bluegrass (*Dicanthium*) Dominant Grasslands of the Brigalow Belt Bioregions (North and South) |
| Brigalow (*Acacia harpophylla* dominant and codominant) |
| Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions |
| *Corymbia calophylla–Kingia australis* Woodlands on heavy soils of the Swan Coastal Plain |
| *Corymbia calophylla–Xanthorrhea preissii* Woodlands and Shrublands of the Swan Coastal Plain |
| Cumberland Plain Woodlands |
| Eastern Stirling Range Montane Heath and Thicket |
| Eastern Suburbs Banksia Scrub of the Sydney Region |
| Grassy White Box Woodlands |
| Natural Temperate Grassland of the Southern Tablelands of New South Wales and the Australian Capital Territory |
| Perched Wetlands of the Wheat belt region with extensive stands of living sheoak and paperbark across the lake floor (Toolibin Lake) |
| Sedgelands in Holocene dune swales of the southern Swan Coastal Plain |
| Semi-evergreen Vine Thickets of the Brigalow Belt (North and South) and Nandewar Bioregions |
| Shale/Sandstone Transition Forest |
| Shrublands and Woodlands of the eastern Swan Coastal Plain |
| Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain |
| Shrublands and Woodlands on Perth to Gingin ironstone (Perth to Gingin ironstone association) of the Swan Coastal Plain |
| Shrublands on southern Swan Coastal Plain ironstones |
| Silurian Limestone *Pomaderris* Shrubland of the South East Corner and Australian Alps Bioregions |
| The community of native species dependent on natural discharge of ground water from the Great Artesian Basin |
| Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond) |

**Source:** Wildlife Australia, Environment Australia (http://www.environment.gov.au/cgi-bin/forms/sprat/public/publiclookupcommunities.pl).

## Number and extent of ecological communities of high conservation potential

[BD Indicator 11.2]

Many Australian vegetation communities have high biodiversity significance. At the regional, state and territory level, many communities have been formally identified for priority reservation. There are also a number of 'grey' lists of threatened communities (e.g. from the assessments undertaken through the RFA process and from Queensland and Western Australian agencies). At a continental level, there are 27 threatened ecological communities that have been listed recently under the Commonwealth government's EPBC Act (Table 57).

Sites that qualify as centres of diversity are geographically defined regions that contain many endemic species (see *Endemism* on page 126). One difficulty in selecting areas for protection is that the sites of endemism and richness for different taxa usually do not occur in the same place (Prendergast et al. 1993). For example, areas of tropical rainforests in northern Queensland are renowned for their extraordinary plant and bird diversity and these areas now have World Heritage Status and are well protected. However, areas of wet sclerophyll forest that border the margins of tropical rainforest are not protected yet support rich endemic bat and ant faunas (Harrington, pers. comm., in Burgman & Lindenmayer 1998).

# Increase in the knowledge of biodiversity

This section reports on the following environmental indicators, which are defined in Saunders et al. (1998).

| Environmental Indicator | |
|---|---|
| **BD 14** | Proportion of bioregions covered by biological surveys |
| **BD 24.1** | Number of species described per reporting cycle |
| **BD 24.2** | Number of taxonomists involved per reporting cycle |
| **BD 24.3** | Amount of funding for taxonomy |
| **BD 24.4** | Number of research programs into surrogates |
| **BD 24.5** | Number of research programs into the role of biodiversity in ecological processes |
| **BD 24.6** | Number of long-term ecological monitoring sites |

In order to sustainably manage Australian landscapes for both conservation and production purposes, there needs to be improvement in our understanding of the various elements of biodiversity. The previous sections illustrated how our understanding of even the most basic measure of biodiversity, the number of species, is poorly lacking.

## Taxonomic endeavour in Australia

### Number of taxonomists and species described [BD Indicators 24.1 and 24.2]

Results of the ABRS survey indicate that there were around 185 taxonomists working in Australia in June 2000 (Table 58; Figure 54). These figures capture roughly 75% of the taxonomic endeavour in Australia, due to non-respondents and private collectors from Australia and other countries not covered by the survey. All Australian institutions known to hold major collections were contacted, including museums, herbaria and universities. Taxonomists described about 2300 new species and 240 new genera between 1 July 1995 and 30 June 1999 (Table 58). Roughly two-thirds of the taxonomic effort was expended on animals and one-third on plants. There is currently no-one working on many of the taxa in Australia (some groups are being handled in other countries on a world basis).

Among the plants, vascular plants were the main focus. Fungi are expected to be far more numerous than vascular plants, but only about 6% of the total taxonomic effort was directed towards fungi, compared to about 75% of the effort on vascular plants. Among the animals, slightly more than one-half of the effort was directed towards the most numerous taxa (insects, arachnids and crustaceans). Just fewer than 20% of the effort was directed towards vertebrates, which make up less than 1% of all animal species.

The mismatch between effort and the amount of outstanding work is apparent in Figure 54. Fungi in particular are underresourced, relative to other taxa, when the total numbers of undescribed taxa are taken into account. Fungi are important in ecosystem services and biogeochemical cycles making them just as important as vascular plants from a utilitarian perspective. The ABRS lists them as a high priority. Part of the difficulty is the lack of taxonomists in these areas and lack of people willing to work in them. Similarly, taxonomic priorities among animals reflect to some extent social and immediate economic imperatives, rather than ecological ones.

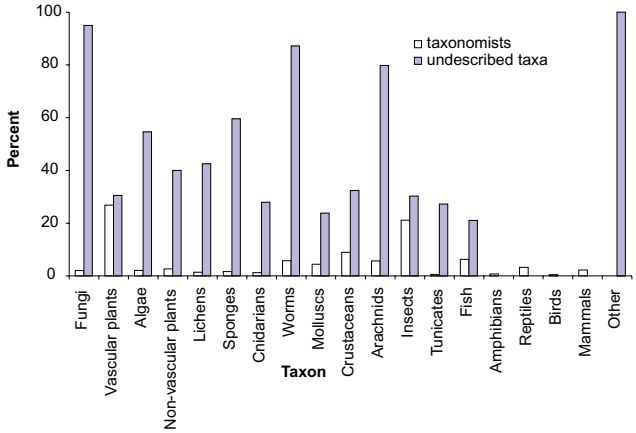



**Figure 54: The percentage of taxonomists working on each taxon out of the total number of taxonomists and the percentage of undescribed taxa remaining in each taxon, in June 2000.**

This figure demonstrates the paucity of information available for most native species in Australia. The category 'worms' includes annelid worms, flatworms, roundworms, velvet worms and thornyheaded worms.

**Source:** ABRS; see text for further details about the plant and animal survey that formed the basis of these figures.

### Funding for taxonomy [BD Indicator 24.3]

Taxonomic work was undertaken by 57 different institutions in all states and territories (Table 59). The funding for this work comes from Commonwealth and state

**Table 58: The number of taxonomists working in Australia (in full-time units) in June 2000, and the number of new Australian taxa described between 1 July 1995 and 30 June 2000**

| Group | No. of taxonomists working on each taxon in July 2000 | No. of institutions working on each taxon | New genera | New Australian species |
|---|---|---|---|---|
| **Protoctistae (Unicellular organisms)** | | | | |
| | 6.9 | 7 | — | 12 |
| **Fungi** | | | | |
| Fungi (excluding lichens) | 3.7 | 6 | — | 132 |
| Lichens | 2.5 | 3 | — | 29 |
| **Plantae (Plants)** | | | | |
| Vascular plants (flowering plants, cycads, conifers, ferns and fern allies) | 50 | 18 | 3 | 500 |
| Algae | 3.8 | 4 | 1 | 6 |
| Bryophyta (mosses and allies) | 4.9 | 7 | | |
| **Total Australian Flora (Plants and Fungi)** | **65** | **—** | **4** | **667** |
| **Animalia (Animals)** | | | | |
| **Invertebrates** | | | | |
| Porifera (sponges) | 3 | 2 | — | 70 |
| Cnidaria (corals, anemones, jellyfish) | 2.2 | 2 | 16 | 34 |
| Platyhelminthes (flatworms, parasites) | 2 | 1 | 9 | 52 |
| Acanthocephala (thorny-headed worms) | 0.2 | 1 | 1 | 1 |
| Nematoda (roundworms, threadworms) | 4.9 | 6 | 5 | 45 |
| Mollusca (squid, octopus, mussels, clams, snails) | 8.1 | 8 | 4 | 75 |
| Annelida (ringed worms, earthworms) | 3 | 2 | 4 | 37 |
| Onychophora (velvet worms) | 0.5 | 1 | | |
| Crustacea (crayfish, crabs, prawns etc.) | 16.7 | 10 | 20 | 107 |
| Arachnida (spiders, mites etc.) | 10.5 | 10 | 31 | 242 |
| Insecta (insects) | 39.3 | 19 | 141 | 868 |
| **Chordates** | | | | |
| Tunicata (sea squirts, doliolids, salps) | 1 | 1 | 2 | 2 |
| Pisces (fish) | 11.6 | 10 | — | 57 |
| Amphibia (frogs) | 1.2 | 2 | — | 1 |
| Reptilia (snakes, lizards) | 6 | 5 | 2 | 26 |
| Aves (birds) | 0.8 | 1 | — | 46 |
| Mammalia (mammals) | 4 | 4 | — | 1 |
| **Total Australian Fauna** | **115** | **—** | **235** | **1 664** |

**Source:** figures are derived from a survey of taxonomists in Australia, conducted by the ABRS (see text).

institutional support, and it occurs in museums and herbaria, state and Commonwealth regulatory agencies, and tertiary research and teaching institutions. Despite the significant gaps in taxonomic effort in Australia, the budget for the ABRS, which is producing the multivolumed *Flora of Australia* and *Fauna of Australia*, was cut by $400 000 in the 1999–2000 financial year. Fourteen Large Research Grants were awarded from the Australian Research Council (ARC) for taxonomic research between 1997 and 2000 (Table 60).

**Table 59:** **The number of institutions undertaking taxonomic work in each state and territory of Australia**

| State/Territory | Flora | Fauna | Total |
|---|---|---|---|
| Antarctica | 1 | 1 | 1 |
| Australian Capital Territory | 3 | 3 | 5 |
| New South Wales | 6 | 8 | 11 |
| Northern Territory | 1 | 3 | 4 |
| Queensland | 3 | 6 | 9 |
| South Australia | 2 | 5 | 7 |
| Tasmania | 2 | 2 | 5 |
| Victoria | 3 | 6 | 8 |
| Western Australia | 5 | 4 | 7 |
| **Total** | **26** | **38** | **57** |

**Source:** figures are derived from a survey of taxonomists in Australia, conducted by the ABRS (see text and Table 58).

**Table 60:** **Australian Research Council Large Research Grants funding for taxonomic projects between 1997 and 2000**

| Year | Number of grants | Amount ($) | Groups |
|---|---|---|---|
| 2000 | 2 | 297 500 | *Davesia*, insects (ordinal relationships) |
| 1999 | 1 | 140 000 | Doryctine wasps |
| 1998 | 6 | 1 238 000 | Hymenoptera, crabs, insects, amphibians, reptiles, birds, mammals, Trematodes |
| 1997 | 5 | 830 000 | Caenogastropod molluscs, *Eucalyptus*, gall-forming thrips, *Styhelieae*, Cockroaches (*Paratemnopteryx*) |

## Biodiversity in ecological processes

### Number of research programs into the role of biodiversity in ecological processes

[BD Indicator 24.5]

There have been no ARC Large Research Grants into the role of biodiversity in ecological processes in the last five years.

## The use of surrogates for the management of biodiversity

### Number of research programs into surrogates [BD Indicator 24.4]

In the context of State of Environment reporting, and for biodiversity management in general, 'surrogates' measure the spatial distribution of biodiversity. They are distinct from indicators that measure the response of ecosystems to disturbance, and from umbrella species and flagship species that provide de facto protection for species that occupy the same habitat.

The taxon-based biodiversity surrogates approach targets resource management or landscape restoration efforts at a group of species and assumes that the needs of other taxa will be met (see the *Taxon-based biodiversity surrogates* box on page 157).

A simple strategy is to conserve areas that incorporate a range of environmental factors (Faith & Walker 1993). Environmental domains are geographical regions that enclose a continuous range of physical environmental parameters that are expected to be important in determining the distributions of species.

Vegetation maps are perhaps the most frequently used biodiversity surrogates. Much of the vegetation of the Australian continent has been classified and mapped (Commonwealth of Australia 1990; Specht et al. 1995). It is assumed that protection of a proportion of each vegetation type will protect sufficient proportions of the populations of other organisms. Vegetation maps may fail as surrogates in cases where sets of species are dependent on particular successional stages within a vegetation community (e.g. the old growth stage of a particular type of forest), or when species respond to environmental variables to which the vascular flora are insensitive.

## Taxon-based biodiversity surrogates

Taxon-based biodiversity surrogates schemes have been used widely in conservation management efforts in many parts of the world. The search for indicators of biodiversity has tended to focus on biological entities (e.g. gene frequencies, populations, species, species assemblages and communities) that might function as surrogates or proxies for other forms of biodiversity and/or reflect changes in ecosystem patterns or processes (Burgman & Lindenmayer 1998). Many types of biodiversity surrogate schemes have been proposed. Some of these include: indicator species, management indicator species, keystone species, umbrella species, and the focal species approach (Lindenmayer et al. 2000). The biodiversity surrogate scheme that has received greatest attention has been 'indicator species'.

The term indicator species has been used to mean many different things. Some examples of types of indicator species include:

1 a species whose presence indicates the presence of a set of other species and whose absence indicates the lack of that entire set of species
2 a keystone species, *sensu* Terborgh (1986), which is a species whose addition to, or loss from, an ecosystem leads to major changes in abundance or occurrence of at least one other species (e.g. Mills et al. 1993)
3 a species whose presence indicates human-created abiotic conditions such as air or water pollution (often termed a pollution indicator species, Spellerberg 1994)
4 a dominant species in the sense that it provides much of the biomass or number of individuals in an area
5 a species that indicates particular environmental conditions like certain soil or rock types (Klinka et al. 1989)
6 a species thought likely to be sensitive to, and to therefore serve as an early warning indicator of, environmental changes like global warming (Parsons 1991) or modified fire regimes (Wolseley & Aguirre-Hudson 1991) (sometimes termed a bioindicator species)
7 a management indicator species, which is a species believed to reflect the effects of a disturbance regime or the efficacy of efforts to mitigate disturbance effects (Milledge et al. 1991).

Types 1, 2 and 4 have been proposed as indicators of biodiversity and types 3, 5, 6 and 7 as indicators of abiotic conditions and/or changes in ecological processes.

Taxon-based biodiversity surrogate schemes have wide appeal because it is simply impossible to measure, monitor and manage all of biodiversity (Burgman & Lindenmayer 1998). The fundamental assumption of all taxon-based surrogate schemes is that if resource management or landscape restoration efforts are targeted at a group of species, the needs of other taxa will be provided. However, as early as the 1980s, several workers raised concerns about the conceptual, theoretical and practical basis for taxon-based surrogate schemes (e.g. Landres et al. 1988). None of these concerns have been adequately answered in the intervening years (Lindenmayer et al. 2000). Some of the many problems which afflict taxon-based surrogate schemes are outlined below.

The effects of human perturbation such as landscape change and habitat fragmentation varies for each species and also between groups of species. Hence, the response of a given species or suite of species to landscape modification may reveal very little about the response of many other species in the same or different assemblage or group.

Any species that is the specific target for conservation by particular management actions can no longer be an independent yardstick of those actions and, in turn, be regarded as a suitable surrogate for other taxa.

There are problems stemming simply from choosing the wrong biodiversity surrogate that can arise from a lack of understanding of the causal relationship between the response of that species and the ecosystem conditions for which it is supposed to be indicate. There are also problems stemming simply from choosing the wrong indicator species. The case of the Bivalve Mollusc (*Velesunio ambiguus*) in Australian river systems is a classic example. Early research suggested that the species was an indicator of the presence of heavy metals (Walker 1981). Subsequent work found that the uptake of heavy metals by *Velesunio ambiguus* did not reflect the extent of pollution in the surrounding riverine system, making the mollusc an unreliable, and thus entirely unsuitable, indicator species (Millington & Walker 1983). Robust causal relationships between surrogates and other elements of biodiversity have never been demonstrated (Lindenmayer et al. 2000).

A recent study of surrogate schemes by Andelman and Fagan (2000) examined the efficacy of an array of types of taxon-based surrogate schemes including indicator species, flagship species and umbrella species. Andelman and Fagan (2000) found that none of the surrogate schemes captured more species or better protected habitat than a given species selected at random from the large databases they assembled to conduct their tests.

Thus, a key problem with taxon-based surrogate schemes is that when a landscape is managed or restored in an attempt to meet the requirements of a given suite of species such as birds (e.g. through the focal species approach) it may be inappropriate to automatically assume that the food, shelter and breeding requirements of other plants and animals in the landscape have also been met.

The inherent problems associated with the use of indicator species and other biodiversity surrogate schemes means that other approaches may be needed to conserve biodiversity as part of ecologically sustainable natural resource management. In the case of forest landscapes,

## Taxon-based biodiversity surrogates

Lindenmayer et al. (2000) recommended the adoption of what they termed 'structure-based' indicators. These included stand and landscape (spatial) level features of forests such as stand structural complexity and plant species composition, connectivity and heterogeneity. In addition to these structure-based indicators, Lindenmayer et al. (2000) advocated the following four key approaches to enhance biodiversity conservation in forests:

- the establishment of biodiversity priority areas (e.g. reserves) managed primarily for the conservation of biodiversity
- within production forests, the application of structure-based indicators, including structural complexity, connectivity and heterogeneity
- the deployment of a risk-spreading approach in wood production forests using multiple conservation strategies at multiple spatial scales
- the adoption of an adaptive management approach to test the validity of structure-based indices of biodiversity by treating management practices as experiments.

**Source:** David Lindenmayer, Australian National University.

No ARC Large Research Grants have been awarded on the subject of surrogates between 1995 and 2000.

## The use of bioregions

### Proportion of bioregions covered by biological surveys

[BD Indicator 14]

The data on this indicator are not readily available at a national or regional level, even for areas with relatively comprehensive survey records such as north-east New South Wales.

## Long-term monitoring

### Long-term monitoring and research sites

[BD Indicator 24.6]

Long-term monitoring sites are permanent sample locations set up to record trends in a range of ecological and biological characteristics. In Australia, there are numerous agencies and programs responsible for the upkeep and continued measurement of long-term monitoring sites. The first long-term monitoring site was a CSIRO site established at Gilruth Plains, Qld, in 1944. The 20 ha grazing exclosure is located within the Warrego floodplain and includes a mix of Mitchell Grass downs, Gidgee drainage line and Spinifex sandhill vegetation. A total of 14 photopoints were established in 1944 and have been rephotographed and interpreted at irregular intervals since. Several studies into the ecology and demography of Mitchell Grass (*Astrebla* spp.) have been conducted using these data, and the understanding from this study informs the management and resource use of the plains.

There is a broad range of motivations for the establishment of long-term monitoring sites. Many of the early sites were established to monitor production systems such as forests and fisheries. Most of the ecological monitoring sites with a non-production focus were established in the 1980s and 1990s, with some notable exceptions. There are also many community monitoring programs which are covered in following sections. Over 80 biodiversity or monitoring programs, covering 1995 to 2001, are also recorded for the AAT (http://www.aad.gov.au).

Global scientific interest in developing a Long-Term Ecological Research (LTER) program is expanding very rapidly, reflecting the increased appreciation of their importance in assessing and resolving complex environmental issues. In 1993,

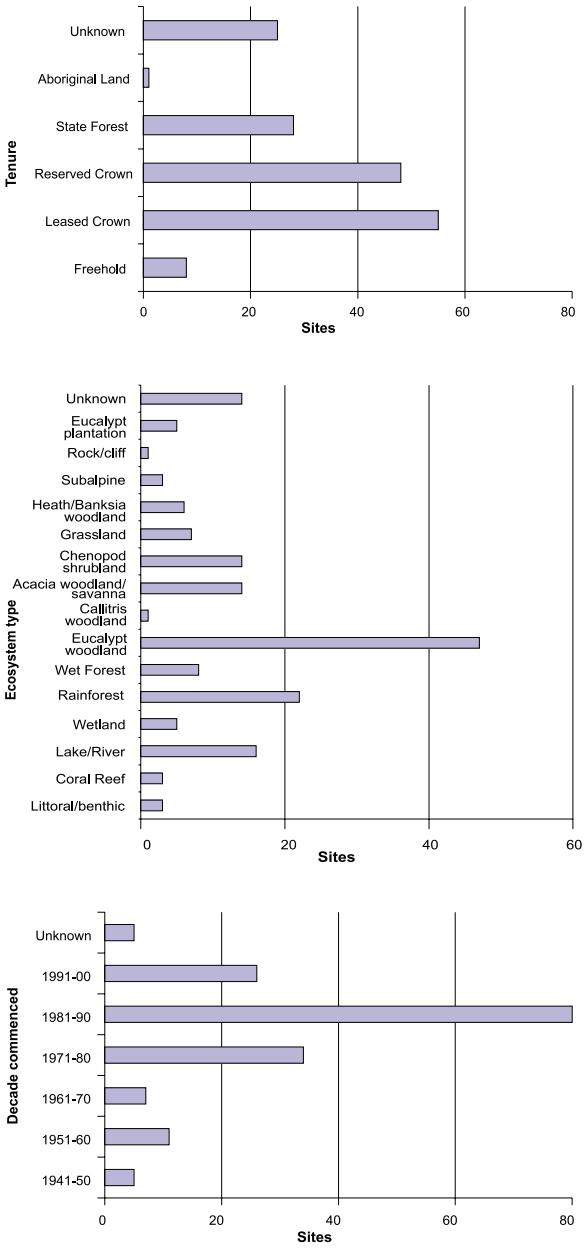



**Figure 55: The number of long-term research and monitoring sites by tenure, ecosystem type and decade commenced.**

About 130 sites are recorded in the ESA database, which while incomplete, provides a base-line for documenting long-term sites around Australia.

**Source:** ESA.

**Table 61: The eight sites recorded in the Ecological Society of Australia's database on long-term ecological research and monitoring sites that sample vertebrates, invertebrates and plants**

| Ecosystem | No. of sites | Location | Project commenced |
|---|---|---|---|
| Coral reef/lagoon | 1 | One Tree Island Reef, Qld | 1974 |
| Eucalypt forest | 1 | Barren Grounds, NSW | 1983 |
| Eucalypt woodland | 1 | Gladstone Block, Qld | 1988 |
| Savanna | 1 | Manbullo, Katherine, NT | 1975 |
| Savanna | 1 | Lake Mere, NSW | 1985 |
| Wet forest | 3 | Central Plateau, Tarraleah, Tas. | 1992 |

**Source:** ESA database (see Figure 55).

the International Long Term Ecological Research (ILTER) network was formed to develop a worldwide program, and the infrastructure necessary to facilitate communication and to manage distributed databases. Australia is a member of this international network and has four sites registered—three of these focus on production forests (two in Queensland and one in Tasmania) and the fourth, which began operations in 1998, is centred around rainforest canopy research at Cape Tribulation, north Queensland.

The only national register of long-term research and monitoring sites is maintained by the Ecological Society of Australia (ESA) (Figures 55 and 56). The database mainly contains sites contributed by members of the Society, and would benefit from a more systematic approach to collecting information. However, with over 130 sites listed, this database represents a very useful starting point to develop a national strategy. The database has site location details for roughly 90% of the study sites listed.

Of the more than 130 long-term monitoring and research sites in the ESA database, only eight are comprehensive in the sense that they sample vertebrates, invertebrates and plants (Table 61). Most sites are dedicated to sampling just one, or more rarely two, taxonomic groups. There is a distinct bias towards monitoring vascular plants, and there is a very uneven distribution of effort across taxa and among ecosystems (Figure 57).

**Figure 56: Distribution of long-term ecological research and monitoring sites across Australia.**

Offshore points are located on islands. Large-scale monitoring programs with many study sites are not mapped. For example, the Rangelands Assessment Program in South Australia, and the Great Barrier Reef long-term change monitoring sites for the Reef CRC in Queensland are not included.

**Source:** ESA database.

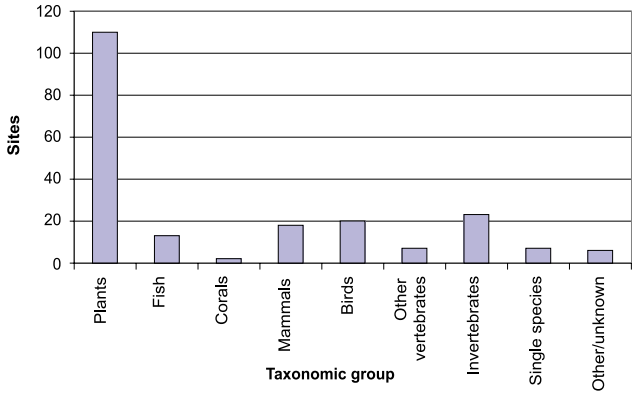



**Figure 57: The number of long-term research and monitoring sites in Australia devoted to sampling various taxa.**

See also Figures 55 and 56.

**Source:** ESA database.

# Roles and responsibilities

This section reports on the following environmental indicators, which are defined in Saunders et al. (1998).

| Environmental Indicator | |
|---|---|
| **BD 13.3** | Number of interest groups involved in protected area planning |
| **BD 13.4** | Resources committed to protected areas |
| **BD 18.3** | Number of lending institutions considering biodiversity |
| **BD 23.1** | Number of local governments with management plans for biodiversity |
| **BD 23.2** | Number of companies with management plans for biodiversity |
| **BD 24.7** | Percentage of budgets spent on conservation |
| **BD 24.8** | Amount of Indigenous ethnobiological knowledge |
| **BD 25.1** | Local government management of biodiversity |
| **BD 25.2** | Involvement of community groups in conservation |

## Introduction

The roles and responsibilities of those involved in biodiversity management have changed significantly in Australia in recent years, and continue to evolve. In the past, different levels of government have traditionally been involved in the conservation and management of biodiversity. Local government and the private sector are now becoming increasingly involved.

## Expenditure on biodiversity

### Government spending on biodiversity

From the ABS (ABS 1999b), it can be seen that governments were the largest users of services and products designed to protect Australia's biodiversity and landscape in 1995–96 and 1996–97, the latest years for which these data are available (Table 62). This provides a broad indication of the level of expenditure of Commonwealth and state governments although it was not possible to present this as a percentage of the overall level of government expenditure. However, a broad comparison can be undertaken with spending at the Commonwealth level on other programs. Budget papers for 1999–2000 indicate that $23.8 billion was spent on Health, $18 billion on Defence, $49.4 billion on Family and Community Services and $11.3 billion on Education, Training and Youth Affairs. More detailed information about spending at the Commonwealth, state and territory and local government level follows.

**Table 62:** **National expenditure for biodiversity and landscape**

| Components | 1995–96 ($000) | 1996–97 ($000) |
|---|---|---|
| **Final consumption** | | |
| General government | **928 643** | **1 056 942** |
| Households | 143 800 | 168 700 |
| Total | 1 072 443 | 1 225 642 |
| **Intermediate consumption** | | |
| All industries | 131 331 | 153 010 |
| **Gross capital formation** | | |
| General government | **305 808** | **115 201** |
| Corporate | 34 097 | 19 008 |
| Total | 339 905 | 134 209 |
| **National expenditure**[A] | | |
| Current | 1 205 994 | 1 379 194 |
| Capital | 339 905 | 134 209 |
| Total | 1 545 899 | 1 513 403 |

[A] Includes subsidies.

**Source:** ABS (1999b).

**Table 63: Natural Heritage Trust funding, 1996 to 2002**
Amounts are in millions ($m). Due to rounding, some column totals may vary within overall totals.

| | 1996–97 $m (actual) | 1997–98 $m (actual) | 1998–99 $m (actual) | 1999–2000 $m (actual) | 2000–01 $m (estimate) | 2001–02 $m (estimate) | Total $m |
|---|---|---|---|---|---|---|---|
| **Vegetation** | | | | | | | |
| Bushcare[A] | 3.7 | 22.2 | 50.2 | 81.6 | 104.8 | 83.8 | **346.5** |
| Farm Forestry Program | —[B] | 2.8 | 6.5 | 11.9 | 16.8 | 9.2 | **47.2** |
| **Inland Waters** | | | | | | | |
| Murray–Darling 2001 Program | 3.8 | 27.5 | 35.0 | 43.0 | 53.8 | 32.6 | **195.6** |
| National Rivercare Program[C] | — | 5.9 | 14.3 | 19.1 | 28.8 | 14.9 | **82.9** |
| Riverworks Tasmania[A] | 1.8 | 2.6 | 0.3 | 4.2 | 0.0 | — | **8.8** |
| National River Health Program[A] | 0.1 | 1.6 | 1.7 | 2.6 | 7.6 | 1.8 | **15.8** |
| Waterwatch[A] | 0.2 | 2.2 | 2.4 | 3.1 | 2.9 | 2.6 | **13.0** |
| National Wetlands Program[A] | 0.5 | 1.6 | 1.6 | 3.8 | 5.8 | 3.8 | **17.1** |
| **Biodiversity** | | | | | | | |
| Endangered Species Program[A] | 2.0 | 2.1 | 6.9 | 5.8 | 5.6 | 5.5 | **27.8** |
| National Reserve System Program[A] | 0.4 | 2.9 | 11.2 | 11.4 | 38.2 | 20.0 | **84.2** |
| **Land Resources** | | | | | | | |
| National Land & Water Resources Audit | 1.3 | 2.4 | 11.8 | 9.8 | 13.7 | 5.4 | **44.4** |
| National Feral Animal Control Program[D] | 3.7 | 3.1 | 1.6 | 2.0 | 6.1 | 2.7 | **18.9** |
| National Weeds Program[D] | 2.1 | 1.3 | 1.6 | 0.9 | 17.8 | 4.8 | **28.5** |
| National Landcare Program (including Landcare Tax measures)[E] | 10.2 | 30.1 | 49.0 | 49.2 | 109.4 | 78.5 | **326.5** |
| Farm Business Improvement Program: Farmbis | 0.4 | 0.3 | 2.6 | 5.6 | 6.0 | — | **15.0** |
| **Coasts and Oceans** | | | | | | | |
| Oceans Policy[AF] | — | — | — | 1.5 | 10.0 | 8.5 | **20.0** |
| Coasts and Clean Seas[A] | — | 8.6 | 20.2 | 28.1 | 35.4 | 24.4 | **116.8** |
| Fisheries Action Program | — | 1.7 | 2.2 | 3.2 | 3.8 | 2.1 | **13.0** |
| **Environment Protection** | | | | | | | |
| Waste Management Awareness Program[A] | 0.2 | 0.6 | 0.7 | 1.0 | 2.4 | 1.1 | **6.0** |
| **Atmosphere** | | | | | | | |
| Air Pollution in Major Cities[A] | 1.3 | 1.5 | 2.4 | 2.9 | 6.3 | 4.1 | **18.5** |
| **Australian Heritage** | | | | | | | |
| World Heritage Area Management and Upkeep[A] | 4.7 | 10.7 | 10.0 | 8.6 | 9.7 | 8.9 | **52.5** |
| **Total** | **36.3** | **131.4** | **232.1** | **299.4** | **485.0[G]** | **314.7** | **1 499.0** |

[A] Programs managed by Environment Australia; [B]Denotes nil; [C]The National Rivercare Program includes funding for Fisheries Action Program freshwater activities; [D]Programs managed jointly by Environment Australia and Agriculture, Fisheries and Forestry—Australia; [E]The National Landcare Program also receives funding from an appropriation under the *Natural Resource Management (Financial Assistance) Act 1992*; [F]Australia's Oceans Policy commitment includes $30 million to come from consolidated revenue funds; [G]Includes $123 million carryover from 1999–2000 to 2000–2001.

**Source:** Natural Heritage and Parks Division, Environment Australia.

## Natural Heritage Trust expenditure [BD Indicator 24.7]

The NHT is a public finance mechanism through which a proportion of the proceeds from the privatisation of the Commonwealth's telecommunications utility are being expended on environmental and resource management programs. Many programs within the Trust are continuation of past programs. Of the programs financed in whole or part through the Trust, some have clear relevance to biodiversity, and thus those expenditures can be identified as

**Table 64: Number and cost (in $000s) of projects funded under the Natural Heritage Trust and related Programs for each state and territory, 1996 to 2000**

| Program | ACT | | External Territories | | NSW | | NT | | Qld | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | $000s | No. | $000s | No. | $000s | No. | $000s | No. | $000s |
| Advanced Property Management Planning | | | | | 1 | 1 190 | 1 | 108 | 1 | 1 475 |
| Air Pollution in Major Cities | | | | | | | | | | |
| Bushcare | 17 | 836 | | | 543 | 30 931 | 86 | 6 028 | 216 | 27 454 |
| Coastcare[A] | | | | | 360 | 4 096 | 9 | 119 | 213 | 2 728 |
| Coasts and Clean Seas | | | 2 | 305 | 90 | 13 450 | 15 | 1 398 | 63 | 9 313 |
| Endangered Species Program | 2 | 184 | | | 53 | 1 739 | 15 | 1 344 | 42 | 3 323 |
| Farm Forestry Program | 1 | 89 | | | 39 | 3 328 | 1 | 273 | 24 | 3 176 |
| Fisheries Action Program | 11 | 184 | 1 | 11 | 14 | 589 | 5 | 352 | 24 | 686 |
| Indigenous Management of Protected Areas | | | | | 3 | 142 | 6 | 344 | 6 | 298 |
| Invasive Species Program (EA) | 2 | 48 | | | 7 | 116 | | | | |
| Landcare Tax Credits | | | | | | | | | | |
| Murray-Darling 2001 Program | 4 | 407 | | | 377 | 39 859 | | | 67 | 11 288 |
| NHT World Heritage Program | | | | | 94 | 9 992 | | | 85 | 19 728 |
| National Feral Animal Control Program | | | | | 6 | 922 | 2 | 106 | 5 | 183 |
| National Land & Water Resources Audit | | | | | | | | | 1 | 158 |
| National Landcare Program | 14 | 961 | | | 522 | 62 193 | 104 | 10 858 | 364 | 40 937 |
| National Moorings Program | | | | | 1 | 22 | | | 2 | 123 |
| National Reserves Program | | | | | 24 | 10 361 | 4 | 671 | 12 | 9 713 |
| National River Health Program | | | | | 2 | 417 | 5 | 347 | 1 | 149 |
| National Rivercare Program | 2 | 241 | | | 99 | 5 562 | 15 | 1 631 | 73 | 8 214 |
| National Weeds Program | | | | | 1 | 70 | 1 | 2 073 | 3 | 1 185 |
| National Wetlands Program | 4 | 251 | | | 29 | 2 084 | 15 | 894 | 13 | 574 |
| Oceans Policy | | | | | | | | | | |
| Pre-Bushcare | 5 | 18 | | | 33 | 492 | 30 | 206 | 35 | 315 |
| Riverworks Tasmania | | | | | | | | | | |
| Tasmanian Regional Forest Agreement | | | | | | | | | | |
| Tasmanian Strategic Natural Heritage Program | | | | | | | | | | |
| Waste Management Awareness Program | 1 | 15 | | | 3 | 450 | 1 | 60 | | |
| Waterwatch | 7 | 394 | | | 28 | 1 267 | 9 | 529 | 18 | 1 199 |
| **Totals** | **70** | **3 628** | **3** | **316** | **2 329** | **189 272** | **324** | **27 341** | **1 268** | **142 219** |

**Table 64: Number and cost (in $000s) of projects funded under the Natural Heritage Trust and related Programs for each state and territory, 1996 to 2000 (continued)**

| Program | SA | | Tas. | | Vic. | | WA | | Nat. | | Total projects | Total funding |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | $000s | No. | $000s | No. | $000s | No. | $000s | No. | $000s | | No. |
| Advanced Property Management Planning | 1 | 780 | 1 | 372 | 1 | 1 757 | | | | | 6 | **5 682** |
| Air Pollution in Major Cities | | | | | | | | | 18 | 5 093 | 18 | **5 093** |
| Bushcare | 305 | 16 909 | 114 | 10 524 | 334 | 19 689 | 245 | 24 661 | 27 | 25 861 | 1887 | **162 893** |
| Coastcare[A] | 290 | 2 007 | 133 | 1 028 | 334 | 2 807 | 218 | 3 986 | | | 1557 | **16 771** |
| Coasts and Clean Seas | 33 | 3 223 | 59 | 7 242 | 44 | 6 144 | 53 | 5 192 | 15 | 2 261 | 374 | **48 528** |
| Endangered Species Program | 37 | 1 524 | 27 | 2 151 | 42 | 2 695 | 59 | 5 045 | 44 | 5 554 | 321 | **23 559** |
| Farm Forestry Program | 18 | 1 474 | 20 | 1 362 | 37 | 3 290 | 13 | 3 282 | | | 153 | **16 274** |
| Fisheries Action Program | 12 | 446 | 15 | 1 129 | 14 | 622 | 13 | 723 | | | 109 | **4 742** |
| Indigenous Management of Protected Areas | 9 | 562 | 6 | 324 | 4 | 146 | 8 | 593 | | | 42 | **2 409** |
| Invasive Species Program (EA) | 1 | 40 | | | 1 | 25 | 4 | 383 | 5 | 296 | 20 | **908** |
| Landcare Tax Credits | | | | | | | | | 1 | 499 | 1 | **499** |
| Murray-Darling 2001 | 173 | 11 732 | | | 216 | 51 485 | | | 2 | 5 907 | 839 | **120 678** |
| NHT World Heritage Program | 29 | 1 417 | 21 | 15 315 | | | 53 | 2 151 | | | 282 | **48 603** |
| National Feral Animal Control Program | 2 | 496 | 5 | 947 | 9 | 912 | 5 | 494 | 14 | 1 735 | 48 | **5 795** |
| National Land & Water Resources Audit | 2 | 265 | | | 1 | 97 | 2 | 515 | 6 | 20 967 | 12 | **22 002** |
| National Landcare Program | 240 | 39 778 | 138 | 12 582 | 338 | 43 289 | 286 | 45 521 | 1 | 5 700 | 2007 | **261 819** |
| National Moorings Program | 1 | 56 | 1 | 9 | | | 1 | 75 | 1 | 136 | 7 | **421** |
| National Reserves Program | 14 | 2 778 | 6 | 775 | 16 | 1 752 | 38 | 5 128 | 3 | 87 | 117 | **31 265** |
| National River Health Program | 2 | 840 | | | 1 | 65 | 2 | 331 | | | 13 | **2 149** |
| National Rivercare Program | 27 | 2 388 | 65 | 6 539 | 34 | 3 769 | 73 | 9 005 | | | 388 | **37 349** |
| National Weeds Program | | | | | | | 1 | 35 | 5 | 410 | 11 | **3 773** |
| National Wetlands Program | 23 | 957 | 21 | 512 | 23 | 794 | 21 | 644 | 25 | 3 552 | 174 | **10 262** |
| Oceans Policy | | | | | | | | | 2 | 166 | 2 | **166** |
| Pre-Bushcare | 75 | 359 | 47 | 356 | 74 | 449 | 59 | 548 | 2 | 300 | 360 | **3 043** |
| Riverworks Tasmania | | | 37 | 7 916 | | | | | | | 37 | **7 916** |
| Tasmanian Regional Forest Agreement | | | 27 | 3 164 | | | | | | | 27 | **3 164** |
| Tasmanian Strategic Natural Heritage Program | | | 5 | 13 357 | | | | | | | 5 | **13 357** |
| Waste Management Awareness Program | | | 1 | 400 | 1 | 100 | | | 11 | 1 459 | 18 | **2 484** |
| Waterwatch | 8 | 1 043 | 16 | 1 077 | 8 | 1 383 | 6 | 1 024 | 5 | 499 | 105 | **8 415** |
| **Totals** | **1 302** | **89 074** | **765** | **87 081** | **1 532** | **141 270** | **1 160** | **109 336** | **187** | **80 482** | **8 940** | **870 019** |

[A] Coastcare is jointly funded by the Commonwealth, through the Natural Heritage Trust, and the States and Northern Territory. These total project costs are combined Commonwealth and State/NT funds

**Source**: Environment Australia

biodiversity expenditure (e.g. NRSP, ESP). For the bulk of programs, biodiversity may benefit from expenditure, but the focus is on other issues (e.g. Waterwatch, Landcare). Tables 63 and 64 provide details of NHT funding for several programs as an overall figure (Table 63) and at the state and territory level (Table 64). The total numbers vary because of the different periods covered.

In 1999 to 2000, those projects under NHT funding and directly related to biodiversity conservation (the NRSP and the ESP) received a total of $17.2 million (Table 63). This amount has grown considerably since 1996 to 1997, although as a proportion of total NHT spending, has fallen to 5.7% after an outlay of 7.8% in 1998–99. Projections to 2001–02 indicate that this proportion will rise again to around 8.1% of total NHT funding.

New South Wales receives the most funding for biodiversity-related projects funded under the NHT with a total of 2329 projects receiving $189 million. Victoria and Queensland closely follow with around $142 million. Nationally, around $870 million has been spent on NHT projects with the National Landcare Program receiving the greatest funding.

### Parks and conservation expenditure [BD Indicators 13.4 and 24.7]

Budget allocations to the prime nature conservation agency in each jurisdiction are one measure of expenditure. Total expenditure by parks and conservation services in each state (Table 65) shows that New South Wales has by far the largest budget at over $220 million. However, estimates of expenditure per person for each state reveals that although it has a small total budget, the Northern Territory has the largest expenditure per capita. Tasmania, with the smallest area and population, has the second highest expenditure per person on protected areas of all the states ($55.82 per head).

**Table 65: Total expenditure on Protected Areas by State and Territory, 1998 to 1999**
Data on spending across jurisdictions are rarely comparable, given different accounting and budget reporting formats.

| | NSW[A] | NT[B] | SA[C] | Vic.[D] | Qld[E] | Tas.[F] | WA[G] |
|---|---|---|---|---|---|---|---|
| Total expenditure ($000) | 224 512 | 35 696 | 64 826 | 114 817 | 169 398 | 26 345 | 40 010 |
| Population (No.) | 6 342 000 | 190 000 | 1 487 000 | 4 661 000 | 3 456 000 | 472 000 | 1 831 000 |
| Expenditure per person ($/head) | 35.40 | 187.87 | 43.60 | 24.63 | 49.02 | 55.82 | 21.85 |

Annual Reports for: [A] NSW NPWS (1999); [B] PWC of the Northern Territory; [C] National Parks and Botanic Gardens (1999), Department of Environment, Heritage and Aboriginal Affairs; [D] Parks Victoria (1999); [E] Environment Protection Agency (1999) (including the Queensland Parks and Wildlife Service); [F] Department of Primary Industries Water and Environment, National Parks and Public Land Management Services (1999); [G] Conservation and Land Management, Nature Conservation Division.

**Source:** ABS (1999c) and Annual Reports for state government agencies.

Within each jurisdiction, investment is spread across a range of activities. However, both in practice and as reflecting through reported budgets, these allocations are not comparable. For example, expenditure in some states and territories on research and law enforcement is recorded separately, while in others it is not. An example of the allocation of expenditure within a nature conservation agency is provided by the Northern Territory PWC. These data reveal that most of the expenses (42%) are incurred in park management (Table 66); scientific services account for 22% of total expenditure.

## Local government and biodiversity

Australia has around 700 local government authorities, including large city councils with many hundreds of staff; rural councils with large land areas and few human and financial resources; wholly urban councils; and Indigenous community councils. Councils have a range of policy and management functions, including:

- land use planning and development control, within the framework of state and territory planning legislation
- maintenance and development of physical infrastructure, such as drainage and roads
- waste management, including household and industrial wastes and sewerage treatment and disposal
- provision of local community educational infrastructure (e.g. libraries) and community awareness programs
- management of open space for recreation and conservation
- pollution control.

**Table 66:** **Northern Territory Parks and Wildlife Commission expenditure by activity**

| Activity | Expenditure ($000) |
|---|---|
| Alice Springs Desert Park | 3 290 |
| Bushfire Protection | 3 645 |
| Community Service Obligation | 2 825 |
| Corporate Management | 2 823 |
| Park Management | 15 111 |
| Scientific Services | 8 002 |
| Total | 35 696 |

**Source:** PWC (1999).

These and other functions are highly relevant to the local and regional management of biodiversity, which is a relatively new responsibility for local government. Over recent decades, the number and complexity of local government functions have increased, but support in terms of policy, legislation, information and human and financial resource has very often not kept pace. Full discussion of the implications of this situation with respect to native vegetation management can be found in Binning et al. (1999), Cripps et al. (1999) and Binning and Young (1999).

The importance of local government in biodiversity conservation is recognised in the NSCABD. Over recent years, considerable policy development has occurred through revised planning schemes, local conservation strategies and the Local Agenda 21 initiative that flowed from the 1992 United Nations (UN) Conference on Environment and Development. More recently, a national policy for local government biodiversity management has been developed (ALGA 2000). Two examples of how local governments are responding to these challenges are given in the *Vegetation and koala protection in Redland Shire* box below and the *Manningham City—Greenprint and LEAF* box on page 166.

### Local government provisions for biodiversity [BD Indicator 23.1]

In November 1998, the National General Assembly of Local Government unanimously voted to endorse a National Local Government Biodiversity Strategy (NLGBS). This important development establishes a common policy direction for all local government bodies across Australia, recognising the importance of biodiversity and the need for integrated local

## Vegetation and koala protection in Redland Shire, Queensland

Redland Shire, to the south-east of the main Brisbane city area, contains a mixture of urban and non-urban land uses and has the range of environmental and biodiversity issues typical of such an area. It is a high-population growth area with many pressures for development and significant remnant native vegetation areas. Among other specific issues, some vegetation in the Shire is habitat for the Koala (*Phascolarctos cinereus*) and is subject to the Queensland Government's State Planning Policy (SPP) 1/97 *Conservation of koalas in the Koala Coast*. Redland Shire Council's gazetted Strategic Plan of 1998 incorporates detailed provisions for environmental protection and ESD, including habitat protection and the implementation of SPP 1/97 (Strategic plan S3.1.1c).

Redland reflects a wider trend in local government to extend traditional 'tree preservation orders', that concentrated on urban trees and their visual amenity, toward more broadly based vegetation protection policies including a range of biodiversity values. In Redland Shire *Local Law No. 6: Protection of Vegetation* (No. 1 of 1998), the Shire sets out the process for permission to remove or damage vegetation, assessment procedures, possibilities for removing protection orders, and so on. The definition of 'significant vegetation' in the Law covers a wide range of values, including Indigenous cultural significance, role as wildlife habitat or wildlife corridor, rare or threatened species status, educational or recreational use, aesthetic appeal, and importance to 'maintaining life-supporting capacities of ecological systems for present and future generations'. While, as with all recent policies and laws, implementation of this measure cannot be assessed as yet, this is an example of some of the key definitions and intents of the Convention for Biodiversity being translated into practical local contexts in a relatively short time.

## Manningham City—Greenprint and LEAF

Manningham City covers 113 square kilometres, 12 km north-east of the Melbourne central business district, with a population of 110 500. The council area comprises suburban, rural and natural areas, with significant scenic and biodiversity values attached to some riparian zones and to remnant forest areas. Manningham City's overall Greenprint and specific biodiversity programs are characteristic of evolving trends in environmental management in local government. The former City of Doncaster and Templestowe produced a conservation strategy in 1991 and following the 1992 Earth Summit was active in Local Agenda 21. Review of these experiences led to the development of the broader Greenprint, which is a council-wide strategy. Greenprint includes the Council's EMS, staff training programs, and public awareness initiatives. Core to the strategy are five 'stretch goals' to be pursued in the longer term:

- zero climate damage
- zero extinction
- zero pollution
- zero soil degradation
- zero waste.

For each, there is a defined range of targets, indicators for each target, and evolving action plans and time lines. The proposed actions for zero extinction include maintenance of a database of flora and fauna, various strategies for pest and weed control, promotion of the use of native plants in gardens and development of incentives for conservation on private land. Targets relevant to biodiversity conservation include:

- number of nurseries in Manningham City stocking more than five environmental weeds or potential weed species; currently ten, target zero by the end of 2004.
- number per area of properties in Manningham registered under the Victorian governments 'Land for Wildlife' program; currently 37 properties, target 70 by the end of 2004
- area of land per number of properties under conservation covenant; currently one property per 119 ha, target 10 properties by end of 2005.

To encourage conservation on private land, in 1999 the council made $40 000 available through the Local Environment Assistance Fund (LEAF). Under this program, landholders can gain assistance for conservation in the form of Land Protection Works grant (dollar-for-dollar up to $800), a Property Management Planning Course, and through Melbourne Water's Rural Stream Frontage Program.

**Source:** Manningham City Council (1998).

government approaches and actions. It complements the national biodiversity strategy. The Strategy defines the following objectives and suggested actions to address five key issues (ALGA/BDAC 1999).

1 *Awareness, training and education*: to develop a national awareness, training and education program. *Suggested actions include*: establishing a local biodiversity support network, promotion of success stories and establishment of an award system, and provision of specific support to rural councils to develop and implement local planning regulations to assist biodiversity conservation.
2 *Local government resourcing*: Local government resourcing is needed to ensure adequate resource for all interested Councils or regional organisations in order to have a greater role in biodiversity conservation. This includes addressing the specific requirements of Indigenous communities. *Suggested actions include*: auditing of existing programs to ensure cost effective delivery, supporting environmental officers in Councils or regional groups to develop and implement local biodiversity conservation strategies, and introducing rate rebate schemes for biodiversity conservation (see Binning & Young (1999) for a discussion and examples).
3 *Regional partnerships and planning*: To encourage regional partnerships and planning, preferably along existing regional boundaries. *Suggested actions include*: directing resources to regional planning and implementation and, where appropriate, providing statutory support for regional authorities to have a coordinating role, integrate biodiversity concerns with existing processes and programs (e.g. catchment planning, NHT); and support regionally administered incentive schemes (e.g. Greening Australia's fencing incentives program).
4 *Legislative frameworks*: to encourage state governments to review, and possibly amend legislation relating to the role of local government in managing biodiversity (e.g. planning, local government and environment Acts). *Suggested actions include*: developing all catchment and regional plans in cooperation with local government and incorporating them into Council planning schemes; allowing local government to raise special purpose levies, if they wish to have a greater role in biodiversity conservation (as is done in

Brisbane City and elsewhere); and encouraging consistency between states and state Acts that relate to biodiversity.

5 *Information and monitoring*: to establish a nationally coordinated information and monitoring system which is integrated with existing databases, to provide Councils with basic information on biodiversity in their area. *Suggested actions include*: ensuring local government has access to existing state and national data systems, preferably on GIS; establishing data standards and protocols, and ensuring data are delivered at a relevant scale; and providing training, tools and technology transfers to local managers.

These objectives serve to focus efforts, and provide a basis for monitoring and evaluation of local government needs and achievements in biodiversity conservation.

### Environment Resource Officers

The Commonwealth, through Environment Australia, funds environment resource officers (EROs) at state level to serve as a focus and a resource for local government in environmental management, operating at the strategic level of state local government associations. EROs report quarterly to EA and their reports serve as a valuable interjurisdictional information flow. Much of their work is directly relevant to biodiversity. Examples include fauna road-kill education programs in Tasmania, assistance to local councils in accessing NHT funding in Queensland, representation of a local government perspective into SoE reporting in New South Wales, and development of urban biodiversity programs (e.g. Bush Forever) in the Perth region in Western Australia.

### Local government spending

Recent surveys have begun to build a picture of the financial and human resources committed to biodiversity and other environmental issues by Australian local authorities. On the basis of resources committed, the ABS (ABS 2000) established that local government has a significant part in managing Australia's environment.

In 1998 to 1999, it is estimated that local governments spent $2.1 billion in environmental expenditure, or an average of $114 per capita. Of the total, 90% was sourced from council's household and business rates rather than from intergovernmental transfers (the states provided $118 million and the Commonwealth $20 million to total revenue in this area). Tasmania spent more than other states on a per capita basis, and Western Australia the least. Of the total, most was spent in traditional areas such as waste water treatment and waste management. But $106 million was spent on measures directly relevant to biodiversity, such as tree planting, preventing land degradation, weed control and protecting streams. Relative to other areas of local government environmental expenditure, biodiversity programs were more reliant on grants and subsidies from other levels of government.

### A progress report [BD Indicator 25.1]

The Australian Local Government Association (ALGA) completed a recent study (ALGA 2000) that explored the situation and progress with implementing the NLGBS. This survey provides a very important baseline data set, with some two-thirds of local authorities responding. At the broadest level, 40% of responding councils have incorporated biodiversity considerations into their corporate planning exercises, indicating a significant level of 'mainstreaming' of biodiversity at this level of government. More specifically, 46% of councils own or manage natural or constructed wetlands and 58% have planning provisions aimed at wetland conservation. One-quarter of councils have or are drafting recovery plans for threatened species, and 43% have policies for the management of native vegetation occurring on roadsides. About 34% have developed a Local Agenda 21 or ESD plan.

The work of many staff in local government involves them in biodiversity issues, but the clearest indication of commitment is the provision of a dedicated environmental officer. The ALGA survey (ALGA 2000) provides the percentage of councils (that responded to the survey) that have environmental officer (Table 67).

The ALGA survey also sought to determine the number of councils with an environmental conservation strategy (Table 68).

## The Australian private sector and biodiversity

The private sector is crucial to the protection of biodiversity, but the importance of including firms and industries in biodiversity policy formulation and implementation has only been fully recognised in recent years. Traditionally, simple regulatory approaches have been relied

**Table 67: The percentage of local councils with an environmental officer**
The figures are based on those that responded to the ALGA (2000) survey.

| State | Percentage (%) |
|---|---|
| NSW | 28.2 |
| NT | 40.0 |
| Qld | 30.0 |
| SA | 33.9 |
| Tas. | 37.0 |
| Vic. | 60.7 |
| WA | 27.7 |

**Table 68: The proportion of local councils with an environmental conservation strategy**
The figures are based on those that responded to the ALGA (2000) survey.

| State | Percentage (%) |
|---|---|
| NSW | 13.7 |
| NT | 20.0 |
| Qld | 16.0 |
| SA | 11.9 |
| Tas. | 22.2 |
| Vic. | 47.5 |
| WA | 14.5 |

on, with little proactive involvement by the private sector. Now, consistent with evolving policy and management approaches – use of non-regulatory approaches, participation, self-regulation, development of green markets, etc.—the position of the private sector in environmental management has changed.

Proposed and emerging market-based approaches, such as biodiversity, carbon credits, ecosystem service credits or tradeable water rights and fisheries quotas, have significant implications for biodiversity. Some attention has recently been given to ecological aspects of water market reform (Cullen et al. 2000).

## Plans to minimise impact of development: Corporations [BD Indicator 23.2]

This information was unavailable for this report.

*Environmental management guidelines*

Broad guidelines for environmental management for corporations have become available in recent years. The development of these by standards organisations is an indicator of how mainstream environmental management is in the corporate world. However, the guidelines tend to be non-specific in terms of biodiversity. Of potentially high significance to biodiversity management, as a management area pervaded by uncertainty and poorly understood causal relationships, is the development of an Australian Standard for Risk Management (Standards Australia 1999), and the production of a handbook for the implementation of the Standard in the environment arena (Standards Australia 2000).

Codes of practice and similar mechanisms have increasingly been developed as self-regulatory approaches within sectors, although the inclusion of biodiversity issues is rarely specific or detailed. Some examples include the following:

- The Responsible Care Program of the chemical industry
- The Environment Institute of Australia's Code of Ethics and its (under development) Policy Statement on EMSs
- Electricity Supply Association of Australia Code of Environmental Management
- Minerals Council of Australia's Code for Environmental Management (see *The mining sector*)
- Development of standards and accreditation schemes in the ecotourism sector (see the *Certification and accreditation in the Ecotourism industry* box on page 169).

## Certification and accreditation in the ecotourism industry

Australia's biodiversity and natural landscapes are crucial to the economically and socially important tourism industry. Nature-based tourism can be a strong justification and source of resources for preservation, but also, if inappropriately managed or poorly informed, a threat to biodiversity in some locations. The capability and competence of tourist operators and guides can, therefore, determine the potential to assist with protection of biodiversity, both by allowing recognition of its economic importance, and in an educational sense, by exposing the public to quality experiences and information. With the great bulk of the industry comprising domestic tourism, the educational dimension is particularly important.

Rapid growth of nature-based tourism in Australia in the 1990s has led to concerns over the quality, information base, competency and effect of tourism service providers with respect to natural history, biodiversity, Indigenous culture and other issues. The need for standards of practice and competence has been increasingly recognised.

The need for proper accreditation, skills and training has been the subject of a new initiative by the Ecotourism Association of Australia (EAA 2000), which is supported by funding from the Office of National Tourism, and works together with industry, government and other stakeholder interests. Building on the existing Nature and Ecotourism Accreditation Program (NEAP II, released in 2000), this collaboration has led to the development of a national Nature and Ecotour Guide Certification Program (NEGCP).

The NEGCP, launched in late 2000, is a voluntary, industry-based initiative aimed at promoting, recognising and rewarding best practice by nature and ecotour guides. It has been designed to suit both experienced operators with existing skills, as well as people entering the industry. Certification is based on benchmarks defined around:

- core tour guide competencies for the tourism sector generally
- specific competencies developed for ecotourism, including minimal impact procedures, ecological knowledge, cultural sensitivity and interpretation skills
- experience
- commitment to professional development
- adherence to a code of ethics.

A flexible scheme of certification both assesses competencies of guides and contributes to further professional development by identifying training needs. A nationwide cadre of trained assessors is being developed to implement the Program.

This Program reflects the growing acceptance of biodiversity issues and the environment more generally as matters of accepted industry concern and practice, and deserving of high and consistent professional standards. In the case of the NEGCP, it will assist in ensuring that nature-based tourism will be better managed, and that people's experience of Australia's biodiversity will be based on quality information and high levels of professional practice.

**Source:** Ecotourism Association of Australia 2000, *Nature and Ecotour Guide Certification Program: Progress report June 2000*. Unpublished report.

*Environmental reporting*

Many corporations and industry sectors are now participating in 'green' labelling and accreditation systems. The fisheries and forestry sectors have developed initiatives to encourage and deliver market-driven incentives for sustainable production: the Forest Stewardship Council (FSC) (1993) and the Marine Stewardship Council (MSC) (1996). The Councils combine industry, environmental, community and Indigenous interests, and display of the FSC or MSC logos requires that products are harvested and processed in line with stated principles and criteria. The Western Rock Lobster fishery gained MSC certification in 2000.

Public environmental reporting by Australian corporations is an area of increasing activity and can be regarded as a major, recent development. Potentially, environmental reports can be a key mechanism for public disclosure of a corporation's effect on the environment (including biodiversity) and for continual monitoring and improvement in performance. However, the apparent relevance of available reports to biodiversity is generally compromised by lack of detail or specificity.

*The mining sector*

A major NGO concerned with biodiversity issues, World Wildlife Fund (WWF) Australia, independently assesses environmental reporting in the mining sector undertaken in line with the Australian Minerals Council's (AMC) Code for Environmental Management (WWF Australia 2000). This review does not deal with actual environmental performance, but rather the adequacy of reports. The assessment considered 32 reports out of 45 total signatories to the AMC's Code. The reports themselves do not contain consistent or detailed information

on biodiversity. However, given that the mining industry has been a leader in environmental reporting, the sector's reports can be viewed as a benchmark against which future reporting across sectors can be assessed. Some key findings of the WWF review include that:

- reporting standards have improved in some regards between the first (1999) and second (2000) surveys, but that considerable room for improvement exists
- larger firms and those who have a specific environmental report (rather than including it in a general annual report) produce better reports
- lack of stated performance standards and targets continues to be a problem
- external verification and review of reports is a consistent weakness in reporting processes, a problem the WWF believes can be addressed through the inclusion of external stakeholders in the reporting process; however, external verification of reports is subject to considerable debate (e.g. Solomon 2000).

With respect to external verification and participation in corporate environmental management, an example has been set by BHP Cannington's invitation to the North Queensland Conservation Council (NQCC) to appraise the environmental performance of its operation (BHP/NQCC 2000). Utilising its own resources as well as engaging independent expertise, the Council assessed performance against legislative standards, stated corporate goals, and ESD principles as defined by the Council. The process and resulting evaluation are viewed by both the firm and the Council as improving transparency, establishing better understanding between the corporation and community, and supporting ongoing improvement of environmental performance. This collaboration sets an important precedent.

*Other sectors*

Environmental reporting is less common in sectors other than mining, and very often the relevance to biodiversity is less clear. Jeyaretnam et al. (1999) noted that the frequency and quality of Australian reporting are both lower than in Europe or North America, but that both are increasing.

## Number of lending institutions considering biodiversity [BD Indicator 18.3]

Australia's biodiversity is used every day to support economic activity. The agricultural, pharmaceutical and forestry industries are just a few sectors of the Australian economy that benefit and profit from the use of biodiversity. Since virtually every industry relies on using, or having access to, biological resources, it is in the best interests of industry to ensure that the supply of those resources is not diminished or destroyed.

In Australia, several institutions and businesses now provide environmentally responsible investment advice and investment funds that support a diverse range of activities including regional reafforestation programs, land rehabilitation, native vegetation protection and regional ecotourism. As a result of concerns regarding the environmental damage done in Papua New Guinea to the Ok Tedi and Fly Rivers by BHP's Ok Tedi copper mine, shareholders in BHP have formed a group known as 'BHP Shareholders for Social Responsibility' to encourage socially and environmentally responsible codes of corporate practice. BHP Iron Ore has developed its EMS in accordance with the international standard ISO 14001.

If governments and business are to be 'part of the solution' rather than 'part of the problem' in the push for sustainable development and biodiversity conservation, then their governance and day-to-day activities need to reflect this role. Progressive businesses, for example, would be expected to adopt and implement environmental codes of practice, and to ensure that their investments were environmentally sound and consistent with sustaining biodiversity (Gasser & Cocker 2000).

Since investors increasingly try to objectively assess the environmental performance of companies when making investment decisions, Westpac and Monash University have introduced the Eco Index. This is Australia's first index of share price performance for leading eco-rated listed companies and is intended to identify better environmental performers on a relative basis. As at 31 July 2001, the index contained 82 companies from 24 sectors (Westpac 2001). Analysis of the performance of these companies suggests that good environmental performance need not hinder economic performance, even under the current legal and policy framework.

Lending institutions such as banks and superannuation funds provide much of the investment capital for business in Australia. The way these funds are used can benefit

biodiversity and support its conservation, or degrade and destroy it. Hence, lending institutions can contribute to good environmental and biodiversity outcomes in Australia if the principles by which they are prepared to loan money strongly reflect these needs.

*Ethical investments*

As yet, few lending institutions have adopted biodiversity conservation as a primary principle or criterion for lending. Instead, several lending institutions and the companies in which they invest have adopted principles for socially responsible investment (SRI). SRI may be driven by perceived financial advantages to companies that invest in this manner, by ethical reasons or by the so-called 'triple bottom line' (i.e. good financial, environmental and social outcomes). Some entities such as Australian Ethical Investments (AEI) Limited, which commenced in 1986, and Australian Ethical Superannuation have been operating using a SRI framework for over 10 years. AEI is owned by around 100 shareholders who share the aims and aspirations of the Australian Ethical Charter (Table 69) which guides the investment of funds. The Charter supports outcomes such as the preservation of endangered ecosystems and the development of sustainable land use and food production, and avoids investments that may unnecessarily pollute the land, air and water.

**Table 69: Ethical investment charter**

| **The Australian Ethical Charter seek out investments which provide for and support the:** |
|---|
| development of worker participation in the ownership and control of their work organisations and places |
| production of high quality and presented products and services |
| development of locally based ventures |
| development of appropriate technological systems |
| amelioration of wasteful or polluting practices |
| development of sustainable land use and food production |
| preservation of endangered ecosystems |
| activities which contribute to human happiness, dignity and education |
| dignity and well-being of non-human animals |
| efficient use of human waste |
| alleviation of poverty in all its forms |
| development and preservation of appropriate human buildings and landscapes. |
| **Avoid any investment which is considered to unnecessarily:** |
| pollute land, air or waters |
| destroy or waste non-recurring resources |
| extract, create, produce, manufacture, or market materials, products, goods or services which have a harmful effect on humans, non-human animals or the environment |
| market, promote or advertise, products or services in a misleading or deceitful manner |
| create markets by the promotion or advertising of unwanted products or services |
| acquire land or commodities primarily for the purpose of speculative gain |
| create, encourage or perpetuate militarism or engage in the manufacture of armaments |
| entice people into financial overcommitment |
| exploit people through the payment of low wages or the provision of poor or unsafe working conditions |
| discriminate by way of race, religion or sex in employment, marketing, or advertising practices |
| contribute to the inhibition of human rights generally. |

**Source:** after Australian Ethical Investment (2000).

Since the mid-1990s, many more lending institutions have begun to give attention to environmentally responsible investments including those consistent with biodiversity conservation. For example, the Hunter Hall Trust is the largest ethical fund in Australia. Its investment policy restricts investment in companies that derive profits from alcohol, tobacco, armaments, gambling, destruction of the environment or cruelty to animals. The Trust also

donates 10% of performance fees to charities that support good environmental and biodiversity conservation outcomes. The HESTA Superfund has developed an 'ecopool', allowing members to invest a portion of their superannuation into cash and shares of companies listed on the Australian Stock Exchange that have been screened for environmental performance. AEI Ltd supports a number of trusts, including the Australian Ethical Equities Trust, which provides a service that has been taken up as an investment choice by the Credit Union Superannuation Fund. Quadrant Superannuation Fund offers an ethical investment strategy in a choice of five options, which commenced in July 1997, while the Health Employees Superannuation Trust of Australia offers an environmental screened investment strategy in a choice of options that commenced 1 February 2000.

The Bendigo Bank recently commenced an alliance called The Ethical Investment Trust, which is a Community Aid Abroad initiative. The fund is offered exclusively through and managed by the Bank. Investments are required to be beneficial both socially and environmentally, and all proceeds are distributed to Community Aid Abroad. Earth Sanctuaries Limited offers investors the opportunity to directly and principally support biodiversity conservation goals. This publicly traded company establishes safe areas or sanctuaries for the introduction of rare and endangered Australian wildlife that have declined or become regionally extinct as a result of European activities on the Australian continent. UniSuper, the major superannuation fund for Australian universities, has recently tested the interest of members in an ethical investment option.

Estimates of the total amount of ethical investment funds in Australia vary greatly, but may approach $1 billion. This range compares to an estimate of US$350 billion for similar investments in the United States economy (Gasser & Cocker 2000). Whatever the true amount, investments of this kind in Australia are modest in the context of the billions of dollars managed by national lending institutions. Even so, this situation has the potential to change rapidly as commercial and ethical concerns and policy changes give enhanced prominence to environmental sustainability and biodiversity conservation.

*Philanthropic funding*

In addition to the investment funds managed by these lending institutions, many philanthropic groups and trusts regularly donate and provide very important funds and significant support for biodiversity conservation and research. For example, the Westfield Trust allocates $2 million per year in six key areas of community development including heritage conservation. The Myer Foundation provides vital funding such as the recent $1 million donation to CSIRO for research on the role of essential ecosystem services for humanity.

The Australian Bush Heritage Fund has, as a result of a generous bequest, acquired a 59 000 ha property (Carnarvon Station adjacent to the Carnarvon National Park) in southern Queensland that encompasses seven regionally endangered ecosystems, while Birds Australia have recently acquired 'Newhaven', a large and biologically rich pastoral property in central Australia. The Victorian Trust for Nature has supported biodiversity conservation across a range of ecosystems in Victoria and provides funds for research on rare and endangered species across this region. In Western Australia, the Lotteries Commission, through the Gordon Reid Foundation, makes available a portion of its tax revenue for investment in good environmental outcomes at the community level. It is able to do so because conservation is deemed a 'charity'.

## Involving the community in conservation

### Community involvement in biodiversity conservation [BD Indicators 13.3 and 25.2]

In recent years, there has been a strong trend towards community-based or participatory approaches to biodiversity policy and planning. As attention shifted from reservation and the management of the reserve estate to off-reserve areas and management of biodiversity across tenures and landscapes, the broader involvement of groups and individuals is necessary. Broadly, the justifications for increased community participation are: a democratic ideal that people should be involved in policy and management that affects them, the greater likelihood of lasting and more effective management strategies when these are subject to wider support in the community, and that managing biodiversity involves public and private sector and community decisions.

Against this, there is a tension perceived by some commentators that community-based programs may replace, rather than build on or complement, government's own efforts, with the latter declining through cost shifting or reduction in traditional public sector activities at state and territory level.

By far the greatest emphasis has been on community-based groups such as Landcare and Waterwatch, and these are discussed below. However, organised community groups and individuals may participate in biodiversity policy, management and practice in a much wider variety of ways, including:

**Community-based Citizens Wildlife Corridor project, Northern Tablelands of New South Wales.**

The series of 1:100 000 map sheets show native vegetation in the Armidale region and the properties that are part of the wildlife corridor scheme.

- as voters at three levels of government
- as members of, for example, interest or advocacy groups and industry associations
- through legal standing and access to information in planning law
- through representatives on statutory boards or advisory committees, informal advisory bodies, reserve management boards and similar organisations
- through involvement in particular policy processes
- as members of or through representatives on regional or catchments organisations
- as members of community-based management or monitoring groups
- as consumers making choices based on biodiversity considerations
- in workplaces subject to environmental codes of practice
- as individuals engaging in biodiversity-related activities on private land.

Since the mid-1990s, representatives of major interest groups have been closely involved in development of major policies, such as the NSCABD, Oceans Policy and National Principles and Guidelines for Rangelands Management. Public participation in the RFA process varied widely across jurisdictions. In some jurisdictions, standing and rights to object to development proposals have been curtailed. Development of a clearer mutual understanding of expectations of and roles in policy development processes between interest groups and governments may be desirable as part of the ongoing evolution of partnership arrangements.

Most jurisdictions have created arrangements whereby interest groups have ongoing input into biodiversity policy, whether this is ad hoc or through statutory arrangements. The EPBC Act enables broader input through continuation of BDAC and through a Threatened Species Scientific Committee and Indigenous Advisory Committee. This participation is, however, largely expertise based rather than representative.

The Commonwealth undertakes community education programs through Environment Australia, and supports the community biodiversity network (CBN) (see the *Community Biodiversity Network* box on page 173).

## Community-based programs [BD Indicator 25.2]

In Australia, involvement in the protection of biodiversity by individuals and community groups is encouraged by both federal and state governments. The number and size of these programs, and even more so of the activities and groups funded through them, render consistent reporting of activities impossible in the absence of large-scale surveys of all groups across all jurisdictions. Very often, particular groups or landholders will access support from more than one program over time to achieve different goals (see the *On-farm biodiversity conservation* box on page 175). Table 63 identifies a selection of recent state and territory government activities and programs encouraging or funding community participation.

### *The Natural Heritage Trust*

At the Commonwealth level, the NHT is the mechanism for funding different community involvement programs that involved over 305 000 individuals in 1999 (Figure 58; see *Government spending on biodiversity* on page 160). The NHT is not in itself a community-based program, but rather a public finance mechanism through which a variety of programs are funded. The largest number of participants are involved in Landcare (33%), followed by Waterwatch (23%), Bushcare (18%) and the Murray–Darling 2001 Program (13%). These

## Community Biodiversity Network: Adding value to community efforts

Around Australia, thousands of community groups and organisations are working to increase community understanding of biodiversity and involvement in its conservation. The NSCABD (ANZECC 1996) recognises that these initiatives can be catalysed by integrated measures that increase awareness and involvement. In line with this, in 1995 the Humane Society International, with the support of the Commonwealth government environment department, established the CBN.

The CBN is a national network of hundreds of organisations, which aims to increase community understanding, support for, and involvement in biodiversity conservation, and to provide easier access to biodiversity conservation information.

Each year the CBN works with over 100 organisations to stage 'Earth Alive! Biodiversity Month' in September. Biodiversity month provides a national community and mass media focus to highlight the value of Australia's rich biodiversity, relate biodiversity to lifestyle and welfare, and encourage people to become more involved in conserving the habitat of local native species and ecosystems (see photo).

This includes relating biodiversity to simple household actions, such as creating a habitat garden and keeping pets indoors to keep them and native wildlife safe, as well as the major biodiversity conservation issues, such as ongoing habitat loss. Local community events include bush regeneration days, nature walks, seminars and school working bees to create habitat gardens. To highlight the positive efforts of thousands of Australians in conserving wildlife habitat, the CBN also awards EcoHero Awards during Biodiversity Month.

To help groups avoid 'reinventing the wheel' when developing community education products, and to provide 'one stop shop' information resources, the CBN has developed a range of tools including the:

- Earth Alive Directory of Biodiversity Resources, Programs and Organisations
- On-line Biodiversity Education Centre, for teachers and students
- Earth Alive Biodiversity Communicators Kit.

The CBN also produces a range of reference, news and community education products, such as its Earth Alive Home Guide, LifeLines bulletin, television and radio community service announcements, and various booklets and fact sheets. Many of these are available on the CBN website http://www.cbn.org.au.

**Source:** Andreas Glanznig, CBN.

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

**Source:** Grant Ellmers, CBN.

four programs account for 87% of the total community participation under NHT funds. There are around 1500 Waterwatch groups monitoring water quality and aquatic biodiversity, and over 4000 Landcare groups.

It is difficult to ascertain precisely the relevance of thousands of different activities to biodiversity, but broad programs can be classified as more directly or indirectly targeted. Of the four largest programs, Bushcare and Waterwatch are the most clearly relevant, although the other major participatory programs may produce biodiversity benefits. Bushcare facilitators operate at state, territory and regional level to liaise with landholders and community groups. However, as Curtis (1998) suggests, the ability of some programs targeted at other issues such as Landcare and land degradation to deliver biodiversity benefits on private land should not be overestimated. The most biodiversity-specific of the NHT programs, the NRSP and ESP, involve far fewer people as they are not as clearly community based.

Commonwealth government funding for mostly community-based NHT projects is administered through the Environment and Agriculture, Fisheries, Forestry portfolios. In 1999–2000, $299.4 million was provided

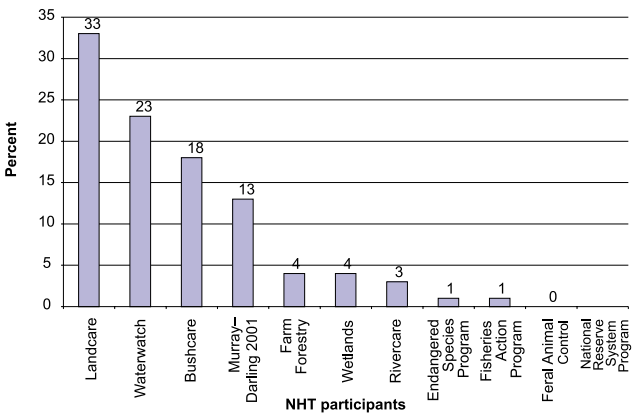



**Figure 58: The percentage of participants in Natural Heritage Trust programs, 1996 to 2000.**

**Source:** Environment Australia.

## On-farm biodiversity conservation: 'Millpost'

On 31 August 2000, the Director-General of the NSW NPWS, Brian Gilligan, launched the State's new Community Assistance Program (CAP) at 'Millpost', a 1100 ha fine wool sheep property run by David Watson and Judith Turley on the southern tablelands of New South Wales. Acknowledging the results of 20 years of planning and management to combine production and conservation, Mr Gilligan said:

> the property contains a wide variety of highly significant wildlife habitats, which have been maintained and enhanced while retaining a successful and viable agricultural enterprise. 'Millpost' is a significant wildlife haven hosting native animals including a truly remarkable bird life, many of which are declining elsewhere. The property is a testament to the land management abilities of the Watsons and a fine demonstration that agricultural production can and does coexist with the conservation of biodiversity.

The philosophy behind the management of 'Millpost' combines rotational grazing practices, permaculture design principles and a belief that economic viability requires maintenance of the integrity of the biological resource base.

Since 1979, tens of thousands of trees have been planted, from direct seeding and raised tube stock. The plantings have been for wildlife habitat, catchment protection and windbreaks, with most being local species such as *Eucalyptus viminalis, E. mannifera, E. pauciflora* and *E. stellulata*, and *Acacia rubida* and *A. dealbata*. Tree plantings are complemented by understorey plantings for habitat, including *Bursaria, Grevillea, Callistemon* and *Melaleuca*. Extensive areas, including a sizeable wetland area, are excluded from grazing pressure.

'Millpost' has seen production as well as conservation benefits from planned revegetation. An increase in bird life has been the most noticeable change, especially of smaller species not previously common in the area (i.e. honeyeaters, pardalotes and whistlers). Increased shelter for stock, and a prolonged growing season from greater retention of soil moisture in spring and early summer, have benefited the grazing enterprise.

While the great bulk of the investment and work over the last 20 years has been by the owners, they acknowledge various forms of assistance, such as from Greening Australia, the National Tree Program and the National Afforestation Program. The latest assistance, in August 2000, came when workers from the Australian Trust for Conservation Volunteers, under the CAP and funded through the NSW government's Environment Trust, helped with new planting and maintenance work on existing plantings. Such partnerships between private landholders, community groups and government are seen as crucial to on-farm biodiversity enhancement.

As for the future, Mr Watson and Ms Turley acknowledge that, even after 20 years of progress, achieving a balance between production and conservation is a long-term task. Further challenges include dryland salinity, weeds such as Serrated Tussock and St John's Wort, the breakup of surrounding farmland under non-productive uses and, above all, the overall viability and decline of rural communities and economies.

(Table 63). In contrast to the number of participants involved, the largest amount of funding was provided to Bushcare ($81.6 million), followed by Landcare ($49.2 million), Murray-Darling Basin 2001 ($43 million) and then the Coasts and Clean Seas Initiative ($28.1 million).

*Voluntary agreements*

These programs essentially involve voluntary contributions by individuals who have an interest in environmental issues usually local to their areas. Programs also exist where private landholders can be encouraged to enter into voluntary agreements with governments to put aside land specifically for the purposes of wildlife conservation (Williams & Sutherland 2000). Such programs include Voluntary Conservation Agreements, wildlife refuges and Land for Wildlife (see *Selected government programs encouraging private landholder and community programs* box on page 176).

*Legislative mechanisms*

Governments also have legislative means by which landholders can contribute to biodiversity conservation, in the form of property and conservation agreements and covenants. These allow agencies of the State to make legal


**The Genaren Hill Sanctuary near Peak Hill, central-western New South Wales, is a 400 ha remnant on private land.**

The Genaren Hill Landcare Group installed 86 km of predator-proof fencing and have reintroduced the Brush-tailed Bettong (*Bettongia penicillata ogilbyi*) and Bridled Nailtail Wallaby (*Onychogale fraenata*), which were both regionally extinct.

**Source:** JE Williams.

## Selected government programs encouraging private landholder and community programs, 1998 to 1999

Australian Capital Territory (1999–2000)

- Landcare groups include the Ginninderra Catchment Group, Canberra Ornithologists Group, O'Connor Ridge ParkCare Group, Sullivans Creek Catchment Group
- funding for community groups to attend International Landcare Conference, March 2000
- National Heritage Trust (NHT) funding of $941 326 for environment projects
- support for the Murrumbidgee Catchment Coordinating Committee.

New South Wales

- nine Voluntary Conservation Agreements signed in 1998–99 bringing the total to 49 (5340 ha) with a further 90 under negotiation
- under the Wildlife Refuge program, 600 refuges have been declared since 1950
- Land for Wildlife program and Farming for the Future, which includes a module on biodiversity issues
- NPWS Discovery program, Save Our Species Program and Community Biodiversity Survey Manual
- Community Assistance Program (CAP).

Northern Territory

- Indigenous involvement in protected area management
- 'Friends' groups for individual parks (e.g. Friends of Alice Springs Desert Park launched in 1998–99 with over 900 members
- Volunteers on Parks Program and a Junior Ranger Program.

Queensland

- Environment Protection Agency (EPA) grants totalling $988 917 to coastal community organisations for 60 projects under the Coastcare Grants Program
- EPA approved 53 out of 227 applications for funding projects under the Queensland Community Heritage Grants Program (local government, Indigenous and heritage groups) totalling $507 000
- QPWS funded 59 projects totalling $234 300 for non-profit, non-government, community-based organisations
- QPWS re-established the NatureSearch Program with part-time coordinators and volunteers to gather records about Queensland's native species
- funding of $7 million from the NHT for Bushcare programs for 95 projects
- Queensland extended the Land for Wildlife Program to assist landholders to integrate wildlife habitat protection principles into management of their properties
- Community Nature Conservation extension network was established to deploy extension officers to assist landholders and community groups to pursue conservation objectives
- under the *Nature Conservation Act 1992*, the government can enter into Nature Conservation Agreements with private landholders to create protected areas
- over 120 volunteers from community groups and industry enlisted as part of the Queensland Turtle Conservation Program
- the Gladstone-based volunteer group Friends of Capricornia established to control weeds and monitor wildlife on Capricorn and Bunker Islands
- volunteers at Airlie Beach and the Whitsunday Islands coordinated to help run the visitor information centre and undertake monitoring.

South Australia

- Protected area Consultative Committees and Friends Groups have been established
- establishment of a network of NHT facilitators, Bush Management Advisers and regional state government ecologists to provide assistance to landholders
- provision of funding including: service programs for Indigenous people ($3.4 million); Coastcare grants ($377 000); National Estate program grants ($209 000); NHT grants ($1.1 million) including Heritage Agreements for private landholders; Waterwatch program ($259 000)
- Land for Wildlife Program being developed to encompass a range of private landholder nature conservation initiatives.

Tasmania

- programs include Wildcare, Bushcare, Rivercare
- Weedplan established to educate the farming community in identifying new weed threats
- establishment a $30 million reserve project for private land under the RFA process: 150 properties have been assessed, with two purchased so far and another 45 possible.

Victoria

- Parks Victoria granted $5.3 million to community groups and local government to improve Victoria's extensive network of parklands. This included projects under start-up grants, 'Friends' programs, National Estate Grant Program, Coast Action/ Coastcare projects and Coasts and Clean Seas projects.

Western Australia

- Minister for the Environment's Community Conservation Grants
- Land for Wildlife Scheme
- Remnant Vegetation Protection Scheme
- Gordon Reid Foundation for Conservation Grants Scheme.

agreements with private landholders or with other public sector agencies for resource management. The agreements may provide financial incentives for meeting the objective of conservation on private land (e.g. assistance for fencing) and involve a contractual arrangement and may in some cases attach to the title of the land so as to bind future owners. Some earlier legislation includes agreements more targeted at land degradation but which may also yield biodiversity benefits. Acts under which voluntary conservation or resource protection agreements and covenants can be made include:

- *Nature Conservation Act 1992* (Qld)
- *Conservation and Land Management Act 1984* (WA)
- *Conservation, Forests and Lands Act 1987* (Vic.)
- *Flora and Fauna Guarantee Act 1988* (Vic.)
- *Native Vegetation Act 1991* (SA)
- *Soil Conservation and Land Care Act 1989* (SA)
- *National Parks and Wildlife Act 1974 (1995)* (Cwlth)
- *Threatened Species Conservation Act 1995* (NSW)
- *EPBC Act 1999* (Cwlth).

In New South Wales, some 600 wildlife refuges have been declared, and over 80 Voluntary Conservation Agreements made over individual properties. In a move that links landholder and community efforts, the NSW NPWS in 2000 launched the CAP. The CAP is funded from the NSW Environment Trust, run by the NPWS and the Australian Trust for Conservation Volunteers and involves volunteers assisting with biodiversity conservation projects on properties subject to a Voluntary Conservation Agreement.

### Number of interest groups involved in protected area planning [BD Indicator 13.3]

Interest group involvement is usually voluntary, may contribute to protected area planning in a consultative capacity and some may even be involved in preparation of management plans.

The basis and intent of interest group involvement in protected area planning and management varies. Interest groups identified as being 'explicitly involved' in protected area management and planning by the Victorian government illustrate this, including environmental groups (e.g. ACF and Birds Australia), recreational user groups (e.g. Australian Anglers' Association, Victorian Association of 4WD Clubs, Sporting Shooters Association of Australia) and industry associations (e.g. Tourism Council, Victorian Apiarists Association, Victorian Fishing Industry Association). This illustrates the range of interests increasingly involved in negotiating multiple values and uses of protected areas.

Community participation has become more central to the strategic planning and operations of nature conservation agencies. For example, in Queensland, the EPA (including the QPWS) describes detailed plans for consultation in its 'Agency Consultation Plan 1999–2000'. This sets out, for example, across a wide range of programs and reserves, the kind of consultation planned, time period, groups to be consulted and budget requirements. Groups identified include local residents, environmental groups, Indigenous organisations, industry interests, local government and other state agencies.

## Indigenous people and biodiversity

The involvement of Australia's Indigenous peoples in understanding and managing biodiversity is crucial, for three reasons. First, there is widespread recognition of the past, present and future custodianship of Australia's biodiversity by Indigenous peoples, and of their rights and responsibilities toward it under both customary and western law. Second, traditional and ongoing Indigenous knowledge is increasingly accepted as a valid and necessary information input to biodiversity management, alongside scientific information. Third, with some 15% of the continent under Indigenous ownership and/or management in 1996, often in remote environments that represent a management challenge, achieving protection of biodiversity without strong participation by local communities would be impossible.

An important aspect of Indigenous involvement in biodiversity is the recognition, continuity and use of traditional ecological or ethnobiological knowledge. The NSCABD recognised that an important means of protecting and managing biodiversity would be the discovery, documentation and continuity of the knowledge of Australia's Indigenous peoples who have maintained this biodiversity for many thousands of years before European occupation. One of the key objectives of the Strategy was to recognise and ensure the

continuity of the contribution of the ethnobiological knowledge of Australia's Indigenous peoples to the conservation of Australia's biodiversity. A further recommendation in Action 4.1.8 (ANZECC 1996) was to:

Recognise the value of the knowledge and practices of Aboriginal and Torres Strait Islander peoples and incorporate this knowledge and those practices in biodiversity research and conservation programs by:

(a) encourage the recording (with the approval and involvement of the Indigenous peoples concerned) of the knowledge and practices of Indigenous peoples;

(b) assess the potential of this knowledge and these practices for nutritional and medicinal uses, wildlife and protected area management and other purposes; and

(c) apply the knowledge and practices in ways that ensure equitable sharing of the benefits arising from their use.

However, the review of the Strategy's implementation (ANZECC 2001) found the outcome of Objective 1.8 was 'not achieved'. In particular, the authors of this review noted that:

> To date, cooperative ethnobiological programs are limited and do not appear well-coordinated Australia-wide. Concerns have been raised about the lack of protection that would be given to the intellectual property rights of Indigenous peoples were they to offer information. There is a need to respect the knowledge of Indigenous peoples as an expression of a way of life and cultural identity as well as a tool for biodiversity conservation.

The Council for Aboriginal Reconciliation in its report on *Achieving economic independence* (2000, p. 6) recommended that:

> (2E) State and national parks review their management and employment practices to ensure there is genuine opportunity for Indigenous participation in planning and employment which acknowledges Indigenous community obligations and uses traditional knowledge and skills.

Use of Indigenous knowledge is mostly occurring in protected areas managed either by nature conservation agencies, Indigenous organisations or in joint management arrangements. The Commonwealth in 1999 established an inquiry into use of biological resources in Commonwealth areas (Voumard 2000) and Williams (1998) provided a review of the importance of traditional knowledge, and of its status as crucial intellectual property. There is a discernible transition from treating Indigenous heritage as comprising 'sites' and 'relics' only, toward appreciation of the Indigenous legal, social and management importance of total landscapes and a wide suite of biota. English and Brown (2000) described previous approaches as involving a division between cultural and natural heritage that is only now being appreciated as inadequate and not representing Indigenous custom, knowledge or law.

Governments in Australia have increased employment of Indigenous peoples in protected area management, established Indigenous Protected Areas (IPAs), entered into joint management arrangements for protected areas and created registers of Indigenous historic and cultural sites.

## Commonwealth government policies and programs [BD Indicators 13.3, 24.8 and 25.2]

*Joint management*

The Commonwealth government has entered into partnerships with Indigenous peoples in nature conservation through joint management arrangements with Indigenous traditional owners of Kakadu, Uluṟu-Kata Tjuṯa and Booderee National Parks. The traditional owners lease back the parks to the Commonwealth. Both Kakadu and Uluṟu-Kata Tjuṯa are World Heritage Areas. Booderee National Park contains the only Indigenous-owned botanical gardens in Australia.

Management arrangements with these parks provide for access and equity in Indigenous employment and training. For example, Indigenous employment is 30% of the workforce for Kakadu, 33% for Uluṟu-Kata Tjuṯa and 52% for Booderee. Boards of management for these parks provide for a majority Indigenous representation and an Indigenous chairperson (e.g. The Kakadu Management Board consists of 10 Indigenous members and four non-Indigenous members). Board meetings at Uluṟu-Kata Tjuṯa National Park are translated into Pitjantjatjara. At some parks, non-Indigenous staff undertake training in local Indigenous

**Table 70: IBRA Regions (version 4) and IPAP (Indigenous Protected Areas Program) projects**

| IBRA region | IBRA region size (ha) | % IBRA as Protected Area (1997) | Priority for National Reserve System | IPAP Project | IPAP Area (proposed or actual) (ha) | Year declared as IPA |
|---|---|---|---|---|---|---|
| Cape York Peninsula | 11 590 399 | 13.72 | Low | Pula and Deliverance | 53 | — |
| Central Ranges | 9 706 061 | 0 | Moderate | Central Ranges | NA[A] | — |
| Central Ranges | 9 706 061 | 0 | Moderate | Watarru and Walalkara | 1 980 000 | 2000 |
| Dampierland | 8 945 678 | 0.84 | High | Dampier Peninsula | NA | — |
| Furneaux | 240 654 | 26.63 | Moderate | Tasmanian LM | 1 650 | — |
| Furneaux | 1 892 251 | 5.65 | Moderate | Wilsons Promontory | NA | — |
| Gibson Desert | 15 553 049 | 12 | Moderate | Central Ranges | NA | — |
| Great Sandy Desert | 39 459 921 | 2.33 | Moderate | Great Sandy Desert | 271 700 | — |
| Great Sandy Desert | 39 459 921 | 2.33 | Moderate | Paraku | NA | — |
| Great Victoria Desert | 42 375 084 | 16.44 | Low | Anangu Pitjantjatjara Lands | 1 000 000 | — |
| Jarrah Forest | 4 601 333 | 3.94 | Low | Manguri | NA | — |
| Mount Isa Inlier | 6 658 586 | 2.69 | Moderate | Lake Moondarra | NA | — |
| Murray–Darling Depression | 19 748 019 | 12.44 | Moderate | Mutawintji[B] | — | 1998 |
| Nullarbor | 19 500 428 | 18.59 | Low | Yalata | 456 300 | 1999 |
| South East Coastal Plain | 1 892 251 | 5.65 | Moderate | Deen Maar | 453 | 1999 |
| Simpson-Strzelecki Dunes | 27 787 605 | 27.87 | Low | Witjira | — | — |
| South Eastern Queensland | 6 860 424 | 4.03 | High | Guanaba | 100 | — |
| Stony Plains | 18 159 145 | 4.82 | High | Finniss Springs | 171 270 | — |
| Stony Plains | 18 159 145 | 4.82 | High | Nantawarrina | 58 000 | 1998 |
| Stony Plains | 18 159 145 | 4.82 | High | Witjira | NA | — |
| Tanami | 31 665 582 | 0.43 | Moderate | Purta | 390 000 | — |
| Tasmanian Midlands | 769 751 | 2.02 | High | Risdon and Oyster Coves | 141 | 1999 |
| Top End Coast | 6 931 917 | 15.8 | Moderate | Amorrduk | — | — |
| Top End Coast | 6 931 917 | 15.8 | Moderate | Dhimmuru | 20 000 | — |
| Warren | 1 044 781 | 26.16 | Low | D'Entrecasteaux | — | — |
| West and South West | 1 839 898 | 70.62 | Low | West Coast Tasmania | — | — |
| Woolnorth | 966 686 | 7.26 | High | Preminghana | 524 | 1999 |

[A] Not available; [B]Joint Management Area.

**Source:** Centre for Environment Management 1999.

languages. These languages are also used for some Plans of Management (Uluru-Kata Tjuta Board of Management and Parks Australia 2000).

The Great Barrier Reef Marine Park Authority and the Aboriginal and Torres Strait Islander Commission have proposed a strategy to develop a framework for Indigenous co-management of the Southern Great Barrier Reef. Plans of management are in the process of being developed for specific issues in the Hope Vale and Mossman regions.

*Other Commonwealth programs*

The IPAP was initiated to encourage Indigenous involvement in the establishment and management of IPAs recognising the close links and compatibility between Indigenous culture and biodiversity (see *The Indigenous Protected Area Program* box on page 70). Table 70 provides a number of statistics about the IPAP, including the number of projects that have been supported per IBRA region:

- An Indigenous Advisory committee has been established under the EPBC Act. This committee will advise on Indigenous knowledge and practices in conservation and sustainable land management practices.

- An inquiry to examine access to biological resources was conducted in early 2000 to advise on a scheme that could be implemented to provide for the control and access to biological resources in Commonwealth areas (Voumard 2000). The inquiry focused on ensuring equitable sharing of benefits arising from the use of Indigenous knowledge and practices and also addressed issues of intellectual property rights.
- In July 2000, Environment Australia announced a newly developed Indigenous Career Development and Recruitment Strategy to build on the 65 Indigenous staff already employed.
- The Contract Employment Program for Aborigines in Natural and Cultural Resource Management and the Aboriginal Rural Resource Initiative were both wound up.

## State and Territory-based policies and programs [BD Indicators 13.3, 24.8 and 25.2]

*Australian Capital Territory*

- The ACT does not specifically mention Indigenous involvement in biodiversity or conservation management in its latest Nature Conservation Strategy 1998 or the Annual Report of the ACT Environment Advisory Council 1999.

*New South Wales*

- In 1998, Mutawintji National Park and Historic Site and Coturaundee Nature Reserve were transferred to the Mutawintji Local Aboriginal Land Council and leased back to NPWS under a joint management arrangement (see the *Mutawintji National Park* box on page 181). The IPA program funded some of the activities that helped to establish this management structure under its cooperative management component.
- Lake Mungo National Park, Mount Yarrowyck Nature Reserve, Mount Grenfell Historic Site and NSW Jervis Bay National Park have also been transferred back to their traditional owners for co-management with the NPWS. As part of the Eden Regional Forest Agreement process, Biamanga National Park is also under joint management.
- In 1998–99, NPWS allocated $350 000 to 55 discrete Indigenous heritage conservation projects.
- The NPWS employs the highest number of Indigenous people of all the Australian conservation agencies and provisions continue to be developed for employing and training Indigenous peoples as NPWS officers. The NPWS also maintains detailed and readily available statistics on Indigenous employment in the Service.

*Northern Territory*

- The influence of Indigenous preferences, beliefs and practices are more apparent in the Northern Territory PWC annual reporting than for any of the other conservation agencies and there is provision for the Commission Board to have not less than three Indigenous members.
- The Commission does not have other readily available statistics on such aspects as Indigenous employment in the Commission.
- The PWC works with traditional owners in the establishment of IPAs and in cooperative land management and planning, such as with the Indigenous landowners of the Amorrduk clan areas with a view to later establishment of an IPA.
- Traditional knowledge has been very important in the development and implementation of fire mitigation programs, using both traditional and other (e.g. aerial survey) methods.
- The Commission also encourages involvement from Indigenous people in the development of park information relating to Indigenous culture and history. A report on *Aboriginal Cultural Interpretation Guidelines for the Northern Territory* has been produced.
- In 1998–99, the *Aboriginal Employment and Career Development Strategy* commenced.

*Queensland*

- The Queensland Government is developing legislation at present under the Commonwealth's *Native Title Act 1993* that may have some bearing on the way in which Indigenous affairs are approached by government departments. This is of particular importance to the QPWS as more than 140 of Queensland's national parks are subject to claims under the *Native Title Act 1993*, as at July 1999.

## Mutawintji National Park: Integrating Indigenous ownership, nature conservation and recreational use

Mutawintji National Park (formerly Mootwingee) and the nearby Coturaundee Nature Reserve in far western New South Wales are one example of evolving tenure and management approaches that seek to balance and integrate nature conservation, Indigenous peoples' land rights and management, heritage protection and recreational use. Situated 130 km north-east of Broken Hill, Mutawintji National Park has in recent years attracted increasing numbers of campers, naturalists, bushwalkers and other visitors.

Protection of the area's Indigenous art sites, among the State's most significant, dates from 1927, and the 486 ha Mootwingee Historic Site was gazetted in 1967. The Park was gazetted in 1982 and covers 69 000 ha, including 47 600 ha of wilderness. Coturaundee Nature Reserve was established in 1979. As well as the key art sites, the Park contains dramatic scenery, geological sites, European historical associations, and diverse flora and fauna attracted by permanent waterholes in steep gorges. Significantly, the Park and Reserve support the sole New South Wales population of the Yellow-footed Rock-wallaby (*Petrogale xanthopus*), an endangered species numbering fewer than 200 individuals. Evidence of Indigenous occupation, ceremonial uses and use of the area as an important meeting place has been dated to more than 8000 years before present.

Since 1983, the significance of the area to the Malyankapa and Pandjikali people has been recognised, and mechanisms established for joint management via the Mutawintji Local Aboriginal Land Council. Traditional owners continue to use the area for meetings and cultural purposes. In September 1998, the Park was handed back to the traditional owners by the New South Wales government and a Board of Management oversees the management of the Park.

Access within the Park is zoned carefully to balance protection and use. Intensive use areas exist for camping and walking, including disabled access to some gorge and art sites. Public use of the wilderness area is allowed but constrained by limited access. The Historic Site is a restricted zone, with public access only via guided tours under the control of the traditional owners. Management issues include feral animal and weed control, user impacts, protection of cultural heritage and protection of the Yellow-footed Rock-wallaby population. As the primary purpose of the Coturaundee Nature Reserve is the preservation of this species, no public access is allowed.

- In the QPWS, officers from individual regions engage in consultation on management expectations with Indigenous groups. Management expectations were developed in consultation with Indigenous people in Mount Moffatt (Carnarvon), Currawinya, Chesterton Range, Hell Hole Gorge and Moreton Bay and Islands in the Southern Region, Gumoo Woojabuddee Marine Park, Blackdown Tableland, Simpson Desert, Diamantina, Keppel Bay and Cape Hillsborough in the Central Region and Lawn Hill, Lizard Island, Cape Melville, Flinders Island, Lakefield, Cliff Islands and Mungkan Kandju in the Northern Region.
- Discussions have been initiated in 1999 for cooperative management with Ghungalu, Iman and Wadja claimant groups for Blackdown Tableland National Park.
- The QPWS trains Indigenous people in turtle biology.
- In 1998–99, a review was carried out of Indigenous involvement in the management of the Wet Tropics World Heritage Area, with a view to fostering more effective involvement. A report on the *Review of Aboriginal Involvement in the Management of the Wet Tropics World Heritage Area* was released in 1999 with many of the review recommendations able to be implemented immediately.
- In early 2001, the Wet Tropics Management Authority was in the process of appointing the High Level Negotiator recommended in the review. Discussions are still continuing, however, over issues such as native title and World Heritage management, traditional resource use and harvesting practices.

*South Australia*

- The first IPA was declared at Nantawarrina in South Australia in 1998. In June 2000, this initiative received the United Nations Global 500 Award for outstanding environmental achievement. There are now a total of four IPAs in South Australia (see *The Indigenous Protected Area Program* box on page 70).
- Joint management arrangements operate in Witjira National Park.
- A report on *Sustainable Resource Management Strategy for Aboriginal Managed Lands in South Australia* was prepared in 2000 to promote the sustainable management of

Indigenous freehold and leasehold lands and to support the priorities of Indigenous people in nature management.

*Tasmania*

- As of early 2001, there were five IPAs declared in Tasmania at Oyster and Risdon Coves, Preminghana and Mt Chappell and Clarke Islands. These are all Indigenous owned lands declared and managed by the landowners as IPAs.
- With the exception of the IPAs, most Indigenous involvement in the Tasmanian National Parks and Public Land Management Group of the DPIWE is concerned with cultural heritage conservation rather than nature conservation.
- Indigenous sites are protected and managed in consultation with the Tasmanian Aboriginal Land Council.
- Issues in Indigenous heritage are included in ranger training programs.

*Victoria*

- In 1998–99, Parks Victoria established an internal Indigenous Cultural Liaison Group to provide advice on Indigenous cultural heritage matters and to help develop cross-cultural awareness and training.
- A Memorandum of Understanding was signed with the Mildura Aboriginal Corporation over the management of Lindsay Island in the Murray-Sunset National Park.
- Liaison continues with the Yorta Yorta and Goulburn Clans Group over the management of the Dharnya Centre in Barmah Forest.
- Parks Victoria trains employees in working with Indigenous communities and in protecting Indigenous cultural heritage sites. Surveys of Indigenous cultural sites are undertaken with some surveys (e.g. Gabo Island) used in the preparation of management plans. Assessments are also made of the effect of fire on major Indigenous sites.
- In 1998–99, the Dreaming Theatre in the Brambuk Aboriginal Living Cultural Centre in the Grampians National Park was opened. This provides a venue to educate visitors about links between Indigenous people and the land, among other things.

*Western Australia*

- In August 2000, CALM announced a Draft Policy on Aboriginal Involvement in Nature Conservation and Land Management.
- The draft policy covers topics such as liaison and consultation, cooperative management, nature conservation on Indigenous land, management planning, Indigenous representation on advisory committees, employment and training, and legislative amendments to recognise Indigenous interests in CALM managed lands.
- In addition, the Western Australian RFA addresses the introduction of amendments to the *CALM Act 1984* to permit Indigenous peoples to undertake traditional and cultural activities including hunting, gathering and ceremonies on State forests and public land.
- CALM also maintains an Aboriginal Employment and Training Plan.

## Indigenous employment in conservation agencies

Table 71 gives an indication of Indigenous employment in nature conservation in jurisdictions for which data were available for this report.

**Table 71: State Conservation Agency employment of Indigenous peoples**

| State | Indigenous people employed 1998–99 (No.) | Indigenous employment as a proportion of total agency employment (%) |
|---|---|---|
| New South Wales (NPWS) | 157 | 7.5 |
| Queensland (Environment Protection Agency and QPWS) | NA | 2.7 |
| Tasmania (DPIWE) | 18 | 1.1 |

**Source:** NSW NPWS 1999; Queensland Environment Protection Agency and Parks and Wildlife Service 1999; Tasmanian Department of Primary Industry, Water and Environment 1999.

### Intellectual property rights

The establishment of intellectual property rights for Indigenous peoples is one area which would directly contribute to continuing and preserving the knowledge of Australia's Indigenous peoples. Further research is needed, however, on securing such rights and implementing workable practices. Some progress has been made on an ad hoc basis in the area of Australian bush foods (e.g. with the establishment of the Australian Native Bushfood Industry Committee). However, the issue of property rights could become much more important in terms of pharmaceutical products, where the monetary returns are much higher.

Addressing the issue of intellectual property rights for Indigenous Australians could have benefits not only for biodiversity conservation in Australia but also for Indigenous communities when their vast knowledge of native flora and fauna is used for commercial purposes. The Commonwealth government inquiry into access to biological resources (Voumard 2000) addressed issues of intellectual property rights for Indigenous peoples. As well, the Aboriginal and Torres Strait Islander Commission has established an Indigenous Cultural and Intellectual Property Taskforce.

## The international dimension

This section reports on the following environmental indicator, which is defined in Saunders et al. (1998).

| Environmental Indicator | |
|---|---|
| **BD 26** | Australia's international role in conservation |

### Australia's international obligations [BD Indicator 26]

As a wealthy, scientifically literate country with unusually high biodiversity, Australia arguably has both the responsibility of protecting its own biological heritage, and the capacity to assist other countries to protect theirs. Biodiversity management has many international dimensions.

Australia traditionally has been an active participant in international fora and agreements in the environment area. In some cases, there has been legislative expression of commitments under agreements, but in most cases fulfilment is pursued under policy initiatives. Recent decades have seen an increase in international instruments concerning the environment, to which Australia is a party. Table 72 identifies the principal ones, either those most directly relevant to biodiversity or which are major, overarching environmental instruments. As with domestic policy and law, however, there is a larger range of international agreements and

**Table 72: Principle international agreements relevant to biodiversity conservation in Australia**

| Entry into force | Title, date, place of agreement |
|---|---|
| 1948 | International Convention for the Regulation of Whaling, 1946, Washington |
| 1961 | Antarctic Treaty, 1959, Washington |
| 1975 | Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971, Ramsar |
| 1975 | Convention for the Protection of World Cultural and Natural Heritage, 1972, Paris |
| 1975 | Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973, Washington |
| 1982 | Convention on the Conservation of Antarctic Living Marine Resources, 1980, Canberra |
| 1983 | Convention on the Conservation of Migratory Species of Wild Animals, 1979, Bonn |
| 1985 | International Tropical Timber Agreement, 1983, Geneva |
| 1993 | Convention on biodiversity, 1992, Rio de Janeiro |
| 1993 | United Nations Convention to Combat Desertification in those Countries experiencing Serious Drought and/or Desertification, particularly in Africa, 1994, Paris |
| 1994 | United Nations Convention on the Law of the Sea, 1982, Montego Bay |
| 1994 | United Nations Framework Convention on Climate Change, 1992, New York |

processes of relevance to biodiversity, whether directly or indirectly. In this Report, discussion is limited to Australia's core and recent activities under the principal agreements, and brief reference to other, selected agreements and processes. As a comparison, SoE (1996) contained an Appendix identifying the full range of international agreements.

## Convention on Biodiversity

The primary international agreement is the CBD (United Nations CBD 1992b, vol. 31, 818–841). Article 6 of the Convention requires parties to:

1 Develop national strategies, plans or programs for the conservation and sustainable use of biodiversity or adapt for this purpose existing strategies, plans or programs which shall reflect, *inter alia*, the measures set out in this Convention relevant to the contracting party concerned
2 integrate, as far as possible and as appropriate, the conservation and sustainable use of biodiversity into relevant sectoral or cross-sectoral plans, programs and policies.

The development of the NSCABD and subsidiary policies, discussed elsewhere in this report, and the existence of the EPBC Act fulfil the obligation at (1) in the general sense. As with most international instruments, the obligations agreed to through treaty ratification are not stated in clearly defined terms or in a testable manner, and must be interpreted in each national context.

The degree to which detail and implementation of the obligation is sufficient will always be a subject of debate over the detail of domestic policy, and is covered elsewhere in this report. The obligation at (2), in most analyses, would be fulfilled only partially, a situation that would apply in any country. The nature of biodiversity issues makes cross-sectoral policy integration both a necessary and difficult long-term task. Integration is required across domestic policies and the range of international agreements (ANZECC 2001).

From an international perspective, Australia is seen to be active in the CBD through its support of the Subsidiary Body on Scientific, Technical and Technological Advice and by organising international conferences to help improve the scientific basis of the Convention. It is also well regarded for its support of sustainable natural resource management in partner countries. For example, Australia helps Pacific countries to participate in the CBD and AusAid has supported efforts of developing countries to alleviate their environmental problems. Australia also promotes the development of the information clearing-house mechanism of the CBD.

Australia participated in the development of the Cartagena Protocol on Biosafety under Article 19(3) of the CBD. As of January 2001, the Protocol has been ratified by 81 nations and signed by two. The Protocol deals with movements of 'living modified organisms' and Australia is exploring the inclusion of capacity building for corporations involved with biosafety issues.

Other obligations under the CBD include identification and monitoring of biodiversity, *in situ* and *ex situ* conservation efforts, management for sustainable use, public education and awareness, inclusion of biodiversity in impact assessment, access to genetic resources, transfer of technology, and information exchange and scientific cooperation. On international comparison, Australia has made significant progress against these requirements although, again, whether this progress is considered sufficient is contestable (see relevant issues and biodiversity indicators in this Report).

## Other international conventions and agreements

The 1999 National Principles and Guidelines for Rangelands Management fulfils Australia's obligations under the Convention to Combat Desertification. However, compared to the NSCABD, this domestic policy is not detailed and does not substantially guide decision-making through either defined processes or goals.

The EPBC Act covers Australia's obligations under the Convention for the Protection of World Cultural and Natural Heritage. The Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) is expressed in Australia through the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (under review, see *Harvesting* on page 73).

*The Antarctic Treaty System*

Australia's international obligations with respect to the Antarctic environment are discharged primarily through the *Antarctic Treaty (Environment Protection) Act 1980* and the *Antarctic Living Marine Resources Conservation Act 1981*. Australia is an original signatory to the 1959 Antarctic Treaty and has long been influential in the Antarctic Treaty System, which provides a regime for managing activities on the Antarctic continent and in the vast surrounding Southern Ocean. The Protocol on Environmental Protection to the Antarctic Treaty was the direct result of an Australian initiative. The Protocol, which entered into force in 1998, provides comprehensive and legally binding rules to protect Antarctica's environmental values. Among other things, the Protocol requires prior assessment of the potential effects of all Antarctic activities, prohibits mining anywhere in Antarctica, regulates waste disposal and establishes a wide-ranging system of protected areas. Australia continues to provide leadership in protecting the Antarctic environment, including through the Protocol's Committee on Environmental Protection. In addition, Australia is a leading advocate within the Commission for the Conservation of Antarctic Marine Living Resources for scientifically based management and sustainable fishing in the Southern Ocean, including promotion of strong action to combat illegal, unreported and unregulated fishing for the highly valued Patagonian Toothfish.

*The Ramsar Convention*

Ramsar wetlands are listed under the EPBC Act as matters of 'national environmental significance'. The Ramsar Convention is an example of where international agreements may, over time, become dated or inadequate as a guide to standards of management. Although principles of 'wise use' have been developed in association with the Convention, the Convention itself may not properly reflect emerging ecological understanding and approaches to management (Farrier & Tucker 2000). This stems from the focus on wetlands rather than the total catchment, and on waterbirds rather than on the full suite of taxa dependent on wetlands. In part, such limitations are dealt with through domestic policy (e.g. catchment management and Commonwealth Wetlands Policy). But there is also need for constant evolution of approaches under international agreements and for coordination across agreements to reflect the more integrated definition and management demands of biodiversity.

*The United Nations Framework Convention on Climate Change*

Two international instruments and processes of apparently indirect relevance to biodiversity can be expected to assume great significance. The UNFCCC is likely to be a significant international instrument for biodiversity conservation in coming years, in two ways. First, the effects of climate change on Australia's biodiversity are expected to be significant, as discussed in the section on *Human-induced climate change* (page 96). Second, carbon sequestration and accounting, which are core to Australia's greenhouse policy response in the UNFCCC and the evolving Kyoto Protocol, have major biodiversity significance. Land clearing, as both a cause of greenhouse gas emissions and a policy response area, is a key threatening process for biodiversity.

*The World Trade Organization*

The WTO and related processes governing international trade are becoming more important to environment and biodiversity management. Relevant areas under WTO negotiations and emerging rules include biosafety concerns, the definition of environmental subsidies (which may conflict with free trade principles), certification of environmentally sound production methods and environmental regulation affecting trade between countries. These areas have been most explored in recent years in fisheries, especially concerning bycatch issues (Bache et al. 2000) but it may be some years before there are any positive environmental benefits from WTO discussions.

## Bilateral and other non-global agreements

Australia is also party to more specific bilateral and other non-global agreements. The conservation of migratory birds is subject to the China–Australian and Japan–Australian migratory birds agreements (CAMBA and JAMBA). In the immediate region, the Convention on the Conservation of Nature in the South Pacific was made in Apia in 1976 and entered into force in 1990. The Convention for the Protection of the Natural Resources and

Environment of the South Pacific Region, which entered into force in 1990 and the Plant Protection Agreement for the Asia and Pacific Region (1956, amended 1979) also influence regional cooperation on biodiversity issues.

Australia has also been active in the 'Valdivia Group' of southern hemisphere countries who have common interests in biodiversity. This Group has addressed weed and pest species issues, and the protection of albatross under the Convention on the Conservation of Migratory Species.

### Other international activities

In addition to specific agreements, Australia participates in various international processes and organisations. Recent activities in this area include:

- Australia is a member of the working group on criteria and indicators for the conservation and sustainable management of tropical and boreal forests. This is known as the Montreal Process and in 2003 Australia will contribute to a major international report on progress made in the implementation of these criteria and indicators.
- Australia is a signatory to the International Tropical Timber Agreement (ITTO) and supports activities under this, which has the primary objective of assuring that trade in tropical timbers is based on sustainable management practices.
- As a member of the International Whaling Commission and in line with Australia's policy of a permanent cessation of all commercial whaling, Australia co-sponsored with New Zealand an unsuccessful proposal for a South Pacific Whale Sanctuary at the Commission's meeting in Adelaide in 2000.
- Through Environment Australia, the Commonwealth supported regional NGO involvement in dialogues surrounding the Intergovernmental Forests Forum processes concerning underlying causes of deforestation and forest degradation in 1998 to 1999.
- AusAid is currently funding $26 million of biodiversity-related projects in other countries, and Environment Australia and other Commonwealth agencies are supporting a range of projects under the CITES and Ramsar conventions and through the United Nations Global Environment Facility.

Overseas development aid has fallen globally in recent years and this has affected biodiversity-related aid as it has affected other areas of Australia's aid program. Agenda 21 defined a target of 0.7% of gross national product (GNP) as a target for developed countries to spend on aid, a target achieved by only four Scandinavian countries in the late 1990s. Australia's overseas aid spending had fallen below 0.3% of GNP by 1997.

The issue of the effect on biodiversity of Australian activities in other countries remains only partially resolved (ANZECC 2001). The EPBC Act places obligations on the Commonwealth in this regard. Some industry sectors have voluntary codes of practice which apply to environmental responsibilities of other countries, but generally these activities are viewed by Australian firms and governments as most appropriately the subject of the environmental regulations and practices of host countries. Industry codes and activities that influence the activities of Australian companies are discussed in *Plans to minimise impact of development: Corporations* (page 168).

### State and territory involvement in international agreements

Although international agreements are an arena of Commonwealth power and responsibility, a cooperative approach has developed in recent years with the states and territories being involved in negotiation and implementation. In some cases, particular states or territories are more directly involved. For example, the Northern Territory provided the state representative for Australia to the Subsidiary Body on Scientific, Technical and Technological Advice under the CBD and the Oceania representative on the CITES Plants Committee (Darwin hosted the 1999 meeting of the Committee). The Northern Territory also has bilateral cooperative arrangements with the South African province of Kwa-Zulu Natal through a ranger exchange program, and with Indonesia in ethnobiology.

### Meeting Australia's international responsibilities

As with domestic policy and law, whether or not Australia has fulfilled its stated or possible responsibilities under international agreements is a judgment that will vary according to the values and priorities of the observer. Outstanding issues that can be expected to be the subject

of public debate and, thus, are deserving of further monitoring, evaluation and future reporting include:

- Integration of biodiversity issues into other sectoral, domestic policy (e.g. regional development, trade, transport), as per Article 6(b) of the CBD.
- Coordination of activities and information relevant to different international instruments, as noted in the review of the NSCABD (ANZECC 2001).
- More explicit recognition is required of the relevance of the UNFCCC to biodiversity conservation. The UNFCCC and the evolving definition of the role that land use change will have in measuring, reporting on and controlling greenhouse gas emissions directly attends the most problematic threatening process operating in Australia: land clearing. There is a high likelihood that the UNFCCC Kyoto Protocol until 2010 will be a significant international arena of negotiation for biodiversity, rather than the CBD or other, apparently more directly relevant instruments.
- The treatment of environment and biodiversity issues in WTO negotiations and rule making. In particular, evolving clarification of issues of environmental subsidies and exemptions from free trade principles.
- Information on the activities in other countries of Australian public agencies and private firms that may affect biodiversity, and further development of guidelines and standards of practice.
- The degree to which the obligations or expectations under international agreements may be viewed as a sufficient standard against which Australia's activities should be judged, or a basic benchmark that should be exceeded.

In many cases, enhanced public discussion and a clearer definition of expectations would inform the current debate over Australia's international role and performance in conserving biodiversity.

# Conclusions: Shaping the future—safe-guarding Australia's biodiversity heritage

According to Wilson (1995, p. 355):

> The one process ongoing in the 1980s that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly that our descendants are least likely to forgive.

Overall, the condition of biodiversity in Australia today is poorer today than it was in 1996. Many serious pressures that undermine biodiversity conservation remain to be dealt with effectively. Many of these issues have been known for a decade or more and were explicitly identified in SoE (1996),

Based on the findings of the present Report, the prognosis for biodiversity in the immediate future is very serious. The destruction of habitat by human activities remains the major cause of biodiversity loss and threats such as weeds, feral animals, altered disturbance regimes, dryland salinity and diseases undermine the quality of the natural systems that remain. Failure to reverse these trends will not only guarantee further loss of biodiversity but also diminish the quality of life enjoyed by Australians and ultimately undermine the Australian economy.

The conservation of biodiversity can be expressed simply as saving biodiversity, studying it and using it sustainably and equitably. Saving biodiversity means taking steps to protect genes, species, habitats and ecosystems. The best way to maintain species is to maintain their habitats. However, since many of Australia's habitats have already been heavily modified for human purposes, steps to save biodiversity need to also include measures to maintain diversity on lands and in waters that have been disturbed. In addition, measures must be taken to restore lost species to their former habitats, and to preserve species held in *ex situ* facilities such as zoos and botanical gardens. Studying biodiversity means documenting its composition, distribution, structure and function; understanding the roles and functions of genes, species and ecosystems; and grasping the complex links between modified and natural systems as a basis to inform management. Using biodiversity sustainably and equitably means managing biological resources so that they last indefinitely, making sure that biodiversity is used to improve the human condition, and seeing that these resources are shared equitably.

This Report on biodiversity is concerned with the progress made in saving, studying and sustainably and equitably using Australia's biodiversity since SoE (1996). Since 1996, there have been several advances. For example, there is now much greater awareness of the importance of local governments in managing biodiversity, whereas previously the focus had largely been on state and Commonwealth governments. There is also now a much greater emphasis on participants other than government in biodiversity conservation and management (e.g. philanthropists, industry, and the broader community). Corporations and industry, more generally, are adopting ethical and environmental codes of practice that can support biodiversity conservation.

Today, Indigenous involvement in land management has a much higher profile, with repeated calls for Indigenous issues to be fully integrated into policy and program management. Increased attention is now paid to the integration of biodiversity conservation with production objectives across landscapes. This is consistent with greater recognition of the vital contribution that areas outside of the formal reserve system make for biodiversity conservation. The 'value' of biodiversity and the significance of ecosystem services to humans in Australia and globally is becoming more widely appreciated. Recently, for example, the Myer Foundation has provided $1 million to CSIRO for research on the value of ecosystem services to the Australia.

Until recently the focus on biodiversity conservation has been in the ILZ where broad-scale clearing for crops has occurred. However, there is a growing appreciation among government and the broader community of the potentially significant effects of altered fire, grazing and hydrological regimes, pests and weeds and mining on biodiversity in the ELZ in central, western and northern Australia. The message is that an area does not have to have been cleared for major changes in biodiversity to occur. Measures to improve the management of key regions such as the rangelands, the Lake Eyre Basin and Great Artesian Basin have been introduced. In addition, the CRC for the Sustainable

Management of Tropical Savannas has recently received approval for a further seven years of funding to enhance land management across northern Australia.

Altered fire regimes were not listed as one of the key threatening process for biodiversity in SoE (1996). Today, however, there is much greater awareness of the links between fire regimes and the conservation of biodiversity, which is reflected in the increasing development of management plans that directly address these issues. There is greater appreciation of the magnitude and importance of fires for biodiversity conservation in northern Australia. The ongoing mapping and monitoring of fire across northern Australia by the Western Australian Department of Land Administration is one example of an agency using smart geospatial technology to support improved land management and biodiversity conservation goals.

Although pests and weeds received considerable attention in the first report, the issue of sleeper weeds, which have the potential to cause major problems in future years was not mentioned in any detail. These weeds are now recognised to be of major concern, as are exotic organisms (e.g. sea stars, Crazy Ants, foot-and-mouth disease) that might find their way through Australia's quarantine barriers as a result of trade, tourism and other human activities.

The potential impact of GMOs on biodiversity is yet to be systematically and comprehensively investigated in Australia. Thus far, the focus of discussions of GMOs has been principally the potential impacts on human health and the organic farming industry. However, there would appear to be considerable potential for these organisms to threaten native biota and regional biodiversity.

There has been an increased emphasis on the need for active management of landscapes and aquatic and marine ecosystems, and that this be done at the regional level if effective natural resource management is to be achieved. This thinking has resulted in the development of a numerous regional processes and plans. At present, there has been only limited success in achieving active and integrated management at the regional level whereby different people and groups and the full range of land tenures are involved. The best way to incorporate biodiversity into the objectives, plans and strategies of regional organisations is an issue that has arisen out of these activities (see Dore and Woodhill 1999). One issue in this regard is the reconciliation of overlapping and maybe conflicting non-traditional scales of management (regions, catchments) with traditional scales (Commonwealth, State and local) and the treatment of biodiversity issues (management, but also information-related) in and across these.

Given the on-going emphasis on microeconomic reform and rationalisation of public institutions, the impact of these changes on the quality of long-term management and monitoring of biodiversity is of concern and requires greater attention. Have these reforms brought changes that undermine institutional capacity for biodiversity conservation? Have these changes, for example, resulted in a reduction in field staff responsible for weed control, and led to the closure of stream gauging stations and weather stations? A related emerging issue is how cross-sectoral issues such as biodiversity conservation can be incorporated into the objectives and decision making processes of corporatised or privatised public agencies? Linked to these changes and institutional trends is the increasingly important issue of the applicability of risk management approaches to biodiversity conservation (e.g. AS/NZS 4360, Revised Version 1999, and the forthcoming Standards Australia handbook *Environmental risk management: Principles and processes*). It is essential that microeconomic reform and other changes do not hinder moves towards greater interagency collaboration in support of biodiversity conservation.

The potential impacts of climate change on biodiversity was discussed in SoE (1996), and some predictions of the potential changes in species distribution were presented. Since then, the response of the Australian government to the Kyoto Protocol has significantly changed the way climate change is viewed and the amount of resources going into this area. In terms of climate change policy of the Australian government, emphasis has been placed on the mitigation of greenhouse gases emissions, with the direct and indirect impacts of climate change on biodiversity receiving relatively little attention. The vital role of native vegetation for biodiversity conservation and the role of native vegetation in the carbon cycle has effectively been ignored by governments due to their lack of preparedness to stop land clearing. In contrast, the impacts of the proposed planting of large areas with tree monocultures, and the practice of 'gaming' has government support despite the potential for serious negative impacts on biodiversity in the absence of prudent management including strong controls and enforcement.

Australian governments continue to have a fundamental and critical role in biodiversity conservation in Australia. However, the rhetoric and policies relating to biodiversity conservation are not commonly matched by effective policy implementation and good biodiversity outcomes. During the 1990s, many components of biodiversity have experienced continued degradation and decline. Land management issues such as the clearance of native vegetation, control of exotic weeds and pests, environmental flows in catchments, geographical expansion of dryland salinity, changed fire regimes and intensification of resource use in sectors such as forestry, fisheries and agriculture were well-known and widely reported, including in SoE (1996). Many attempts to address these issues have been lame or have stalled.

Overall, the prognosis for the immediate future is very serious. Informed groups such as the National Farmers Federation and ACF now say that billions of dollars will need to be invested to help redress land degradation in eastern and south-west Australia alone. The recently released *Coordinating catchment management* report, from the bipartisan House of Representatives Standing Committee on Environment and Heritage, recommended that a National Environment Levy be put in place for the next 25 years to help fund programs to address these issues.

At the same time, scientific knowledge of Australia's biodiversity and the ecosystem services it supports for the Australian human population and economy has not improved significantly. The Australian scientific community charged with the responsibility of advancing biodiversity conservation goals remains underutilised as a result of limited financial resources and other support.

In all, as a nation, over the past five years the available data suggest that we have done a relatively poor job at saving, studying and sustainably using biodiversity.

What is the likely fate of Australia's biodiversity over the next 50 years? What are some of the big issues that Australian governments, industry and the community need to address, or address more effectively and comprehensively to safeguard the nation's biodiversity heritage? Will the state of biodiversity have improved by the next national State of the Environment report in 2006? Will the importance of biodiversity to the Australian way of life and the Australian economy be better recognised and valued in 2006? Will the nation have put in place significantly improved measures to safeguard an important component of biodiversity? These are important questions of much concern to many Australians and many people.

Biodiversity conservation must be addressed within the context of sustainable development if it is to succeed. While important progress has been made in regional Australia, new and enhanced contacts and partnerships within communities are required. At the same time, international cooperation is essential, given the global nature of the biodiversity crisis and the lack of national resources in many countries. Climate change and resource degradation to support economic production and global trade are issues common to every nation. Liberalisation of international trade, commodity prices and the clearance of native vegetation in many parts of Australia are linked by economic drivers. As globalisation has a more significant effect on production sectors of the Australian economy, these linkages must be better understood and dealt with if biodiversity conservation and sustainable development goals are to be achieved.

Many essential elements of biodiversity conservation require sustained commitment that may not show immediate results. Policies, institutions, laws, and attitudes do not change suddenly; expanding human capacity, carrying out first-rate research and conducting biodiversity inventories take time and money and may have no immediate pay-off. They create, however, the larger context in which enduring change can take hold. Australian governments have a vital leadership role in this way, and their preparedness and ability to do so will strongly shape the future trajectory of Australia's environment and the quality of human life enjoyed in the 21st century.

Immediate action is still needed by Australian governments. No amount of rhetoric or government policy statements can overshadow that the annual rate of land clearance across the continent, the per capita use of water, or the per capita emission of greenhouse gases by Australians, which is extraordinarily high by world standards. Irreplaceable genes, species and ecosystems are disappearing or are being depleted at an alarming rate and immediate action is required by Australian governments to stem these trends. Immediate action can help retain options for the future management of biodiversity as well as safeguard those components threatened every day by destructive human activities.

# Glossary

**adaptation** a particular part of the anatomy, a physiological process, or a behaviour pattern that improves an organism's chances to survive and reproduce

**adequacy** (in the context of the National Reserve System) the ability of the reserve to maintain the ecological viability and integrity of populations, species and communities

**aerosol** a suspension of particles, other than water or ice, in the atmosphere and ranging in size from approximately 10 to 13 µm to larger than 10 µm in radius; may be either natural or caused by human activity and most of the latter are usually considered to be pollutants

**agricultural land** any land on which crops or pastures are cultivated or domestic stock are grazed

**algal blooms** sudden proliferation of microscopic algae in water bodies, stimulated by the input of nutrients such as phosphates

**allele** a form of a gene, where multiple such forms occur

**anthropogenic** of human origin or human induced; can be used in the context of emissions that are produced as a result of human activities

**aquaculture** the commercial growing of marine (mariculture) or freshwater animals and plants in water

**arid zone** areas receiving less than 250 mm of annual rainfall in the south of Australia and 350 mm (or sometimes higher) in the north

**atmosphere** composite layer of colourless, odourless gases, known as air, surrounding the Earth; it shows distinct vertical zonation

**ballast water** water carried in tanks to maintain stability when a ship is lightly loaded; it is normally discharged to the sea when the ship is loaded with cargo

**baseline** behaviour of a system that has not been affected by human influence (for example river flow with no dams; pre-industrial levels of greenhouse gases). In most cases, the true baseline for natural systems cannot be defined or measured, so a particular condition at an agreed time is used as a substitute baseline, see *benchmark, targets*

**baseline information** information relating to a specific time or defined area of land or water, from which trends or changes can be assessed

**benchmark** the value for an indicator that has some defined environmental significance (or threshold) in the functioning of the natural system. An example is the concentration of pollutants that can be tolerated without damaging health. Whereas targets have a basis in policy and reflect human values, benchmarks are scientifically determined, see *targets*

**benthic** associated with aquatic or sea floor

**biodiversity/biodiversity** the variability among living organisms from all sources (including terrestrial, marine and other ecosystems and ecological complexes of which they are part) and includes: diversity within species and between species; and diversity of ecosystems

**biogeochemical cycles** the movement of chemical elements between organisms and non-living compartments of atmosphere, aquatic systems and soils

**biological control** controlling a pest by the use of its natural enemies

**biodiversity** see *biodiversity*

**biological productivity** the intensity of life form production in an ecosystem or part of an ecosystem

**biomass** the quantity of organic matter within an ecosystem (usually expressed as dry weight for unit area or volume)

**bioregion** a territory defined by a combination of biological, social and geographical criteria rather than by geopolitical considerations; generally, a system of related, interconnected ecosystems

**biota** all of the organisms at a particular locality

**bushfire** a term used to describe almost any form of fire burning out of control whether the fire was planned or unplanned

**bycatch** species taken incidentally in a fishery where other species are the target; may be of lesser value than the target species and are often discarded

**catchment** the area determined by topographic features within which rainfall will contribute to run-off at a particular point under consideration

**clearing** removing vegetation, particularly trees and shrubs, from a landscape, often with the intention of replacing it with plants regarded to be more directly useful to humans

**climate** the synthesis of the day-to-day weather conditions in a given area; the actual climate is characterised by long-term statistics of the state of the atmosphere in an area

**climate change** under the terms of the UNFCCC, the term means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is, in addition to natural climate variability, observed over comparable time periods

**climate variability** the natural year-to-year and season-to-season variation of the climate system

**community participation** procedures whereby members of a community participate directly in decision-making about developments that may affect the community

**comprehensiveness** the degree to which the full range of ecological communities and their biodiversity are incorporated within reserves

**Comprehensive, Adequate and Representative Reserve System (CAR)** a reserve system to conserve all native forest types as well as the plants and animals that depend on them: comprehensive, the full range of forest communities recognised by an agreed national scientific classification at appropriate hierarchical levels; adequate, the maintenance of the ecological viability and integrity of populations, species and communities; representative, those sample areas of the forest that are selected for inclusion in reserves which should reasonably reflect the biodiversity of the communities

**Comprehensive Regional Assessment (CRA)** a joint assessment of all forest values by the Commonwealth and state—environmental, heritage, economic and social—leading to the establishment of a comprehensive, adequate and representative reserve system, agreements on forest management, and the signing of an RFA

**condition indicator** (otherwise referred to as an indicator of state); something that describes the quality of the environment and the quality and quantity of natural resources; highlights changes in environmental conditions over time

**conservation** the protection, maintenance, management, sustainable use, restoration and enhancement of the natural environment

**cryptogram** a plant that has no true flowers or seeds

**discharge** the volume of water that flows through a cross-section of a stream

**domestic animals** animals directly managed by humans, see *feral animal*

**drainage** the interception and/or removal of surface and/or ground water from a given area by natural or artificial means

**dryland salinity** areas where soil salinity levels are high enough to affect plant growth; occurs as a result of natural soil forming process (primary salinity) or in disturbed landscapes through clearing or other activities that interfere with the water and salinity balance and lead to shallow water tables; hydrological response to the replacement of deep-rooted perennial native vegetation with shallow rooted annuals which use less water. As a consequence, more rainfall enters the ground water, causing water tables to rise; where these rise to within 1 to 2 m of the soil surface, salinisation occurs as a result of evapotranspiration and direct evaporation. This can result in both stream and soil salinity

**ecological footprint** the ecological effect of cities, including the direct local effects and the indirect regional and global effects due to the resources they use and the wastes they produce

**ecological processes** processes that have an essential part in maintaining ecosystems; four fundamental ecological processes are the cycling of water, the cycling of nutrients, the flow of energy and biodiversity

**ecological sustainability** the capacity of ecosystems to maintain their essential processes and functions and to retain their biodiversity without impoverishment

**ecologically sustainable development (ESD)** using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained and the total quality of life—now and in the future—can be increased (for the ESD core objectives and guiding principles, see COAG 1992)

**ecology** the scientific study of living organisms and their relationships to one another and their environment

**ecosystem** a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit

**ecosystem integrity** the degree to which the fundamental ecological processes (e.g. water and nutrient cycling, the flow of energy and biodiversity) are maintained

**ecosystem services** the role played by organisms in creating a healthy environment for human beings, from production of oxygen to soil formation and maintenance of water quality

**ecotourism** nature-based tourism that involves education and interpretation of the natural environment and is managed to be ecologically sustainable

**El Niño** an extensive warming of the central and eastern Pacific that leads to a major shift in weather patterns across the Pacific. In Australia (particularly eastern Australia), El Niño events are associated with an increased probability of drier conditions, see *ENSO*

**emissions** substances such as gases, or particles discharged into the atmosphere as a result of natural processes or human activities, including those from chimneys, elevated point sources and tailpipes of motor vehicles

**endangered species** a species which is in danger of extinction and whose survival is unlikely if the causal factors continue; included are species whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that the species are deemed to be in danger of extinction

**endemic** native to a particular area and found nowhere else

**ENSO (El Niño–Southern Oscillation)** a suite of events that occur at the time of an El Niño; at one extreme of the cycle, when the central Pacific Ocean is warm and the atmospheric pressure over Australia is relatively high, the ENSO causes drought conditions over eastern Australia

**environment** includes:

(a) ecosystems and their constituent parts, including people and communities;
(b) natural and physical resources;
(c) the qualities and characteristics of locations, places and areas; and
(d) the social, economic and cultural aspects mentioned in (a), (b) or (c)

**environmental indicators** measures of physical, chemical, biological, social, cultural or economic factors which best represent the key elements of complex ecosystems or environmental issues

**environmental management** effective and active measures taken for the protection, conservation and presentation of the environment, heritage and natural resources for which a government, organisation or individual is responsible

**environmental stress** the damaging influence of human activities on the environment (e.g. through pollution or consumption of natural resources) or that generated by natural events such as storms or droughts

**ephemeral** organisms that have a short life-span, or a watercourse that does not flow all the time

**estuary** area of an inlet or river mouth that is influenced by the tides and also by fresh water from the land; area where fresh and salt waters mix

**eutrophication** process by which waters become enriched with nutrients, primarily nitrogen and phosphorus, which stimulate the growth of aquatic flora and/or fauna

***ex situ* conservation** conservation of species outside their natural habitat (e.g. in zoos, botanical gardens and seed banks)

**Exclusive Economic Zone (EEZ)** a concept recognised under the United Nations Law of the Sea, whereby coastal states assume jurisdiction over the exploration and exploitation of marine resources extending 200 nautical miles (about 370 km) from the shore or baseline

**exotic species** a species occurring in an area outside its historically known natural range as a result of intentional or accidental dispersal by human activities (including exotic organisms, GMOs and translocated species)

**family** in the hierarchical classification of organisms, a group of species of common descent higher than the genus and lower than the order, hence a group of genera

**fauna** the entire animal life of a site or region, see *flora*

**feral animal** an animal that has reverted to a wild state from domestication (e.g. feral cats, pigs, donkeys)

**fire regime** the pattern of fires at a location; includes the frequency, intensity and seasonality of the fires

**flora** the entire plant life of a site or region, see *fauna*

**forest estate** all forests growing on public or private lands

**freehold tenure** land owned privately, see *leasehold*

**gaming** where landowners and land managers may remove or thin vegetation on their property in a manner that allows the vegetation to remain within a certain vegetation class, as broadly defined at a regional level. For example, individual trees, small stands of trees and associated understorey vegetation may be logged and removed from a forest without changing the structure of the overstorey vegetation such that it would fail to meet the agreed definition of 'forest'

**gene** the functional unit of heredity; that part of the DNA molecule that encodes a single enzyme or structural protein unit

**genetic material** any material of plant, animal, microbial or other origin that contains functional units of heredity

**genetically modified organisms (GMOs)** organisms whose genetic make up has been altered by the insertion or deletion of small fragments of DNA in order to create or enhance desirable characteristics from the same or another species

**genome** all the genes of a particular organism or species

**geographic information system (GIS)** a package of computer programs specifically designed to deal with data that are spatially related; a set of tools for collecting, storing, retrieving, manipulating, analysing and displaying mapped data from the real world

**globalisation** the economic and social process whereby local markets and cultures are increasingly dominated by global markets and culture

**Gondwana** the southern supercontinent that started to break up about 150 million years ago, consisting of what are now South America, Africa, Antarctica, Arabia, Australia, India, Madagascar and New Zealand

**grassland** areas dominated by grasses and with few or no trees

**Great Artesian Basin** an enormous store of ground water underlying much of the drier regions of eastern Australia

**ground water** water occurring below the ground surface

**habitat** The biophysical medium or media (a) occupied (continuously, periodically or occasionally) by an organism or group of organisms; or (b) once occupied (continuously, periodially or occasionally) by an organism, or group of organisms, and into which organisms of that kind have the potential to be reintroduced

**heathland** vegetation dominated by small shrubs with small hard leaves

**hectare (ha)** 10 000 square metres

**herbivore** an animal that consumes plants

**heritage** those places, objects and Indigenous languages that have aesthetic, historic, scientific or social significance or other special value for future generations as well as for the community today

**hummock grass** spinifex grasses usually growing together as large rounded 'hummocks' which can be several metres across, often forming rings with a central dead or decaying patch; hummock grasslands are largely confined to the arid interior and to infertile soils

**hybrid** the offspring of two animals or plants of different varieties, species or genera

**hydrocarbon** an organic molecule containing hydrogen and carbon; the major components of petroleum

**indicator species** a species whose presence or absence is indicative of a particular habitat, community or set of environmental conditions

**Indigenous people** the Aboriginal and Torres Strait Islander peoples of Australia

***in situ*** the location of biological, physical or material culture objects in their original physical and cultural context

***in situ* conservation** conserving species within their natural habitat

**intellectual property** intellectual property represents the property of your mind or intellect. This includes information people have as part of their cultural heritage (e.g. knowledge about bush foods or oral history)

**intertidal** between the levels of low and high tide; the intertidal zone is often called the littoral zone in Australia

**introduced species** see *exotic species*

**invertebrate** an animal without a backbone composed of vertebrae; examples include insects, worms, snails, mussels, prawns and cuttlefish, see *vertebrate*

**land cover** the physical state of the land surface, including vegetation, soil, rock and human-made structures

**Landcare** any policy, strategy or practice furthering sustainable land management. Landcare is practised by community groups, formal support services, advisers, land managers and

individuals. The community component of Landcare aims to encourage community groups and landholders to identify and solve the soil, water, vegetation, management and nature conservation problems in their area. Grants help groups with planning, education and training, resource inventories and monitoring

**leasehold** land owned by governments on behalf of the people they represent but leased to specified people or organisations for a specific purpose; about 50% of Australia, mostly in the drier regions, comes under some form of leasehold; governments retain a variety of controls over how leasehold land is used

**littoral** of, or pertaining to, a shore, especially a sea shore; littoral zone—the specific zone of the sea floor lying between high and low tide levels (intertidal)

**mallee** small multi-stemmed eucalypts that often dominate semi-arid and arid areas

**mangrove** a plant (belonging to any of a wide range of species, mainly trees and shrubs) that grows in sediment regularly inundated by seawater; a community (forest, woodland, shrubland) of such plants

**monitoring** routine counting, testing or measuring of environmental factors or biota to determine their status or condition

**monoculture** the cultivation of a single species, usually a single crop on land

**National Forest Policy Statement (NFPS)** a joint Commonwealth, state and territory government response which outlines agreed objectives and policies for Australia's public and private forests

**native forest** any local indigenous forest community containing the full complement of native species and habitats normally associated with that community, or having the potential to develop these characteristics

**native (indigenous species)** species that are native to (i.e. occur naturally) in a region, see *exotic species*

**native vegetation** any local indigenous plant community containing throughout its growth the complement of native species and habitats normally associated with that vegetation type or having the potential to develop these characteristics. It includes vegetation with these characteristics that has been regenerated with human assistance following disturbance. It excludes plantations and vegetation that has been established for commercial purposes

**natural environment** an environment that is not the result of human activity or intervention

**objectives** broad policy goals, which are not precisely quantified (e.g. sustainable resource management)

**old growth** ecologically mature vegetation that has been subject to negligible levels of disturbance such as logging, roading and clearing

**organochlorine** a hydrocarbon compound containing chlorine. Includes many pesticides and industrial chemicals

**ozone** a gas with molecules comprising three atoms of oxygen; in the stratosphere it occurs naturally and provides a protective layer shielding the earth from ultraviolet radiation; in the troposphere, it is usually formed from anthropogenic emissions and is a major component of photochemical smog; ozone is also a greenhouse gas

**pathogen** a disease-causing agent

**perennial** plants that live for more than one year

**periurban** low density housing and road development on the periphery of urban areas, still retaining small areas of rural land within networks of suburban building

**pest** an animal, or sometimes a plant, occurring where it is not wanted by humans, see *weed*

**phytoplankton** small plants that are suspended in water and free-drifting

**plantations** intensively managed stands of either native or exotic trees species, created by the regular placement of seedlings or seed

**point source pollution** pollution from an easily discernible, single source such as a factory

**pollution** the direct or indirect alteration of the physical, thermal, biological or radioactive properties of any part of the environment in such a way as to create a hazard or potential hazard to the health, safety or welfare of any living species

**polychlorinated biphenyls (PCBs)** a group of chlorinated organic compounds that are non-corroding and resistant to heat and biological degradation; used as insulation in electrical equipment; can accumulate in some species and disrupt reproduction

**population** a group of individuals of the same species, forming a breeding unit and sharing a habitat

**precautionary principle** where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation

**precipitation** any form or all forms of liquid or solid water particles that fall from the atmosphere and reach the earth's surface; includes drizzle, rain, snow, snow pellets, ice crystals, ice pellets and hail

**preservation** maintaining the physical material of places or objects in their existing state and retarding deterioration

**pressure indicators** measures that can be used to describe both positive and negative pressures on the environment, including the quality and quantity of natural resources; such pressures can be caused by human inaction as well as action

**productivity (biological)** the rate of accumulation of organic material in an ecosystem

**protected area** a protected area is defined in Article 2 of the International Convention on biodiversity as a 'geographically defined area which is designated or regulated and managed to achieve specific conservation objectives'

**protocol** a formal arrangement defining procedures

**rainforest** a closed forest in areas of high precipitation with a large diversity of species forming a deep, densely interlacing canopy in which vines and ferns are often present

**rangelands** areas of native grasslands, shrublands and woodlands that cover a large proportion of the arid and semi-arid regions, and also include tropical savanna woodlands; regular cropping is not practised and the predominant agricultural use, if any, is grazing of sheep and cattle on native vegetation

**recharge** the action by which water is added to a rock layer either naturally or artificially

**Regional Forest Agreement (RFA)** an agreement about the long-term management and use of forests in a particular region between the Commonwealth and a state government. Its purpose is to reduce uncertainty, duplication and fragmentation in government decision-making by producing a durable agreement on the management and use of forests

**regrowth** native vegetation containing a substantial proportion of individuals that are in the younger growth phase and are actively growing in height and diameter. Regrowth vegetation may contain scattered individuals or small occurrences of ecologically mature, or old growth vegetation

**representativeness** the extent to which areas selected are capable of reflecting the known biodiversity and ecological patterns and processes of the ecological community or ecosystem concerned (in the context of the National Reserves System)

**reserves** areas such as National Parks and nature reserves which are subject to an established degree of protection from disturbance

**response indicator** an indicator that shows the extent to which society is responding to environmental changes and concerns; includes changes in attitude and individual and collective actions aimed at mitigating, adapting to or reversing negative effects on the environment and reversing environmental damage already caused; also includes actions to improve the preservation and conservation of the environment

**run-off** the portion of precipitation not immediately absorbed into or detained upon the soil and which thus becomes a surface flow

**saltmarsh** saltwater wetland occupied mainly by herbs and dwarf shrubs, characteristically able to tolerate extremes of environmental conditions, notably waterlogging and salinity

**savanna** a vegetation type with scattered trees over a grassland, usually found in subtropical areas

**seagrass** flowering plant adapted to living wholly submerged in sea water; not true grasses, but many have a grass-like form

**seaweed** macroalgae (not flowering plants) occurring in the sea; typical examples are kelps, Neptune's necklace and sea lettuce

**sediment** solid material settled from suspension in the water; solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by water, air or ice and has come to rest on the land or sea floor

**seed banks** the seed naturally available at a site; most of it is stored in the soil, but some may be in protective fruits such as banksia 'cones'

**semi-arid lands** lands where rainfall is so low and unreliable that crops cannot be grown with any reliability, see *arid zone*

**shrubland** an area dominated by short, multi-stemmed plants; a typical example is the chenopod shrublands but sometimes the 'mallee' is classified as a shrubland

**siltation** deposition of sediments from water in channels and harbours etc.

**sinks** Processes or places that remove or store gases, sollutes or solids in accumulating parts of the environment

**species** a group of plants, animals or microorganisms that have a high degree of similarity and generally can interbreed only among themselves to produce fertile offspring, so that they maintain their 'separateness' from other such groups

**stakeholders** groups, individuals or organisations who may be affected by a development proposal, whether or not their stake in the outcome is explicit

**State of the Environment reporting** a process that provides a scientific assessment of environmental conditions, focusing on the effects of human activities, their significance for the environment and societal responses to the identified trends

**stock (in fisheries)** a group of individuals of a species that can be regarded as an entity for management or assessment purposes; commonly a distinct local population; some species form a single stock, others several distinct stocks

**suspended solids** any solid substance present in water in an undissolved state, usually contributing directly to turbidity, see *sediment*

**sustainability indicators** selected and/or aggregated indicators for evaluating specific ESD (ecologically sustainable development) goals

**sustainable** referring to an activity that is able to be carried out without damaging the long-term health and integrity of natural and cultural environments

**targets** specified levels or ranges of measurable parameters that decision-makers have agreed they will try to achieve; targets are policy tools, but they may have a scientific base (e.g. Australia's commitment at Kyoto to restrict greenhouse gas emissions to 108% of 1990 levels by 2014); targets may be associated with one or many indicators, see *benchmark*

**taxon (pl. taxa)** the named classification unit to which individuals or sets of species are assigned, such as species, genus and order

**threatened** a species or community that is vulnerable, endangered or presumed extinct

**threatening process** a process that threatens, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community

**trend** a general direction or tendency; an indication of change (or its absence) in a property or condition

**ultraviolet (UV) radiation** electromagnetic radiation of higher frequencies and shorter wavelengths than visible light; ultraviolet radiation is divided into three ranges: UV-A (320–400 nm), UV-B (280–320 nm) and UV-C (40–290 nm)

**vagrant** a migratory bird found outside the normal range of its species, sometimes as a result of being lost during a storm

**value adding** an economic term which describes how a raw product is processed into a product which is of more value than the material in its raw state; in the forest and wood industry context, examples of this include the kiln-drying of sawn timber, and the manufacturing of wood veneers

**vascular plants** a grouping of plants that includes ferns, the gymnosperms (e.g. pines) and flowering plants

**vertebrate** an animal with a backbone composed of vertebrae (e.g. mammals, fishes, frogs, amphibians, reptiles and birds), see *invertebrate*

**vulnerable species** species which may soon move into the 'endangered' category if causal factors affecting their numbers continue. Included are species of which all, or most, populations are decreasing because of overexploitation, extensive destruction of habitat; species which are seriously depleted; under threat from severe adverse factors throughout their range; and species with low or localised populations and dependent upon a limited habitat which would be vulnerable to further threats

**waterlogging** the saturation of soils with water; often associated with insufficient oxygen for good plant growth

**weather** the day-to-day changing atmospheric conditions, which in synthesis constitute the climate of a region

**weed** a plant species growing where it is not wanted by humans

**wet sclerophyll** a type of eucalypt forest found in high rainfall (more than 1000 mm per year) areas; sometimes called 'tall-open forests'

**wetland** areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres

**woodchips** forest product created by processing timber and residues; most commonly used in wood panels, pulp and paper making

**woodland** an area with scattered trees where the portion of the land surface covered by the crowns is more than 30% (open woodland) but less than 60% (forest)

**woody weeds** shrubby plants (both native and exotic) that have increased in numbers to be a problem for pastoralists in parts of the arid and semi-arid zones

**World Heritage** a term applied to sites of outstanding universal natural or cultural significance which are included on the World Heritage List

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