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Natural Heritage Trust

Helping Communities Helping Australia

A Commonwealth Government Initiative

AUSTRALIAN TERRESTRIAL BIODIVERSITY ASSESSMENT 2002

National Land & Water Resources Audit

A program of the Natural Heritage Trust

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NATIONAL LAND AND WATER RESOURCES AUDIT

Providing Australia-wide assessments

The National Land and Water Resources Audit (the Audit) is facilitating improved decision-making on land, vegetation and water resource management in Australia by:

- **Providing a clear understanding** of the status of, and changes in, the nation's land, vegetation and water resources and implications for their sustainable use.
- **Providing an interpretation of the costs and benefits** (economic, environmental and social) of land and water resource change and any remedial actions.
- **Developing a national information system** of compatible and readily accessible natural resources data.
- **Producing national** land and water (surface and groundwater) **assessments** as integrated components of the Audit.
- **Ensuring integration** with, **and collaboration** between, other relevant initiatives.
- **Providing a framework for monitoring** Australia's land and water resources in an ongoing and structured way.

In partnership with Commonwealth, State and Territory agencies, through its theme activities - Water Availability; Dryland Salinity; Native Vegetation; Rangeland Monitoring; Agricultural Productivity and Sustainability; Australians and Natural Resource Management; Catchments, Rivers and Estuaries Condition; and Information Management – the Audit has prepared:

Assessments of the status of and, where possible, recent changes in Australia's land, vegetation and water resources to assist decision makers achieve ecological sustainability. The assessments set a baseline or benchmark for monitoring of change.

Integrated reports on the economic, environmental and social dimensions of land, and water resource management, including recommendations for management action.

An **Australian Natural Resources Atlas and Data Library** to provide Internet-based access to integrated national, State and regional data and information about key natural resource issues.

Guidelines and protocols for assessing and monitoring the condition and management of Australia's land, vegetation and water resources.

Australian Terrestrial Biodiversity Assessment 2002 combines the knowledge of State and Territory agencies on biodiversity and its management. It assesses the trend and condition of wetlands, riparian areas, threatened species, threatened ecosystems, birds, mammals and key values associated with eucalypts and acacias across Australia. The report identifies threatening processes and conservation issues at a regional scale and makes suggestions for improved biodiversity management.

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December 2002

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

Minister for Agriculture Fisheries and Forestry
Parliament House
Canberra, ACT 2600

Minister for Environment and Heritage
Parliament House
Canberra, ACT 2600

Dear Ministers,

I have pleasure in presenting to you *Australian Terrestrial Biodiversity Assessment 2002* – a report of the National Land and Water Resources Audit.

The assessment:

- details the condition and trend of wetlands, riparian areas, threatened species and threatened ecosystems across Australia;
- provides a listing of Australia's threatened ecosystems;
- identifies the processes that threaten biodiversity and their relative frequency in each of Australia's bioregions;
- details the special values, patterns and trends for Australia's birds and mammals, eucalypts and acacias; and
- presents conservation opportunities at both Australia-wide and regional scales.

This report identifies the need to significantly enhance biodiversity conservation through:

- investing in protective management in order to minimise the impact of threatening processes such as clearing of vegetation, overgrazing, weeds, feral animals and inappropriate fire regimes;
- consolidating the national reserve system across priority bioregions to protect poorly conserved and threatened habitats;
- engaging the broader community in the recovery of threatened species and ecosystems;
- identifying specific biodiversity conservation objectives as part of integrated natural resource management;
- building awareness and identifying priorities for investment through the continued collection and assessment of information on Australia's biodiversity.

In many parts of Australia, it is demonstrated that there are currently major constraints and limited regional capacity to achieve effective biodiversity conservation. To overcome this will require significant investment, cooperation across agencies and a strategic focus on key issues if national and regional priorities are to be addressed. This assessment demonstrates the breadth of information that resides with State and Territory agencies and the need to build on and strategically use this information to achieve conservation outcomes at the regional scale.

The information now available through the National Land and Water Resources Audit is needed to underpin regional planning and actions under the National Action Plan for Salinity and Water Quality, the Natural Heritage Trust extension, State biodiversity plans and local government planning.

I am pleased to present this final assessment report from Audit 1 to the Natural Heritage Ministerial Board.

Yours sincerely,

Dr Roy Green
Chair
National Land and Water Resources Audit Advisory Council
December 2002

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2891 Australian ecosystems and other ecological communities are threatened (Photo: QEPA)

EXECUTIVE SUMMARY

About the Terrestrial Biodiversity Assessment

This report presents a landmark assessment of terrestrial biodiversity in Australia.

State and Territory agencies have worked closely with the Commonwealth through the independence of the National Land and Water Resources Audit to create an Australia-wide information set on terrestrial biodiversity.

Bioregions and subregions have been used as the biogeographic framework for the assessment as they represent broad landscape patterns resulting from the association between a range of factors including geology, climate and biota.

The report assesses the condition and trend of wetlands, riparian zones, threatened species and ecosystems and the processes that threaten various elements of biodiversity.

The first listing of threatened ecosystems in Australia has been produced. These have been related to the nationally agreed classification of Major Vegetation Subgroups of the National Vegetation Information System to facilitate conservation planning and Australia-wide comparisons.

Patterns of species richness and endemism for eucalypts and acacias have been examined as an example of the type of analysis required across a range of taxa for values that are not directly related to threatened species issues.

Detailed analysis has been undertaken on birds and mammals. These are key groups which can help us to understand the impact of land use activities on biodiversity.

The assessment examines biodiversity conservation opportunities in three complementary strategies:

- protected area consolidation;
- threatened species and ecosystem management; and
- integrated natural resource management.

Fourteen detailed biodiversity case studies have been carried out across the range of landscape health scenarios and these provide detailed insights into the specific mix of management responses needed across Australia.

The report concludes with recommendations to build on this important benchmark initiative as the basis for cost-effective investment in biodiversity conservation.

Conservation priorities and key management activities are listed for the attributes assessed. Further synthesis of this information will define geographic priorities for biodiversity conservation. This could include the identification of hot spots based on multiple criteria including richness, endemism, irreplacability, rarity and the concentration of threatened species and ecosystems. Development of policy and investment strategies is beyond the scope of this assessment and is a necessary follow-on activity by Australia's nature conservation agencies.

Underpinning this assessment, a wealth of information is available at the subregional and bioregional level on the Australian Natural Resources Atlas (www.environment.gov.au/atlas) to assist regional planning programs.

Acacia axillaris (T. Rudman)

Key Findings

Wetlands and Riparian Zones

- The condition of nationally important wetlands is generally good (58% of subregions where assessments were made), particularly in northern Australia, with wetlands in several subregions assessed as near pristine. In southern Australia, many wetlands (28% of subregions assessed) require significant intervention to bring about their recovery.
- The trend in many nationally important wetlands is declining (38% of subregions assessed).
- Wetlands of regional significance are identified as a significant issue for nature conservation and the protection of ecological processes. Approximately 4700 regionally significant wetlands are recorded with some assessment of their condition, trends and threats.
- The condition of riparian zones is degraded (meaning recovery is unlikely in the medium term) across much of southern and eastern Australia (31% of subregions assessed) and an additional number require significant management intervention to achieve recovery (38% of subregions assessed).
- The trend of riparian zones is declining significantly across much of Australia (73% of subregions assessed).
- Information on the condition and trend of nationally important wetlands is unavailable for a number of subregions. This identifies the need for more information on these wetlands and monitoring to assess their change in condition and fine tune investment in management activities.

Greater long-eared bat, *Nyctophilus timoriensis (A. Robinson)*.

Threatened Ecosystems and Species

- 2891 threatened ecosystems and other ecological communities are identified across Australia.
- 94% of bioregions in Australia have one or more threatened ecosystems, with the greatest numbers in the highly cleared regions of southern and eastern Australia.
- Nearly half of the threatened ecosystems are eucalypt forest and woodlands with shrubby or grassy understorey that have been extensively cleared.
- The highest number of threatened species occurred in southern and eastern Australia, within the subregions from the southern highlands in Victoria and NSW and along the coast from Sydney to north of Brisbane.

Mammals and Birds

- Mammal extinction has been substantial within the last 200 years. Twenty-two Australian mammals are now extinct which represent a third of the world's recent extinctions: a further eight species now persist only on islands.

Sacred Lotus, *Nelumbo nucifera* (R. Lawson).

- There has been massive contraction in the distribution of mammals in arid and semi-arid parts of the continent, particularly the small to medium critical weight range species.
- The rapid decline and loss of many mammal species that respond rapidly to environmental stress provides an insight of what may be occurring with other groups of species over a longer time frame.
- For birds, though the extinction debt has yet to become apparent in many bioregions as they are more mobile and can persist longer, populations of some species have markedly reduced.
- Based on an analysis of 6 million records, 29 species over the past 20 years show significant decrease in agricultural areas where an increased proportion of the landscape has been cleared.
- Birds most affected are the grassland, woodland and ground nesting guilds.

Eucalypts and Acacias

- Subregions and bioregions were used to identify locations of endemic eucalypt and *Acacia* species and areas that are irreplaceable if these species are to be conserved. These locations extend the previously recognized centres of endemism and include landscapes that are under threat. Critical areas for protection include parts of the Murray-Darling Basin and south-west Western Australia.
- Endemism and irreplaceability are important conservation values to be taken into account in regional planning in addition to threatened species issues. These values should be assessed for other species groups.

Threatening Processses

- Vegetation clearing is the most significant threat to species and ecosystems in eastern Australia.
- Overgrazing, exotic weeds, feral animals and changed fire regimes are additional key threats to wetlands, riparian zones, threatened species and threatened ecosystems across much of Australia. These threats are widespread and pervasive.
- Implementing fire regimes and sustainable grazing management will provide major returns for biodiversity from investment as key protective management activities for much of Australia's rangelands.
- Fragmentation of remnants, increased salinity and firewood collection are threats to biodiversity in the highly modified regions of southern and eastern Australia.

Coolibah (*Eucalyptus coolabah)* and Black Box (*E. largiflorens)* woodlands,
Culgoa Floodplains National Park: a threatened ecosystem on the Darling Riverine Plains (P. Sattler).

Yellow Waters, Kakadu National Park (P. Sattler).

Red Mallee (*Eucalyptus socialis*) is widespread in the Great Victoria Desert, Pilbara, South Australia and Central NSW (CSIRO).

Reserves

- As of June 2001, a total of 9.2% of the Australian landscape was protected for nature conservation on public and private lands.
- As a measure of the Comprehensiveness of the protected estate, 67% of Australia's ecosystem diversity was captured by national parks and formal reserves, with a further 5% included in other protected areas and covenants on private land.
- 42 bioregions (approximately half) are a high priority for further reservation actions to ensure Australia has a Comprehensive, Adequate and Representative system of protected areas. An identified 1500 ecosystems that are poorly conserved and in many cases threatened should be the focus of further reservation.
- With 57 of the subregions (31%) in the intensive land use zone having less than 30% vegetation remaining and 88 subregions (48%) now showing little connectivity between remnants, the opportunity for developing a Comprehensive, Adequate and Representative protected area system is rapidly diminishing.

Biodiversity Conservation Across the Wider Landscape

- Management across all lands is essential to fully conserve biodiversity and to protect ecosystem function. Such management should concentrate on the priority threatening processes of the particular bioregion.
- The implementation of species recovery plans and ecosystem repair activities is inadequately resourced. It requires bioregionally specific packages that include incentives, duty of care and cross compliance measures linked to improved policy and legislative frameworks.
- The cost of species and ecosystem recovery in addition to the restoration of ecological processes will far outweigh the cost of managing many threatening processes.
- Considerable limitations, including a lack of regional capacity, exist for integrated natural resource management to deliver effective biodiversity conservation outcomes across a large part of Australia (47% of subregions).

Regional Biodiversity Management

- The detailed case studies of fourteen representative regions can inform biodiversity management in similar subregions across Australia.
- Based on these analyses, Australia needs to significantly increase investment in biodiversity management if key biodiversity objectives are to be met.
- In many highly disturbed bioregions there has been much planning but limited resources or commitment to implement the plans.

Kangaroo Island phebalium, *Leionema equestre*, is endangered (P. Lang).

- An important part of biodiversity conservation is the cooperation of private land owners, but in many regions little capacity exists to address conservation issues.
- Effectiveness of various incentive mechanisms and other strategies in terms of actual biodiversity conservation outcomes should be more closely assessed.

Management Orientated Information

- This assessment has set a baseline for management orientated biodiversity information. Continued collection of data to fill gaps and establish trend in condition is essential.
- A number of jurisdictions have indicated the desire for the co-ordinated Audit biodiversity assessment to continue as it has provided regionally specific information relevant for State and regional management.
- Investment in systematic assessment and coordinated monitoring would provide information for more cost-effective investment in biodiversity conservation activities.

Southern cross silver mallee, *Eucalyptus crucis* (M. Fagg).

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AUSTRALIAN TERRESTRIAL BIODIVERSITY ASSESSMENT 2002

Australian Terrestrial Biodiversity Assessment 2002 is Australia's first comprehensive assessment of terrestrial biodiversity. It provides the basis for an improved understanding of biodiversity values, biodiversity management requirements and investment opportunities.

Australian Terrestrial Biodiversity Assessment 2002 was prepared in partnership with State, Territory and Commonwealth conservation and natural resource management agencies.

Australian Capital Territory
Environment ACT

New South Wales
National Parks and Wildlife Service

Northern Territory
Parks and Wildlife Commission

Queensland
Environment Protection Agency

South Australia
Department of Water, Land and Biodiversity Conservation and the Department for Environment and Heritage

Tasmania
Department of Primary Industries, Water and Environment

Victoria
Department of Natural Resources and Environment

Western Australia
Department of Conservation and Land Management

Commonwealth
Environment Australia
Agriculture, Fisheries and Forestry – Australia
CSIRO Sustainable Ecosystems

TERRESTRIAL BIODIVERSITY AND OTHER AUDIT ASSESSMENTS

The Australian Terrestrial Biodiversity Assessment is one of the series of natural resource assessment and reporting initiatives fostered under the National Land and Water Resources Audit. All other Audit assessments have implications for biodiversity conservation.

Management of water is critical to the management of biodiversity.

- The status of Australia's surface and groundwater resources, including their extent, use, quality and sustainability, is detailed in the Audit's report *Australian Water Resources Assessment 2000.*

Dryland salinity is a land degradation issue that has impact on many agricultural regions of Australia and is a major cause of impacts to land, water and biological resources.

- Assessment of the likely hazard of dryland salinity based on salt stores and an understanding of the water balance and projected groundwater levels is provided in the Audit report *Australian Dryland Salinity Assessment 2000.*

The development of a readily accessible and standardised database of native vegetation is essential to the management of Australia's biodiversity and provides a basis for further development of biodiversity data sets.

- The Audit's National Vegetation Information System provides a hierarchy of vegetation information from structural formations to communities and species. The extent and fragmentation of native vegetation is assessed in *Australian Native Vegetation Assessment 2001.*

Rangelands occupy three quarters of Australia. These are key natural environments and protective management is essential to halt the decline in condition and biodiversity values. Relatively small investment may result in substantial conservation gains.

- The Audit has developed an Australia-wide monitoring framework to assess the condition and trend of Australia's rangelands available in *Tracking Changes – Australian Collaborative Rangelands Information System 2001.*

Application of best management practice systems are gaining impetus as Australian agriculture develops its export and domestic product position based on a combined ethos of food quality, efficient production and sustainable resource use.

- Information on nutrient and sediment loads resulting from land use, mobilised through rivers and estuaries, together with best practice activities in key agricultural industries are detailed in the Audit's report *Australian Agriculture Assessment 2001.*

Natural resource management is multidisciplinary and must take account of not only biophysical conditions but also social and economic constraints and opportunities. Australia has an opportunity to improve the condition of its biodiversity and at the same time enhance economic and social outcomes.

- The Audit has collated resource accounting information on rural land use, the benefits of agriculture production to the Australian economy, costs resulting from land degradation and the opportunities that arise from improved management. This analysis is presented in *Australians and Natural Resource Management 2002.*

Rivers and estuaries are key common property resources that receive the cumulative impact of our land use activities. The Audit's rivers and estuaries assessments complement this assessment by identifying unmodified river reaches and near pristine estuaries as the basis for an Australia-wide program of nature conservation for these resources.

- *Australian Catchment, River and Estuary Assessment 2002* assesses aggregate impacts of natural resource use on catchment, river and estuary condition and identifies priority management challenges to maintain or repair these natural assets.

To underpin further assessments and map trends in resource condition, Australia needs to adopt comparable approaches to data collection and management, assessment and information provision.

The results of monitoring should inform land use management and assess the returns on investment from major programs. This will require an upgrading and improved accessibility of management-orientated natural resource information. This biodiversity assessment has established a core set of biodiversity elements for monitoring across Australia that will directly inform regional planning and strategic investment in conservation.

- Overall natural resource data management maintenance and information provision is reported as part of the *Australian Natural Resources Information 2002* report and the proposed monitoring system for Australia's natural resources detailed within the Audit's final report, *Australia's Natural Resources 1997-2002 and Beyond.*

Integration through the Atlas

Access to information on natural resources provides opportunities for increased awareness and informed debate. This has been improved through internet and database technology.

The web-based Australian Natural Resources Atlas (Atlas) presents Audit products from Australia-wide to regional scales.

The Atlas provides information to aid decision-making across all aspects of natural resource management on the topics of agriculture, coasts, dryland salinity, irrigation, land, natural resource economics, people, rangelands, soils, vegetation and biodiversity, and water. The Atlas is organised by geographic region (national, State, ecological) and by information topic.

The Data Library supports the Atlas with links to Commonwealth, State and Territory data management systems and atlases. The database and associated metadata that underpins the Terrestrial Biodiversity Assessment is available from the Data Library.

The terrestrial biodiversity topic of the Australian Natural Resources Atlas has information at Australia-wide, bioregional and subregional levels (Figure i). Fourteen detailed case studies provide conservation strategy options for subregions of varying levels of landscape stress.

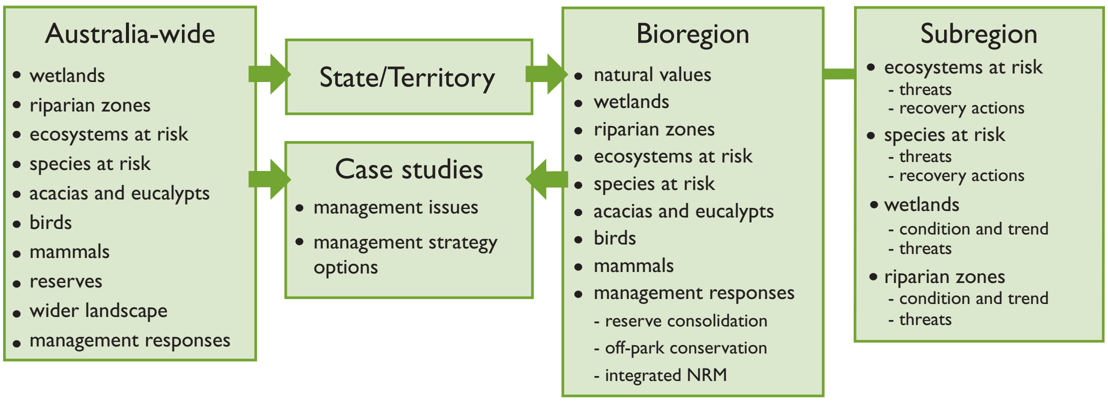


Figure (i): Australian Natural Resources Atlas structure and content (www.environment.gov.au/atlas).

More details about methods used in the Terrestrial Biodiversity Assessment are available in separate reports available on the Atlas. These include:

Garnett, S.T., Crowley, G.M. and Barrett, G. 2002. *Analysis of Birds for the Australian Terrestrial Biodiversity Assessment 2002.* A report to the National Land and Water Resources Audit, Canberra.

McKenzie, N.L. and Burbidge, A.A. 2002, *Australian Mammal Audit.* A report to the National Land and Water Resources Audit, Canberra.

1. Introduction

A riparian zone in pristine condition (J.Tait).

INTRODUCTION

The overall goal of the Australian Terrestrial Biodiversity Assessment was to assess the condition and trend of a number of key attributes at a landscape scale and to detail landscape management priorities for conserving biodiversity at both Australia-wide and regional scales. In doing so, the objective was to assess the conservation values and opportunities for improved management for all regions of Australia so that planning and works can be undertaken in a more systematic and cost-effective fashion. This systematic approach would help focus investment more effectively and efficiently to meet Australia-wide conservation priorities. It would also provide information for monitoring progress towards national biodiversity targets.

Australia's biodiversity

The term biological diversity or biodiversity refers to the variety of life of earth – plants, animals, micro-organisms – as well as the variety of genetic material they contain and of the ecological systems in which they occur. The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* defines biodiversity 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.

Biodiversity is a simple concept, but one which also has great complexity and significance. *The National Strategy for the Conservation of Australia's Biological Diversity* (ANZECC 1996) expands on the three levels at which biodiversity occurs:

- genetic diversity – the variety of genetic information contained in all of the individual

plants, animals and microorganisms that inhabit the earth. Genetic diversity occurs within and between the populations of organisms that comprise individual species as well as among species;
- species diversity – the variety of species on Earth; and
- ecosystem diversity – the variety of habitats, biotic communities and ecological processes.

These different elements of biodiversity occur at a number of scales. For example, genes vary at the scale of individual organisms, whereas species and ecosystems can vary from patches, to landscapes and through to the Australia-wide scale. The emphasis in this report is placed on the landscape scale because it is the scale at which many ecological processes operate and often reflects historical and current land uses and associated threatening processes.

The recognition that species rely on functioning ecosystems is particularly important as it demonstrates the need for integrated regional strategies that encompass protective conservation and natural resource management measures. This assessment includes the role of traditional reserved-based conservation measures as well as the contribution of integrated natural resource management measures for biodiversity conservation. Likewise the assessment recognises that it is not sufficient to focus attention on a few icon ecosystems such as rainforests and wet eucalypt forests. Indeed, one of the key messages arising from this assessment is the large number of threatened ecosystems found across Australia and the numerous processes that threaten them. Many of these ecosystems and their condition receive little attention, yet may represent critical areas for the conservation of biodiversity.

Society places different values on biodiversity and these values often overlap. Elements of biodiversity that have aesthetic or recreational values make an economic contribution through the arts and tourism. Nature based tourism is estimated at 4.7% of the gross domestic product in direct returns and up to 11% indirectly. In addition, Indigenous and many other Australians have a spiritual association with the land. Distinctive landscapes have created a unique cultural heritage for all Australians.

Australia State of the Environment 2001 – lessons learnt so far

The 2001 State of the Environment Report (Environment Australia 2001) concluded that many of the key threats to biodiversity identified in the 1996 report (SEAC 1996) still exist. Some of the key issues identified in the 1996 and 2001 State of the Environment reports and the ways they have been addressed in this assessment are listed in Table 1.1.

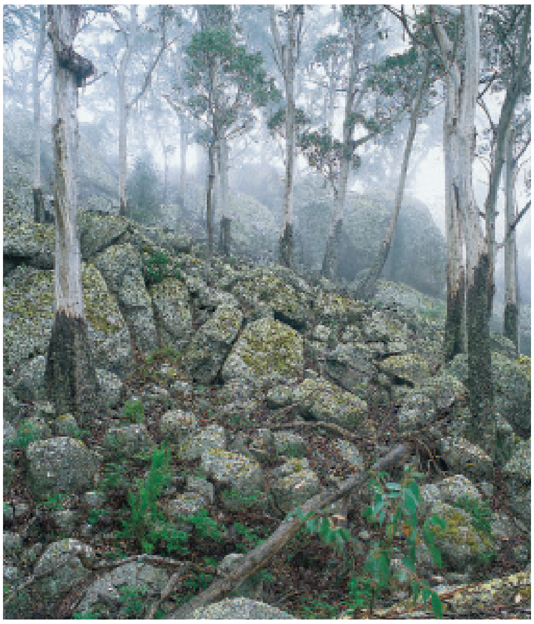
The reports concluded that the prognosis for biodiversity in Australia in the immediate future is continuing decline. Many pressures that undermine biodiversity conservation are still to be effectively dealt with.

Both the 1996 and 2001 State of the Environment reports identified clearance of native vegetation as the most significant threat to terrestrial biodiversity. Dryland salinity, a major legacy of changes to water balance following broad-scale clearing, was also identified as a threat to terrestrial and aquatic biodiversity.

The endangered Ampurta, *Dasycercus hillieri* (A. Robinson).

Table 1.1 Some of the key issues identified in the 1996 and 2001 State of the Environment reports that are addressed in the Australian Terrestrial Biodiversity Assessment.

KEY ISSUES IDENTIFIED IN THE 1996 AND 2001 STATE OF THE ENVIRONMENT REPORTS	ASSESSMENTS IN THIS REPORT
Effects of human population and consumption.	Impacts on observed patterns of some taxa.
Condition of ecosystems.	Listing of Australia's threatened ecosystems, condition and trend of wetlands and riparian zones.
Distribution and abundance of species.	Bioregional distribution of threatened species, and detailed analysis of eucalypts, acacias, birds and mammals.
Land clearance and related activities.	Threatening process detailed at subregional scale.
Effects of introduced species.	Threatening process detailed at subregional scale.
Lack of knowledge of biodiversity.	Adequacy of data examined for fauna surveys; vegetation mapping, floristic and ecological attributes.
Effectiveness of conservation measures outside reserves.	Conservation actions off-park such as recovery plans for species and ecosystems and integrated natural resource management detailed at bioregional and subregional scales.
Adequacy of protected areas.	Gap analysis undertaken on the Comprehensiveness, Adequacy and Representativeness of the protected area system; reserve consolidation priorities and constraints identified.
Adoption of integrated ecosystem-based management of natural resources.	Natural resource management actions identified and assessment of constraints and capacity at subregional scale.
Altered fire regimes (new in 2001 SoE report).	One of the threatening processes examined at subregional scale.



South East Forest National Park (M.Van Ewijk NPWS)

In the arid and semi-arid rangelands, invasive species and altered fire and grazing regimes were identified as the major threats in the 2001 State of the Environment report. Freshwater aquatic systems comprising wetlands and riverine systems continue to be degraded, especially by salinity and other hydrological changes (Environment Australia 2001). Knowledge of the type and number of species in Australia, especially of less visible groups such as invertebrates and microbes, was identified as extremely limited. Emerging issues identified in the State of the Environment report include the potential effects of climate change and genetically modified organisms on biodiversity.

Red Kangaroo, *Macropus rufus* (QEPA).

Some progress was noted between 1996 and 2001 (Environment Australia 2001). For example, the Comprehensiveness and Adequacy of the nation's reserve system was reported to have improved, though some important gaps in the reserve system remained and a range of tenures were needed. The increased involvement of the broader community, corporate Australia, local government and Indigenous Australians in biodiversity conservation was recognised as positive.

The State of the Environment report contended that further progress was restricted by issues such as dysfunctional State-Commonwealth arrangements in respect to data gathering and the level of community commitment. Data and its availability was a key planning issue for State of the Environment reporting.

The Terrestrial Biodiversity Assessment represents a major step forward in planning for biodiversity conservation and for future State of the Environment reporting.

Other Initiatives and this Assessment

The Terrestrial Biodiversity Assessment will inform the development of the National Strategy for the Conservation of Australia's Biodiversity objectives and targets for 2001-2005 (ANZECC 1996, 2001a). This strategy aims to bridge the gap between current activities and those measures necessary to ensure the effective identification, conservation and ecologically sustainable use of Australia's biodiversity.

Recent national programs such as the National Action Plan for Salinity and Water Quality and the extension of the Natural Heritage Trust are significant investment initiatives. Both of these programs are based on the development of integrated regional management plans that include biodiversity. These initiatives are reliant on access to data on a range of biodiversity-related attributes that can be linked to landscapes and regions. The Terrestrial Biodiversity Assessment provides comprehensive regional information for management.

Earlier this year, a Prime Minister's Science, Engineering and Innovation Council working group presented its report on biodiversity (Morton *et al.* 2002). It stressed the need for strategic investment in conservation, particularly the need to address threatening processes rather than focussing only on remedial actions. The prevention of broad-scale vegetation clearing to protect multiple ecosystem services and biodiversity, and the positive cost-benefit to Australia of protecting these values versus the cost of repair, are some issues that were identified.

2. Scope of the Assessment

Diverse wildflower heaths of south-west Western Australia have been extensively cleared (P. Sattler).

INTRODUCTION

A range of conservation measures – both on and off reserves – are needed to conserve and manage biodiversity in Australia. This assessment examined biodiversity conservation in terms of three complementary strategies:

- reserve consolidation;
- threatened species and ecosystem management; and
- integrated natural resource management.

These strategies mirror key actions identified in *The National Strategy for the Conservation of Australian Biological Diversity* (ANZECC 1996). Assessment of their effectiveness in terms of contribution to biodiversity conservation can be used to review progress and return on investment and to identify priorities for further action.

The focus of this assessment is on terrestrial biodiversity, with some elements of freshwater aquatic systems included. This is not intended to downplay the importance of biodiversity and its conservation in freshwater and marine systems, but reflects the resources and time available and complements the Audit's assessment of rivers and estuaries.

Reporting Framework

The Terrestrial Biodiversity Assessment has used 85 bioregions (*Interim Biogeographic Regionalisation for Australia 5.1*, Environment Australia 2000) and their 384 component subregions as the reporting framework. The biogeographic regionalisation was developed in collaboration between the Commonwealth and all States and Territories.

Bioregions represent broad landscape patterns that are the result of the interplay between factors including geology, climate and biota.

Subregions represent relatively homogenous units within bioregions and are principally based on geology, geomorphology, or finer climatic differences (Morgan & Terrey 1990). The hierarchical framework, enabling biodiversity to be examined from continental to local scales, had its genesis in a biogeographic regionalisation for Queensland (Stanton & Morgan 1977) and has been demonstrated as a very useful tool for planning biodiversity conservation (e.g. Sattler & Williams 1999). This framework has been the cornerstone in the development of the National Reserve System and bioregional planning more generally (Ahern *et al.* 2001).

Ecosystems have been delineated for bioregions based on an integrated description of vegetation, landform and geology/soils. The ecosystem level of biodiversity has been specifically assessed as it is highly suitable for addressing biodiversity management needs at a landscape scale. Because ecosystem and vegetation mapping across Australia is at different scales, the information presented in this assessment varies in detail. Nevertheless, the information presented provides an important benchmark for monitoring condition and trend of ecosystems and of landscapes in general, as well as determining priorities for consolidating the protected area system for off-reserve conservation.

Data on invertebrates is patchy: conclusions cannot be drawn at the Australia-wide scale (R. Lawson).

Much of the planning for the National Action Plan for Water Quality and Salinity and the extension of the Natural Heritage Trust programs is being undertaken on a catchment basis. Information collated in this assessment can be spatially related to catchment or other administrative planning frameworks. Figure 2.1 illustrates the relationships between the biogeographic regionalisation used in this assesssment and major river basins.

The Landscape Health in Australia Assessment (NLWRA 2001a) developed and collated the subregions for Australia and was the first Australia-wide assessment to use subregions as a reporting unit. The Landscape Health Assessment has underpinned much of this assessment by providing a continental classification of the health of regional landscapes from a nature conservation perspective (Figure 2.2). Continental landscape stress was determined for each of the subregions using a decision tree that determined the relative importance of key attributes including:

- extent and fragmentation of native vegetation;
- grazing impacts;
- conservative land uses;
- percentage of ecosystems threatened;
- density and number of weeds and feral animals;
- extent of dryland salinity; and
- the number of threatened vascular plant and vertebrate fauna species.

Collating Biodiversity Information

Biodiversity information collated in the Biodiversity Assessment includes:

- natural values for each subregion;
- nationally important wetlands - condition, trend and threatening processes;
- wetlands of regional significance - values, condition, trend and threatening processes;
- riparian condition, trend and threatening processes for each subregion;
- threatened ecosystems categorized by the National Vegetation Information System Major Vegetation Subgroups, their recommended status (vulnerable or endangered), trend, threatening processes and bioregional distribution;
- threatened species in each subregion, their status, trend, threatening processes and recommended recovery actions;

River Basins

No.	RIVER BASIN
001	Georgina River
002	Diamantina River
003	Coopers Creek
004	Lake Frome
005	Finke River
006	Todd River
007	Hay River
011	Bulloo River
012	Lake Bancannia
021	Gairdner
022	Nullarbor
023	Warburton
024	Salt Lake
025	Sandy Desert
026	Mackay
027	Burt
028	Wiso
029	Barkly
101	Jacky Jacky Creek
102	Olive / Pascoe Rivers
103	Lockhart River
104	Stewart River
105	Normanby River
106	Jeannie River
107	Endeavour River
108	Daintree River
109	Mossman River
110	Barron River
111	Mulgrave-Russell River
112	Johnstone River
113	Tully River
114	Murray River (Qld)
115	Hinchinbrook Island
116	Herbert River
117	Black River
118	Ross River
119	Haughton River
120	Burdekin River
121	Don River
122	Proserpine River
123	Whitsunday Island
124	O'Connell River
125	Pioneer River
126	Plane Creek
127	Styx River
128	Shoalwater Creek
129	Water Park Creek
130	Fitzroy River (Qld)
131	Curtis Island
132	Calliope River
133	Boyne River
134	Baffle Creek
135	Kolan River
136	Burnett River
137	Burrum River
138	Mary River (Qld)
139	Fraser Island
140	Noosa River
141	Maroochy River
142	Pine River
143	Brisbane River
144	Stradbroke Island
145	Logan-Albert River
146	South Coast
201	Tweed River
202	Brunswick River
203	Richmond River
204	Clarence River
205	Bellinger River
206	Macleay River
207	Hastings River
208	Manning River
209	Karuah River
210	Hunter River
211	Macquarie - Tuggerah Lakes
212	Hawkesbury River
213	Sydney Coast - Georges River
214	Wollongong Coast
215	Shoalhaven River
216	Clyde River - Jervis Bay
217	Moruya River
218	Tuross River
219	Bega River
220	Towamba River
221	East Gippsland
222	Snowy River
223	Tambo River
224	Mitchell River
225	Thomson River
226	Latrobe River
227	South Gippsland
228	Bunyip River
229	Yarra River
230	Maribyrnong River
231	Werribee River
232	Moorabool River
233	Barwon River
234	Lake Corangamite
235	Otway Coast
236	Hopkins River
237	Portland Coast
238	Glenelg River
239	Millicent Coast
301	Flinders - Cape Barren Island
302	East Coast
303	Coal River
304	Derwent River
305	Kingston Coast
306	Huon River
307	South-West Coast
308	Gordon River
309	King-Henty Rivers
310	Pieman River
311	Sandy Cape Coast
312	Arthur River
313	King Island
314	Smithton-Burnie Coast
315	Forth River
316	Mersey River
317	Rubicon River
318	Tamar River
319	Piper-Ringarooma Rivers
401	Upper Murray River
402	Kiewa River
403	Ovens River
404	Broken River
405	Goulburn River
406	Campaspe River
407	Loddon River
408	Avoca River
409	Murray-Riverina
410	Murrumbidgee River
411	Lake George
412	Lachlan River
413	Benanee
414	Mallee
415	Wimmera - Avon Rivers
416	Border Rivers
417	Moonie River
418	Gwydir River
419	Namoi River
420	Castlereagh River
421	Macquarie-Bogan Rivers
422	Condamine-Culgoa Rivers
423	Warrego River
424	Paroo River
425	Darling River
426	Lower Murray River
501	Fleurieu Peninsula
502	Myponga River
503	Onkaparinga River
504	Torrens River
505	Gawler River
506	Wakefield River
507	Broughton River
508	Mambray Coast
509	Willochra Creek
510	Lake Torrens
511	Spencer Gulf
512	Eyre Peninsula
513	Kangaroo Island
601	Esperance Coast
602	Albany Coast
603	Denmark River
604	Kent River
605	Frankland River
606	Shannon River
607	Warren River
608	Donnelly River
609	Blackwood River
610	Busselton Coast
611	Preston River
612	Collie River
613	Harvey River
614	Murray River (WA)
615	Avon River
616	Swan Coast
617	Moore-Hill Rivers
618	Yarra Yarra Lakes
619	Ninghan
701	Greenough River
702	Murchison River
703	Wooramel River
704	Gascoyne River
705	Lyndon-Minilya Rivers
706	Ashburton River
707	Onslow Coast
708	Fortescue River
709	Port Hedland Coast
710	De Grey River
801	Cape Leveque Coast
802	Fitzroy River (WA)
803	Lennard River
804	Isdell River
805	Prince Regent River
806	King Edward River
807	Drysdale River
808	Pentecost River
809	Ord River
810	Keep River
811	Victoria River
812	Fitzmaurice River
813	Moyle River
814	Daly River
815	Finniss River
816	Bathurst and Melville Island
817	Adelaide River
818	Mary River (NT)
819	Wildman River
820	South Alligator River
821	East Alligator River
822	Goomadeer River
823	Liverpool River
824	Blyth River
825	Goyder River
826	Buckingham River
901	Koolatong River
902	Walker River
903	Roper River
904	Towns River
905	Limmen Bight River
906	Rosie River
907	McArthur River
908	Robinson River
909	Calvert River
910	Settlement Creek
911	Mornington Island
912	Nicholson River
913	Leichhardt River
914	Morning Inlet
915	Flinders River
916	Norman River
917	Gilbert River
918	Staaten River
919	Mitchell River (Qld)
920	Coleman River
921	Holroyd River
922	Archer River
923	Watson River
924	Embley River
925	Wenlock River
926	Ducie River
927	Jardine River
928	Torres Strait Islands
929	Groote Eylandt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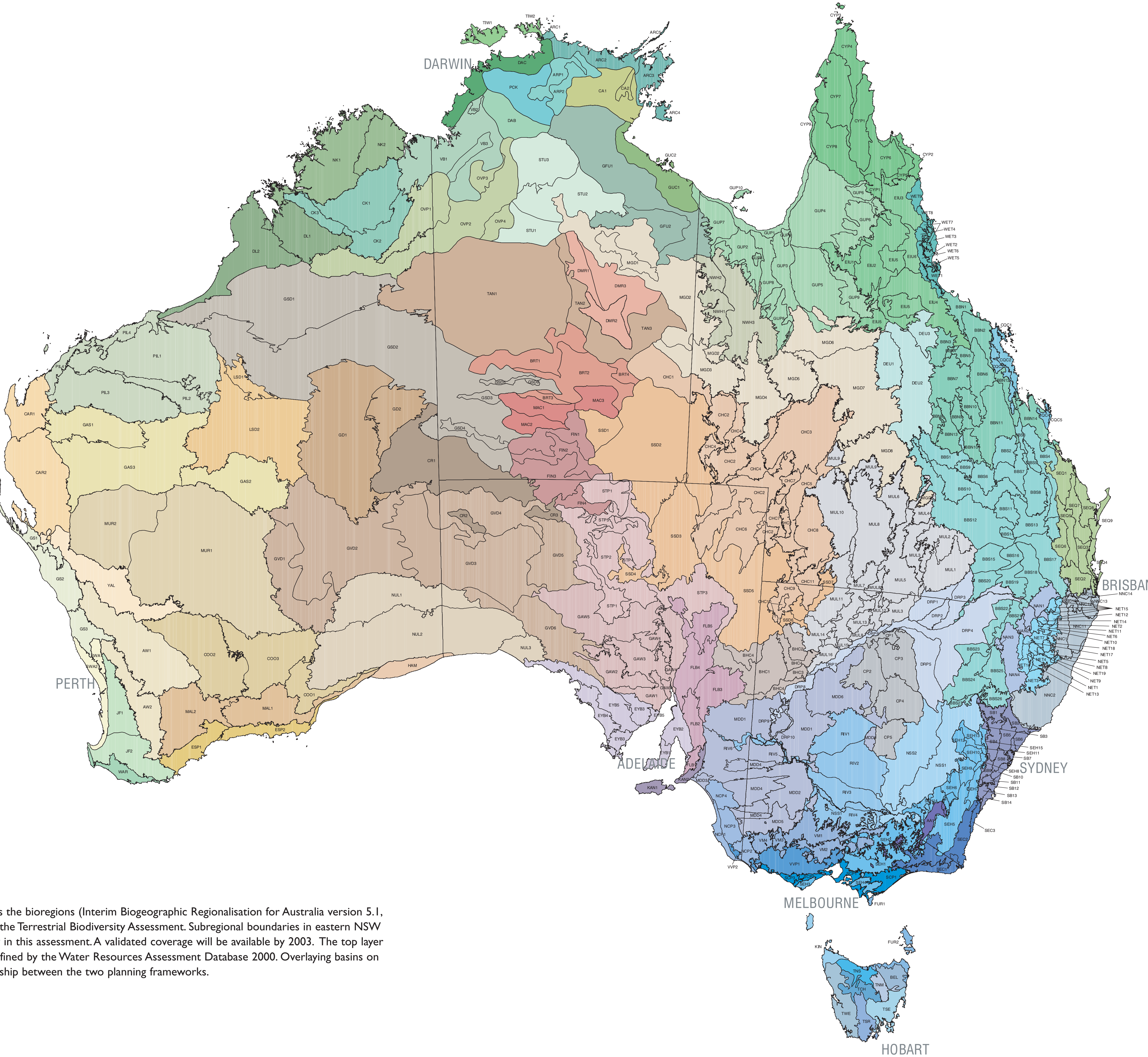


Figure 2.1 The bottom layer is the bioregions (Interim Biogeographic Regionalisation for Australia version 5.1, 2000) and subregions used in the Terrestrial Biodiversity Assessment. Subregional boundaries in eastern NSW are interim for use exclusively in this assessment. A validated coverage will be available by 2003. The top layer is the major river basins as defined by the Water Resources Assessment Database 2000. Overlaying basins on subregions shows the relationship between the two planning frameworks.

Intermin Biogeographic Regionalisation for Australia, version 5.1 and subregions

Arnhem Coast (ARC)
ARC1 Arnhem Coast P1
ARC2 Arnhem Coast P2
ARC3 Arnhem Coast P3
ARC4 Arnhem Coast P4 Groote
ARC5 Arnhem Coast P5 Wessels

Arnhem Plateau (ARP)
ARP1 Arnhem Plateau P1
ARP2 Arnhem Plateau P2

Australian Alps (AA)
AA1 New South Wales Alps
AA2 Victorian Alps

Avon Wheatbelt (AW)
AW1 Avon Wheatbelt P1
AW2 Avon Wheatbelt P2

Brigalow Belt North (BBN)
BBN1 Townsville Plains
BBN2 Bogie River Hills
BBN3 Cape River Hills
BBN4 Beucazon Hills
BBN5 Wyarra Hills
BBN6 Northern Bowen Basin
BBN7 Belyando Downs
BBN8 Upper Belyando Floodout
BBN9 Anakie Inlier
BBN10 Basalt Downs
BBN11 Isaac - Comet Downs
BBN12 Nebo - Connors Ranges
BBN13 South Drummond Basin
BBN14 Marlborough Plains

Brigalow Belt South (BBS)
BBS1 Claude River Downs
BBS2 Woorabinda
BBS3 Boomer Range
BBS4 Mount Morgan Ranges
BBS5 Callide Creek Downs
BBS6 Arcadia
BBS7 Dawson River Downs
BBS8 Banana - Auburn Ranges
BBS9 Buckland Basalts
BBS10 Carnarvon Ranges
BBS11 Taroom Downs
BBS12 Southern Downs
BBS13 Barakula
BBS14 Dulacca Downs
BBS15 Weribone High
BBS16 Tara Downs
BBS17 Eastern Darling Downs
BBS18 Ingkewood Sandstones
BBS19 Moonie R. - Commoron Creek Floodout
BBS20 Moonie - Barwon Interfluve
BBS21 Northern Basalts
BBS22 Northern Outwash
BBS23 Pilliga Outwash
BBS24 Pilliga
BBS25 Liverpool Plains
BBS26 Liverpool Range
BBS27 Talbragar Valley

Ben Lomond (BEL)

Broken Hill Complex (BHC)
BHC1 Barrier Range
BHC2 Mootwingee Downs
BHC3 Scopes Range
BHC4 Barrier Range Outwash

Burt Plain (BRT)
BRT1 Burt Plain P1
BRT2 Burt Plain P2
BRT3 Burt Plain P3
BRT4 Burt Plain P4

Central Arnhem (CA)
CA1 Central Arnhem P1
CA2 Central Arnhem P2

Carnarvon (CAR)
CAR1 Cape Range
CAR2 Wooramel

Channel Country (CHC)
CHC1 Toko Plains
CHC2 Sturt Stony Desert
CHC3 Goneaway Tablelands
CHC4 Diamantina-Eyre
CHC5 Cooper Plains
CHC6 Coongie
CHC7 Lake Pure
CHC8 Noccundra Slopes
CHC9 Tibooburra Downs
CHC10 Core Ranges
CHC11 Bulloo

Central Kimberley (CK)
CK1 Pentecost
CK2 Hart
CK3 Mount Eliza

Central Mackay Coast (CMC)
CQC1 Whitsunday
CQC2 Proserpine - Sarina Lowlands
CQC3 Clarke - Connors Ranges
CQC4 Byfield
CQC5 Manifold

Coolgardie (COO)
COO1 Mardabilla
COO2 Southern Cross
COO3 Eastern Goldfield

Cobar Peneplain (CP)
CP1 Boorindal Plains
CP2 Barnato Downs
CP3 Canbelego Downs
CP4 Nymagee-Rankins Springs
CP5 Lachlan Plains

Central Ranges (CR)
CR1 Mann-Musgrave Block
CR2 Wataru
CR3 Everard Block

Cape York Peninsula (CYP)
CYP1 Coen - Yamba Inlier
CYP2 Starke Coastal Lowlands
CYP3 Cape York - Torres Strait
CYP4 Jardine - Pascoe Sandstones
CYP5 Battle Camp Sandstones
CYP6 Laura Lowlands
CYP7 Weipa Plateau
CYP8 (Northern) Holroyd Plain
CYP9 Coastal Plains

Daly Basin (DAB)

Darwin Coastal (DAC)

Desert Uplands (DEU)
DEU1 Prairie - Torrens Creeks Alluvials
DEU2 Alice Tableland
DEU3 Cape-Campaspe Plains

Dampierland (DL)
DL1 Fitzroy Trough
DL2 Pindanland

Davenport Murchison Ranges (DMR)
DMR1 Davenport Murchison Range P1
DMR2 Davenport Murchison Range P2
DMR3 Davenport Murchison Range P3

Darling Riverine Plains (DRP)
DRP1 Culgoa-Bokhara
DRP2 Narra-Lightning Ridge
DRP3 Warrambool-Moonie
DRP4 Castlereagh-Barwon
DRP5 Bogan-Macquarie
DRP6 Louth Plains
DRP7 Wilcannia Plains
DRP8 Menindee
DRP9 Great Darlin Anabranch
DRP10 Pooncarie-Darling

Einasleigh Uplands (EIU)
EIU1 Georgetown - Croydon
EIU2 Kidston
EIU3 Hodgkinson Basin
EIU4 Broken River
EIU5 Undara - Toomba Basalts
EIU6 Herberton - Wairuna

Esperance Plains (ESP)
ESP1 Fitzgerald
ESP2 Recherche

Eyre Yorke Block (EYB)
EYB1 Southern Yorke
EYB2 St Vincent
EYB3 Eyre Hills
EYB4 Talia
EYB5 Eyre Mallee

Finke (FIN)
FIN1 Finke P1
FIN2 Finke P2
FIN3 Tieyon
FIN4 Pedirka

Flinders Lofty Block (FLB)
FLB1 Mount Lofty Ranges
FLB2 Broughton
FLB3 Olary Spur
FLB4 Sountern Flinders
FLB5 Northern Flinders

Flinders (FLI)
FUR1 Wilsons Promontory
FUR2 Flinders

Gascoyne (GAS)
GAS1 Ashburton
GAS2 Carnegie
GAS3 Augustus

Gawler (GAW)
GAW1 Myall Plains
GAW2 Gawler Volcanics
GAW3 Gawler Lakes
GAW4 Arcoona Plateau
GAW5 Kingoonya

Gibson Desert (GD)
GD1 Lateritic Plain
GD2 Dune Field

Gulf Fall and Uplands (GFU)
GFU1 McArthur - South Nicholson Basins
GFU2 Gulf Fall and Uplands P2

Geraldton Sandplains (GS)
GS1 Edel
GS2 Geraldton Hills
GS3 Leseur Sandplain

Great Sandy Desert (GSD)
GSD1 McLarty
GSD2 Mackay
GSD3 Great Sandy Desert P3
GSD4 Great Sandy Desert P4
GSD5 Great Sandy Desert P5
GSD6 Great Sandy Desert P6

Gulf Coastal (GUC)
GUC1 Gulf Coastal P1
GUC2 Gulf Coastal P2

Gulf Plains (GUP)
GUP1 Karumba Plains
GUP2 Armaynald Plains
GUP3 Woondoola Plains
GUP4 Mitchell - Gilbert Fans
GUP5 Claraville Plains
GUP6 Holroyd Plain - Red Plateau
GUP7 Doomadgee Plains
GUP8 Donors Plateau
GUP9 Gilberton Plateau
GUP10 Wellesley Islands

Great Victoria Desert (GVD)
GVD1 Shield
GVD2 Central
GVD3 Maralinga
GVD4 Kintore
GVD5 Tallaringa
GVD6 Yellabinna

Hampton (HAM)

Jarrah Forest (JF)
JF1 Northern Jarrah Forest
JF2 Southern Jarrah Forest

Kanmantoo (KAN)
KAN1 Kangaroo Island
KAN2 Fleurieu

King (KIN)

Little Sandy Desert (LSD)
LSD1 Rudall
LSD2 Trainor

MacDonnell Ranges (MAC)
MAC1 MacDonnell Ranges P1
MAC2 MacDonnell Ranges P2
MAC3 MacDonnell Ranges P3

Mallee (MAL)
MAL1 Eastern Mallee
MAL2 Western Mallee

Murray Darling Depression (MDD)
MDD1 South Olary Plain
MDD2 Murray Mallee
MDD3 Murray Lakes and Coorong
MDD4 Lowan Mallee
MDD5 Wimmera
MDD6 Darling Depression

Mitchell Grass Downs (MGD)
MGD1 Mitchell Grass Downs P1
MGD2 Barkly Tableland
MGD3 Georgina Linestone
MGD4 Southwestern Downs
MGD5 Kynuna Plateau
MGD6 Northern Downs
MGD7 Central Downs
MGD8 Southern Wooded Downs

Mount Isa Inlier (MII)
NWH1 Southwestern Plateaus and Floodouts
NWH2 Thorntonia
NWH3 Mount Isa Inlier

Mulga Lands (ML)
MUL1 West Balonne Plains
MUL2 Eastern Mulga Plains
MUL3 Nebine Plains
MUL4 North Eastern Plains
MUL5 Warrego River Plains
MUL6 Langlo Plains
MUL7 Cuttaburra-Paroo
MUL8 West Werrego
MUL9 Northern Uplands
MUL10 West Bulloo
MUL11 Urisino Sandplains
MUL12 Werrego Sands
MUL13 Kerribree Basin
MUL14 White Cliffs Plateau
MUL15 Paroo Overflow
MUL16 Paroo-Darling Sands

Murchison (MUR)
MUR1 Eastern Murchison
MUR2 Western Murchison

Nandewar (NAN)
NAN1 Northern Complex
NAN2 Glenelg Plain
NAN3 Kaputar
NAN4 Peel

Naracoorte Coastal Plain (NCP)
NCP1 Bridgewater
NCP2 Glenelg Plain
NCP3 Lucindale
NCP4 Tintinara

New England Tableland (NET)
NET1 Bundarra Downs
NET2 Beardy River Hills
NET3 Walcha Plateau
NET4 Armidale Plateau
NET5 Wongwibinda Plateau
NET6 Deepwater Downs
NET7 Glenn Innes-Guyra Basalts
NET8 Ebor Basalts
NET9 Moredun Volcanics
NET10 Severn River Volcanics
NET11 Northeast Forest Lands
NET12 Tenterfield Plateau
NET13 Yarrowyck-Kentucky Downs
NET14 Binghi Plateau
NET15 Stanthorpe Pateau
NET16 Eastern Nandewars
NET17 Tingha Plateau
NET18 Nightcap
NET19 Round Mountain

Northern Kimberley (NK)
NK1 Mitchell
NK2 Berkeley

NSW North Coast (NNC)
NNC1 Nymboida
NNC2 Manning - Macleay
NNC10 Woodenbong
NNC11 Clarence Basin
NNC12 Richmond - Tweed
NNC13 Murwillumbah
NNC14 Southern Coastal Lowlands
NNC15 Richmond - Tweed

NSW South Western Slopes (NSS)
NSS1 Upper Slopes
NSS2 Lower Slopes

Nullarbor (NUL)
NUL1 Carlisle
NUL2 Nullabor Plain
NUL3 Yalata

OVP Ord Victoria Plain (OVP)
OVP1 Ord
OVP2 South Kimberley Interzone
OVP3 Ord-Victoria Plains P3
OVP4 Ord-Victoria Plains P4

PCK Pine Creek

Pilbara (PIL)
PIL1 Chichester
PIL2 Fortescue
PIL3 Hamersley
PIL4 Roebourne

Riverina (RIV)
RIV1 Lachlan
RIV2 Murrumbidgee
RIV3 Murray Fans
RIV4 Victorian Riverina
RIV5 Robinvale Plains
RIV6 Murray Scroll Belt

Sydney Basin (SB)
SB1 Cerrabee
SB2 Hunter
SB3 Capertree
SB4 Wollemi
SB5 Yengo
SB6 Wygong
SB7 Pittwater
SB8 Cumberland
SB9 Burragorang
SB10 Cataract
SB11 Moss Vale
SB12 Illawarra
SB13 Ettrema
SB14 Jervis

South East Coastal Plain (SCP)
SCP1 Gippsland Plain
SCP2 Otway Plain
SCP3 Warrnambool Plain

South East Corner (SEC)
SEC1 East Gippsland Lowlands
SEC2 East Gippsland Uplands
SEC3 Bateman

South Eastern Highlands (SEH)
SEH1 Highlands-Southern Fall
SEH2 Highlands-Northern Fall
SEH3 Otway Ranges
SEH4 Strzelecki Ranges
SEH5 Monaro
SEH6 Murrumbateman
SEH7 Bungonia
SEH8 Kanangra
SEH9 Crookwell
SEH10 Oberon
SEH11 Bathurst
SEH12 Orange
SEH13 Hill End
SEH14 Western Fall
SEH15 South Eastern Highlands

South Eastern Queensland (SEQ)
SEQ1 Burnett - Cutis Hills and Ranges
SEQ2 Moreton Basin
SEQ3 Southeast Hills and Ranges
SEQ4 Southern Coastal Lowlands
SEQ5 Brisbane - Barambah Volconics
SEQ6 South Burnett
SEQ7 Gympie Block
SEQ8 Burnett - Curtis Coastal Lowlands
SEQ9 Great Sandy

Simpson Strzelecki Dunefields (SSD)
SSD1 Simpson-Strzelecki Dunefields P1
SSD2 Simpson Desert
SSD3 Dieri
SSD4 Warriner
SSD5 Strzelecki Desert
SSD6 Central Depression
SSD7 Bulloo Dunefields

Stony Plains (STP)
STP1 Breakaways
STP2 Oodnadatta
STP3 Murnpeowie
STP4 Peake-Dennison Inlier
STP5 Macumba

Sturt Plateau (STU)
STU1 Sturt Plateau P1
STU2 Sturt Plateau P2
STU3 Sturt Plateau P3

Swan Coastal Plain (SWA)
SWA1 Dandarragan Plateau
SWA2 Perth

Tanami (TAN)
TAN1 Tanami P1
TAN2 Tanami P2
TAN3 Tanami P3

Tasmanian Central Highlands (TCH)

Tiwi Cobourg (TIW)
TIW1 Tiwi-Cobourg P1
TIW2 Tiwi-Cobourg P2

Tasmanian Northern Midlands (TNM)

Tasmanian Northern Slopes (TNS)

Tasmanian South East (TSE)

Tasmanian Southern Ranges (TSR)

Tasmanian West (TWE)

Victoria Bonaparte (VB)
VB1 Victoria Bonaparte P1
VB2 Victoria Bonaparte P2
VB3 Victoria Bonaparte P3

Victorian Midlands (VM)
VM1 Goldfields
VM2 Central Victoria Uplands
VM3 Greater Grampians
VM4 Dundas Tablelands

Victorian Volcanic Plain (VVP)
VVP1 Victorian Volcanic Plain
VVP2 Mount Gambier

Warren (WAR)

Wet Tropics (WT)
WET1 Herbert
WET2 Tully
WET3 Innisfail
WET4 Atherton
WET5 Paluma - Seaview
WET6 Kirrama - Hinchinbrook
WET7 Bellenden Ker - Lamb
WET8 Macalister
WET9 Daintree - Bloomfield

Yalgoo (YAL)

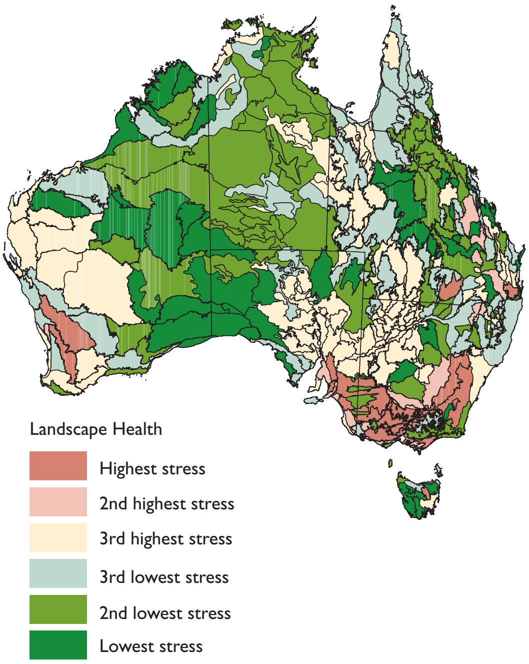


Figure 2.2 Continental landscape stress.

- distribution of eucalypts and acacias, identification of centres of endemism, richness and assessment of irreplacibility;
- status and trend of birds and mammals;
- protected areas and assessment of the Comprehensiveness, Adequacy and Representativeness for IUCN reserve categories (I – IV) and (V – VI) in each bioregion, priorities for additional reservation, and reserve management standards;
- recovery actions for threatened species and threatened ecosystems across subregions:
- assessment of the effectiveness of natural resource management activities, and opportunities for increased activity; and
- 14 detailed case studies stratified across all landscape health classes.

The scope of the Biodiversity Assessment was agreed to by all States and Territories as representing a range of key attributes for reporting on the condition and trend of biodiversity. These attributes were recognised as being particularly relevant for input into regional planning and management.

The assessment has involved a mix of quantitative analysis and the collation of expert opinion drawing upon scientists and field staff within conservation agencies and research institutions across Australia.

To facilitate collation, extrapolation and consistent recording of biodiversity information, a standardised database template was distributed to the agency with primary responsibilty for nature conservation in each State and Territory. The individual databases were combined to derive the summary information and create the tables that are accessible from the Atlas.

Where a subregion crossed a jurisdictional boundary, it was the responsibility of the agency within the State or Territory with the largest proportion of the subregion to consult with their cross-border colleagues. Similar consultation was necessary to assess the status of threatened ecosystems within bioregions that crossed State boundaries. Where data was unavailable in time to complete this cross-border reconciliation, the data from the State with the majority of the subregion is reported.

Natural values were recorded in each subregion at a range of scales. For example, rare landscape features such as lava tubes, rare ecosystems and rare species were recorded along with centres of endemism, refugia and areas with high levels of species or ecosystem richness.

A summary report for each bioregion is available on the Atlas. Each report covers natural values, wetlands, riparian zones, ecosystems at risk, species at risk, eucalypts and acacias, birds, mammals, reserve consolidation, off-park conservation, integrated natural resource management and information gaps. In addition, 14 case studies describe in detail the range of biodiversity management challenges facing Australia, the range of methods used to develop bioregional strategies, and the management responses needed. The complete case study reports are available on the Atlas.

Map Data Source: Landscape Health in Australia Database 2002.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Australia-wide datasets such as the one for birds were used in this assessment (QEPA).

Assessment Criteria

To achieve the broad scope of this Biodiversity Assessment, rapid assessment criteria were agreed to by States and Territories. This included agreed categories for the assessment of condition and trend for wetlands and riparian zones (Figure 2.3). Trend was also recorded for threatened ecosystems and species. Threatening processes were recorded as per a specific list (Figure 2.4) to facilitate overall compilation.

The reliability of a number of assessments was recorded including: wetlands of regional significance; riparian zones; the identification of threatened ecosystems; and trend of threatened species (Figure 2.5).

The standard of management of protected areas across bioregions was categorised into four classes - poor, fair, good, and very good (Figure 8.1, Reserves chapter).

Opportunities for species and ecosystem recovery and for integrated natural resource management were categorised across subregions into five classes ranging from 'major constraints' to 'off-park measures significantly in place' or 'well integrated into production' (Figure 9.1, Conservation across the Wider Landscape chapter).

Condition	Trend in status/condition
1. Degraded (Recovery unlikely in medium term)	1. Extinction e.g. targeted research has not observed species in recent times or no record in last 20 years
2. Fair (Recovery requires significant management intervention)	2. Status/condition rapidly declining e.g. less than 10 year time frame
3. Good (Recovery would occur in short term with minimum intervention)	3. Status/condition declining
4. Near pristine	4. Status/condition static
	5. Status/condition improving
	6. Unknown

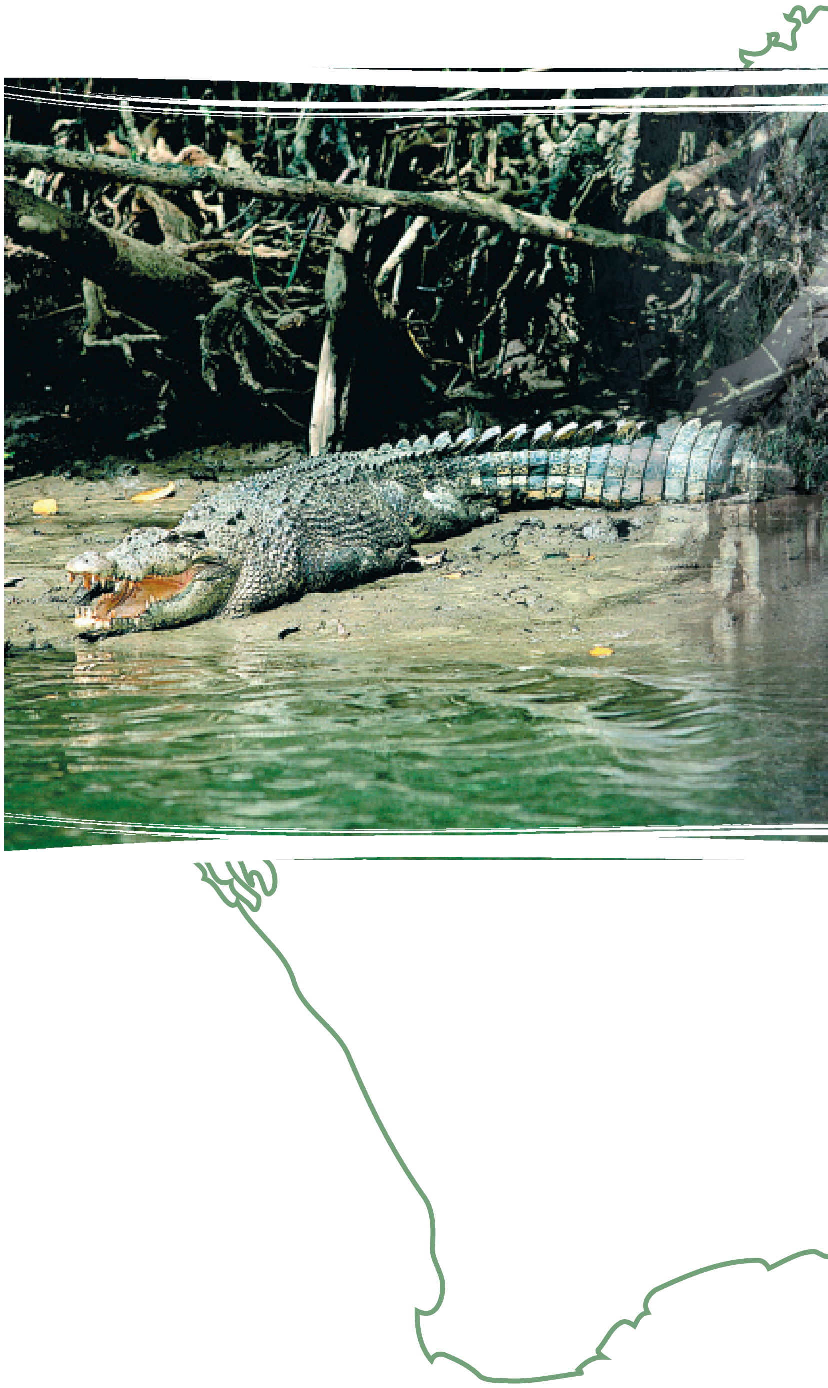
Figure 2.3 Categories used to assess the condition and trend of wetlands, riparian zones, and the trend of species at risk and ecosystems at risk. For riparian zones, the condition assessment is an average across the subregion. The median value was used for subregional scale assessments of condition and trend.

1. Vegetation clearing
2. Increasing fragmentation, loss of remnants and lack of recruitment
3. Firewood collection
4. Grazing pressure
5. Feral animals
6. Exotic weeds
7. Changed fire regimes
8. Pathogens
9. Changed hydrology – dryland salinity and salt water intrusion
10. Changed hydrology – other such as altered flow regimes affecting riparian vegetation
11. Pollution
12. Other – described

Figure 2.4 Threatening processes for nationally important wetlands, wetlands of regional significance, riparian zones and species and ecosystems at risk. Threatening processes are those that are currently operating, not those that have occurred in the past.

1. Anecdotal
2. Qualitative
3. Quantitative and qualitative
4. Quantitative

Figure 2.5 Categories for the reliability of data used for assessments of wetlands of regional significance, riparian zones, the identification of ecosystems at risk, and trend of species at risk.



3. Wetlands & riparian zones

Summary

Diamantina National Park: Channel Country (P. Sattler).

SUMMARY

Wetlands, rivers, watercourses and their associated riparian zones are essential for maintaining biodiversity, clean water and the long-term sustainability of rural and urban populations. Most rivers and other wetland landscapes in Australia are experiencing problems, with significant degradation and continued decline in ecological condition. Many nationally important wetlands are still in good condition, particularly in northern and central Australia, though in many parts, trend is declining.

This chapter reports on the condition and trend of wetlands listed in *A Directory of Important Wetlands in Australia 2001*, other wetlands of regional significance and riparian zones.

Wetlands of national importance associated with the majority of subregions (58%) were assessed as being in good condition, meaning that minimum intervention is required to aid their recovery. These principally occur in northern Australia. Encouragingly, the condition of nationally important wetlands in 64 subregions (16%) are near pristine.

In southern Australia, where information was available, many nationally important wetlands (28% of the total assessed) are in fair condition and requiring significant management to bring about their recovery. Wetlands in the AvonWheatbelt in Western Australia, the Darling Riverine Plains and the New South Wales North Coast bioregions, are degraded with recovery unlikely in the medium term.

The trend of most wetlands of national importance is either static (59% of subregions) or declining (37% of subregions). Two subregions are improving – in the Channel Country of Western Queensland and the South Eastern Highlands of New South Wales. In both these areas, sustainable grazing practices and increased reservation within protected areas has contributed to this improvement.

The main threatening processes identified for nationally important wetlands are grazing, feral animals, exotic weeds and changes in hydrological conditions leading to salinisation and other modifications.

Owing to the important role played by other wetlands for the maintenance of biodiversity and ecological processes, wetlands of regional significance were defined and identified where data were available. Approximately, 4700 wetlands of regional significance were identified and assessed.

The condition of riparian zones is degraded across much of southern and western Australia in 31% of the total subregions assessed. A further 38% of subregions have riparian zones in fair condition. The scale of the problem suggests recovery is unlikely in the medium term or without very significant intervention. Only 28% of subregions have riparian zones classed in good condition.

The trend in riparian condition across most parts of Australia is declining (78% of subregions) with the main exceptions being some arid areas, south-west Tasmania and parts of Cape York Peninsula. The most commonly listed threats associated with this decline are: increased fragmentation, overgrazing, feral animals and weeds, changed fire regimes and changed hydrology with many of these threats having a combined impact on riparian zones. Increased fragmentation was a key threat in the highly cleared regions of southern and eastern Australia. Feral animals, overgrazing, exotic weeds and changed fire regimes were identified as key threats in wide ranging environments – from arid inland Australia to the more intensively used bioregions in Victoria and Tasmania. This demonstrates the widespread and pervasive nature of these threats.

These findings for wetlands and riparian zones in conjunction with the Audit's assessments of rivers and estuaries, means that targeted programs are urgently required to maintain these vital natural resources and their associated biodiversity. An Australia-wide program of protective policies and reservation where appropriate is required. This program could be rapidly developed as an Australia-wide partnership and build on existing activities of States and Territories.

INTRODUCTION

The Ramsar Convention definition of wetlands includes systems that are man-made or natural, that occur in marine or terrestrial areas, and that have water either permanently or temporarily standing still or flowing, fresh or salty. Consequently, rivers, lakes, swamps, marshes, dams, irrigated lands and coral reefs all qualify as wetlands. This definition is widely used and the diversity of wetlands it encompasses is reflected in *A Directory of Important Wetlands in Australia (Environment Australia 2001).*

The third edition of *A Directory of Important Wetlands in Australia* lists 851 wetlands, 56 of which are considered of international importance. Information on the condition and trend of these wetlands was unavailable for many subregions. This highlights the need for more data on these wetlands and on-going monitoring to assess their condition over time.

This Biodiversity Assessment also identifies and assesses wetlands important at the regional level where data were available. Wetlands of regional importance were specifically identified to gain an understanding of the extent and significance of wetlands that have not been listed as nationally important wetlands. Regionally important wetlands are a vital resource for the protection of regional biodiversity and can be easily overlooked and lost through incremental development and other impacts.

Wetlands are ecologically and hydrologically linked to their surroundings. Riparian land is any land that adjoins, directly influences, or is influenced by a body of water. It can include the land and associated flora and fauna immediately alongside small creeks and rivers, billabongs and floodplains. Riparian corridors can also be a key feature for dispersal of small mammals and birds. Because of these special features, rivers, streams and gullies can have a disproportionate importance for biodiversity conservation compared to the area they occupy.

Australia has a wide diversity of wetland systems - from tidal rivers and estuaries on the coast, to ephemeral wetlands such as Lake Eyre in inland Australia. Lake Eyre is one of the largest areas of internal drainage in the world and only fills a few times each century when the rivers of Queensland's channel country receive enough water to push through the dry maze of channels and billabongs on the edge of the Simpson Desert. Such examples illustrate the critical links between wetlands and their associated catchments, with the Lake Eyre Basin covering one sixth of the Australian continent.

The Gulf of Carpentaria wetlands are internationally significant and demonstrate the role and importance of coastal wetland systems. Catchment boundaries disappear during the wet season with floods exporting sediments and nutrients off the land to the shallow Gulf waters, feeding the important finfish and prawn fisheries and their supporting habitats. During the dry season, nutrient cycling is based on occasional inundation of the supratidal salt marshes, supporting the algae of these salt marshes and through the export of the algae with tidal waters to the estuary, supporting fisheries and their habitats.

There is little doubt that most rivers and other wetland landscapes in Australia are experiencing problems, which have largely come about as a result of poor land and water management practices. It is estimated that across Australia about 50% of wetlands have been destroyed since European settlement. Many other wetlands have been subject to major modification. Changes in condition, particularly in the Murray-Darling Basin, have been linked with declines in waterbird numbers (Box 3.1) and are likely to affect other plants and animals that inhabit wetlands.

Lake Buchanan: Desert Uplands bioregion (P. Sattler).

Box 3.1 Waterbirds and wetlands of Lake Eyre and Murray-Darling Basins

Waterbirds are those species that are directly dependent on freshwater aquatic habitat. About 13% (93 species) of Australia's bird fauna fall into this category. They include the grebes (Podicipediformes); Australian Pelican and cormorants (Pelecaniformes); herons, ibis, spoonbills and bitterns (Ciconiiformes); ducks, geese and Black Swans (Anseriformes); the cranes (e.g. Brolga), rails, crakes and gallinules (Gruiformes) and; the shorebirds (e.g. Curlew Sandpiper, Red-necked Avocet), Silver Gull and terns (e.g. Caspian Tern) (Charadriiformes). These birds use an array of habitats, ranging from artificial ponds to swamps, lagoons, mudflats, estuaries, embayments and open shores, freshwater and salt lakes, rivers, floodplains and dams, with most waterbirds found on the wetlands of a river system. These habitats occur at all latitudes, from the tropics to the subantarctic, and are nearly all are affected by flooding regimes of rivers.

Australia probably has the most variable wetland and floodplain systems in the world, reflecting the nature of the continent's climate, particularly in the inland. Large rainfall events produce considerable flooding and create widespread wetland habitat on floodplains. Most of these wetlands are non-permanent or ephemeral and may be dry for a greater period of time. The life cycle of plants and animals within these ephemeral wetlands is geared toward high productivity in short time spans. Such highly productive habitats are important for large numbers and high diversities of waterbirds, contributing to a large population increase ('boom' period) or conversely a substantial decrease in population ('bust' period) when the floodplains are dry for extended periods. More than a million waterbirds occurred on the lower part of Cooper Creek, including Lake Eyre, during the 1990/1991 flood.

During flood periods, large numbers of waterbirds of 100,000 or more, representing a highly diverse community, can colonise a particular lake. They may breed on lakes and swamps if water levels remain high for a sufficiently long period. Wetlands such as the Macquarie Marshes, Gwydir wetlands and Narran Lake are the main breeding areas for some of the ibis and egret species in Australia. Waterbirds move between rivers and wetlands and are capable of movements exceeding 1,000 km in response to climatic events. Relatively little is known about whether these movements are regular or follow particular paths except for the suite of waterbirds that make regular migrations from the northern hemisphere.

Long-term survey data have indicated that some wetland areas (Macquarie Marshes, Lower Murrumbidgee wetlands, Barmah-Millewa Forest, Chowilla floodplain) have declined significantly in area and functionality. River regulation, dams, diversions, floodplain drainage and agricultural development have affected many wetlands, particularly in the Murray-Darling Basin and coastal eastern and southern Australia. Waterbird numbers across all taxa have declined in these wetlands, probably reflecting major changes across the entire ecosystem as different species of waterbirds forage on a range of organisms (e.g. plants and fish).

For the Macquarie Marshes, the building of dams and diversions upstream have significantly reduced the frequency of flooding and the numbers of breeding pairs of ibis, egrets and herons have declined by about 100,000 every 11 years. Similarly, the number of waterbird species breeding in the Barmah-Millewa forest on the Murray River has declined. On the Lower Murrumbidgee floodplain, waterbird numbers declined by more than 80% over a 19 year period from an average of more than 100,000 to less than 20,000 waterbirds. Frequency of breeding in the area also declined.

Natural variation in waterbird distribution at a local level and over long periods of time make conclusions dependent on long-term data sets and methodologies that ensure wetlands can be adequately and rapidly surveyed. Waterbird populations are highly variable and require data sets of decades to separate the effects of natural variation from human impacts. Data sets are now accumulating that allow such assessments to be made over large areas of habitat. Similarly, within wetland habitats, waterbirds can be highly clumped - hence the importance of strategic targeting of wetland surveys. Fortunately, in many cases, coarse waterbird population data can be collected rapidly using aerial surveys for an entire community. Further, the range of organisms that waterbirds rely on – including plants, fish and invertebrates - allow indirect monitoring of other components of the ecosystem important to waterbird populations.

These data now enable us to estimate the considerable loss of wetland habitat that has resulted from the building of dams, river regulation, diversions of water upstream of major wetlands, flood mitigation, floodplain drainage and agricultural development. This loss of habitat has reduced feeding and breeding resources for many waterbirds species. Salinisation of some wetlands, such as the Macquarie Marshes, could further impact on these populations.

Catchment planning to protect these natural values, recognises the importance of focussing on the total catchment, the full suite of native plants and animals dependent on these wetland systems and the critical role that people play in the future of our rivers and other wetlands.

At the national scale, a recent submission on biodiversity to the Prime Minister's Science, Engineering and Innovations Council (Morton *et al.* 2002) recommended that the Commonwealth Government work with the States and Territories to establish an Australia-wide river and estuary protection program.

This submission noted the opportunities that the near pristine river reaches and estuaries provided for nature conservation and nominated examples of Australia's least impacted rivers. It included suggestions that the Mitchell, Ovens, Georgina, Diamantina, Cooper and Paroo be designated as "Heritage Rivers".

THE ASSESSMENT

This assessment and findings is divided into three sections:

- a summary the Audit's previous findings for rivers and estuaries (NLWRA 2002a);
- assessment of wetlands, and
- assessment of riparian zones.

Loss of riparian zone beside cane fields: Wet Tropics bioregion (P. Sattler).

FINDINGS

Audit River Assessment

River reaches for Australia's major rivers in the intensive use zone were used to provide a spatial framework for an assessment of river condition and for management and monitoring. A river reach is a section of river with relatively uniform physical characteristics. In Australia's more intensively used catchments, 14,606 reaches over 5km in length have been defined, with a total stream length of 209,118km (Figure 3.1). With further fine tuning to meet State and Territory needs, these reaches will provide the basis for a rigorous and consistent reporting framework for tracking progress in river management.

Aquatic biota, as represented by macro-invertebrate indicator species provides a partial measure of river condition. The collated National River Health Program Australian River Assessment Scheme (AusRivAS) datasets suggest that, based on macro-invertebrates as indicators, little change from apparently natural conditions has occurred in 67% of river reach length. Within the remaining 33% of river length with impaired aquatic biota, almost 25% has lost between one fifth and one half of the macro-invertebrate groups used as indicators of river biodiversity (Figure 3.2).

An assessment of environmental modification provides key insights to management challenges for Australia's rivers. Over 85% of river length was classified as having undergone some environmental modification, including catchment disturbance, reduced riparian vegetation, hydrological disturbance and increases in the load of suspended sediments and nutrients (Table 3.1). New South Wales, South Australia and Western Australia have the greatest amounts of modified river length (97%, 96% and 93% respectively) and the Northern Territory has the smallest amount (34%).

Largely unmodified rivers occur in far north Queensland, eastern Victoria and Tasmania (Figure 3.3). These require protective management to ensure their condition is maintained. Rivers in the most modified condition are in parts of the Murray-Darling Basin, the Western Australian wheatbelt, western Victoria and the South Australian cropping areas.

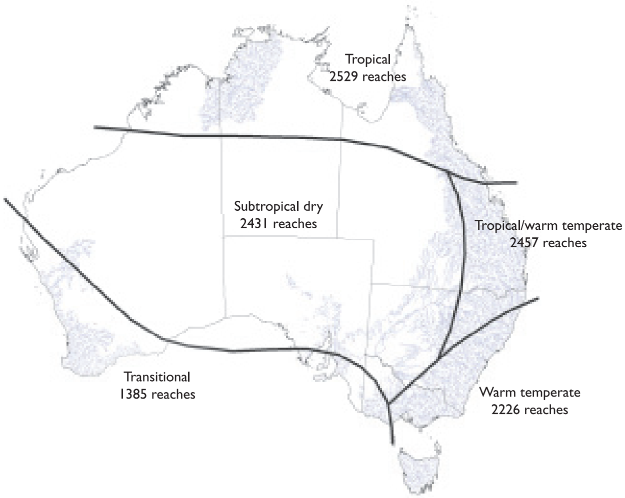


Figure 3.1 Climate zones in Australia relevant to river condition – also shows the extent in terms of reaches for the Audit's work on rivers.

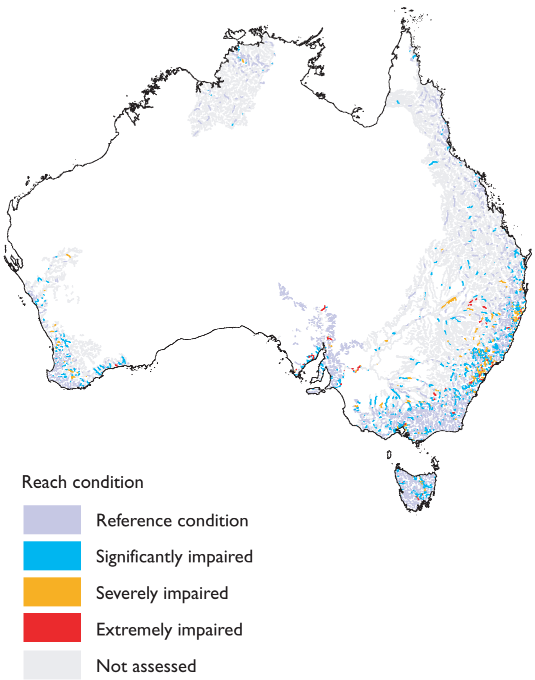


Figure 3.2 Condition of river reaches based on the aquatic biota (macro-invertebrate) index.

Map Data Source: Natural Land and Water Resources Audit, Catchment, River and Estuary Assessment 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Table 3.1 River environment index (catchment disturbance, habitat, hydrological disturbance and nutrient and suspended sediment load) for each State and Territory.

	TOTAL LENGTH OF REACH (KM) IN EACH CATEGORY AND PERCENTAGE OF TOTAL IN PARENTHESES				PERCENT OF TOTAL LENGTH WITH DATA
	Largely unmodified	Moderately modified	Substantially modified	Extensively modified	
Queensland	8 743 (13)	48 214 (71)	10 599 (16)	0 (0)	93
New South Wales	1 619 (3)	39 232 (68)	17 089 (29)	18 (0)	97
Australian Capital Territory	43 (16)	191 (71)	36 (13)	0 (0)	100
Victoria	3 085 (20)	9 042 (60)	3 099 (20)	0 (0)	97
Tasmania	2 028 (37)	3 250 (59)	194 (4)	0 (0)	98
South Australia	299 (4)	4 666 (61)	2 635 (35)	0 (0)	79
Western Australia	1 487 (7)	15 927 (78)	2 929 (14)	12 (1)	80
Northern Territory	9 165 (66)	4 630 (34)	0 (0)	0 (0)	67
Total	**26 468 (14)**	**125 152 (66)**	**36 581 (19)**	**31 (1)**	**90**

The Audit's River Assessment found that riparian and in-stream habitats are key management factors for the health of Australia's rivers. Protection of existing habitat and re-establishment of riparian habitat in most catchments, together with improved catchment management to minimise sediment and nutrient inputs, is essential.

Audit Estuary Assessment

Half of Australia's 1000 estuaries were assessed as being in near pristine condition. Of the remaining 50%, a further 22% are largely unmodified, 19% are considered modified and 9% are regarded as extensively modified (Figure 3.4).

Estuaries are valuable ecosystems for fisheries and play a key role in biodiversity. Many fish species and other organisms are estuary-dependent in larval or juvenile phases. Protective management arrangements for Australia's pristine estuaries will deliver multiple benefits. They will also be more effective in the long term obviating the necessity to undertake rehabilitation that may be expensive or even not possible. These pristine estuaries occur in all jurisdictions (Figure 3.5) and could provide a foundation for an effective national estuarine and marine management program.

The number of estuaries assessed is different to the number of rivers assessed. Not all estuaries have river reaches that were part of the river assessment.

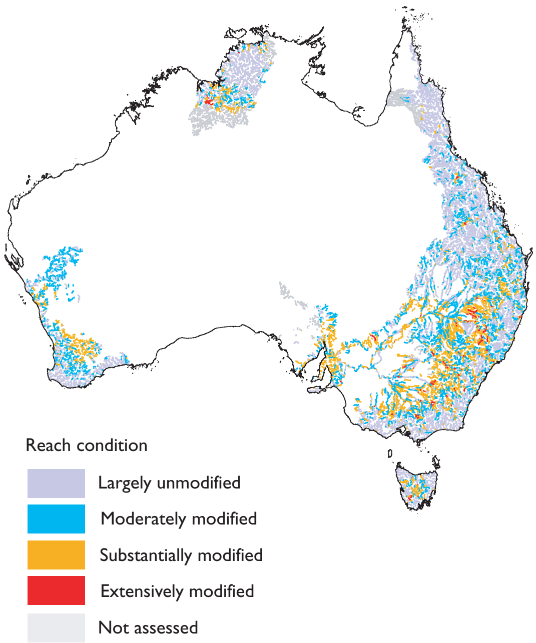
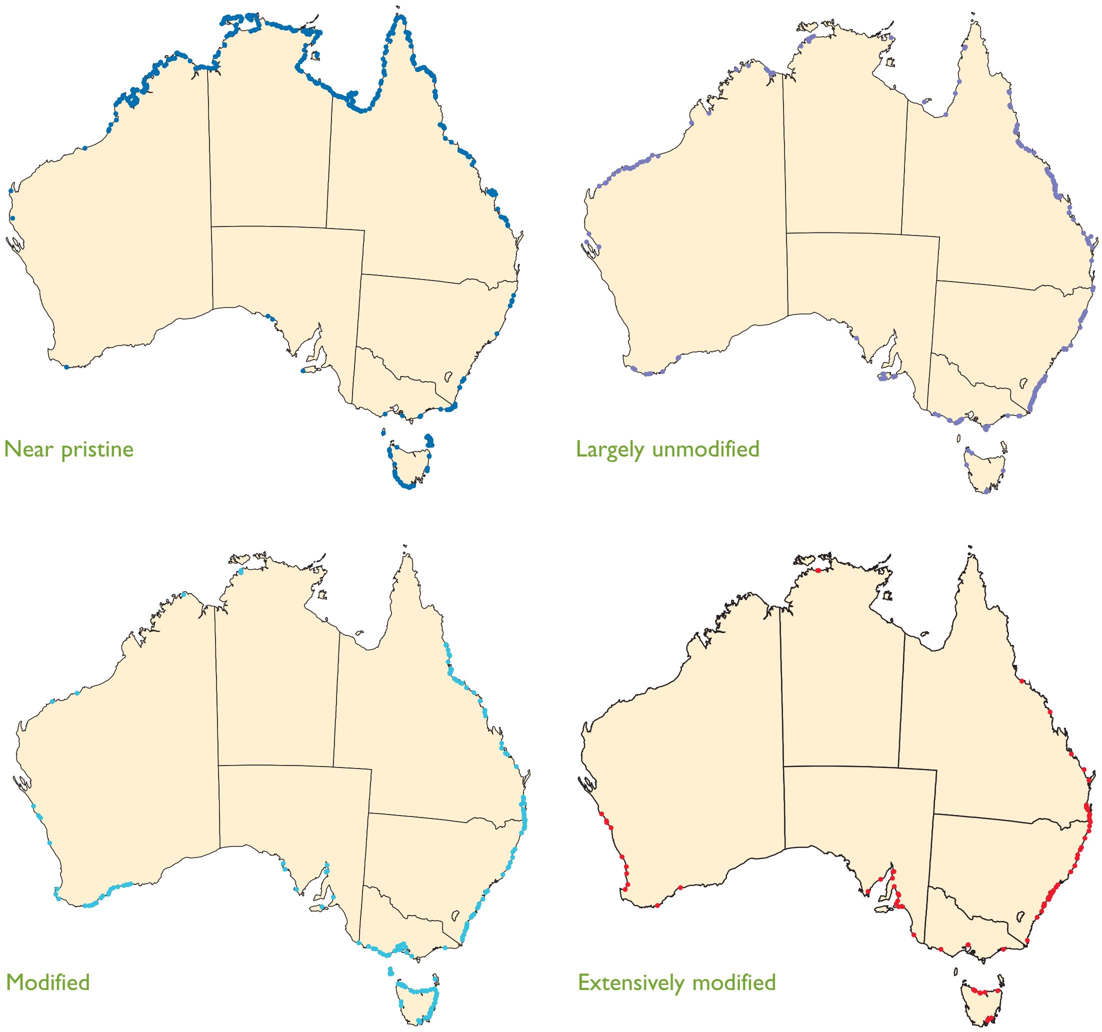


Figure 3.3 Condition of river reaches based on habitat subindex.

Many estuaries assessed are small tidal embayments and strand plain drainage lines. While there is correlation for individual river-riparian-wetland-estuary systems in terms of condition, no comparison should be made between the summary findings associated with each.

Map Data Source: Natural Land and Water Resources Audit, Catchment, River and Estuary Assessment 2002 Database. Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Figure 3.4 Location and condition of Australian estuaries.



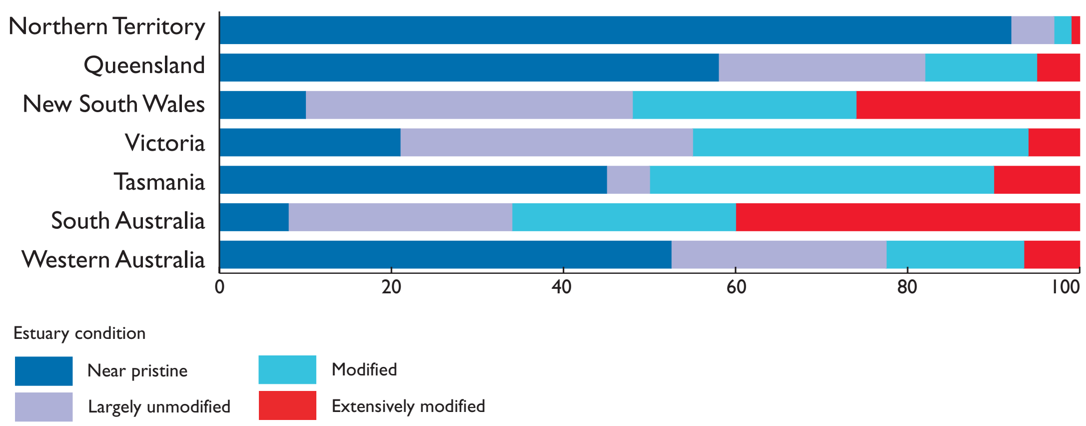


Figure 3.5 Condition of Australian estuaries by State and Territory (%).

Map Data Source: Natural Land and Water Resources Audit, Catchment, River and Estuary Assessment 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Assessment of Wetlands

A Directory of Important Wetlands in Australia (Environment Australia 2001) lists 851 wetlands of which 56 are designated to the List of Wetlands of International Importance of the Ramsar Convention. This section summarises the assessment of the condition and trend of these wetlands and the processes that threaten them. Not all bioregions have been surveyed for wetlands of national significance and there are information gaps in those that have. The identification of significant sites is on-going as there is no systematic national inventory from which wetlands at differing levels of significance have been selected.

The criteria used to identify regionally significant wetlands were consistent with those used to assess nationally important wetlands (Figure 3.6). Data collected on each wetland included the name, location (grid reference), description, special values, condition, trend and threatening processes. For regionally significant wetlands, a reliability assessment for the information collected was made.

Assessing the condition of nationally important wetlands (Figure 3.7) provides a benchmark for their management.

Regionally significant wetlands meet the following criteria:

- identified in State and Territory lists of important wetlands;
- significant for the maintenance of ecological processes at a regional scale;
- important for breeding, feeding, roosting, moulting, nursery areas or refugia for fauna;
- support significant numbers of plant and animal taxa or abundant populations; and
- contain rare or threatened species or ecosystems.

Figure 3.6 Criteria used to identify wetlands of regional significance.

Murray Lagoon, Kangaroo Island (A. Robinson).

The ranking of condition refers to the median value for wetlands within the subregion. While Victoria contains many wetlands of national importance, the information on the condition of these wetlands was not available.

The condition of the majority of nationally important wetlands was assessed as good (58% of the total assessed), occurring principally in northern and eastern Australia. This means that minimum management intervention is required to aid recovery of the wetlands in these regions. Encouragingly, nationally important wetlands in several subregions were also recorded as near pristine. These occurred on Cape York Peninsula, in Tasmania and parts of the Channel Country.

The nationally significant wetlands in the rangelands and the south-west of Western Australia, and most of New South Wales, are either in fair condition (28% of total wetlands assessed) or degraded (Figure 3.7).

The wetlands in these regions would require significant management intervention to bring about their recovery and in locations subject to extensive salting may be beyond practical recovery. Generally, it will be less costly to address threats in rangeland areas such as altered fire and grazing regimes compared to threats in the highly cleared regions of eastern Australia. For example, among the most affected areas, the wetlands in the Darling Riverine Plains bioregion are degraded due to the intensification of agriculture in that region. The recovery of nationally important wetlands in this region is considered unlikely in the medium term.

The trend in the condition of nationally important wetlands (Figure 3.8), shows that most are static (59%) but with a significant proportion declining (37%).

Reductions in Australia's waterbird populations reflect the decline in wetland condition. Fifty percent of Australia's inland waterbirds are listed under various legislation as threatened, mainly from loss of wetland and riparian habitat. Identification of management actions to aid recovery is a priority.

An assessment of the distribution of major threatening processes for wetlands of national importance (Figure 3.9) provides some insights into the condition and trend patterns described above. Grazing pressure, exotic weeds and feral animals are listed most frequently as threats. Changed hydrology, pollution and salinity are the next most frequent group of threats in a range of subregions. Dryland salinity is identified as a key threatening process in southern Australia.

Salt water intrusion is a threat to freshwater wetlands in northern Australia. This occurs when the surface or groundwater hydrology of near coastal areas is affected by drainage, groundwater use or other changes to landform (and sea level rise). For example, in the Northern Territory natural banks that separate salt water and freshwater have been broken by feral animals, notably buffaloes. Saltwater intrusion leads to the loss of freshwater native plants and animals and their replacement by those able to tolerate saline conditions.

Changes to fire regimes is a threat mainly in the seasonally dry tropics, the wet tropics and in Tasmania.

The range of threatening processes at the subregional scale for nationally important wetlands is described in detail in the Australian Natural Resources Atlas (Table 3.2).

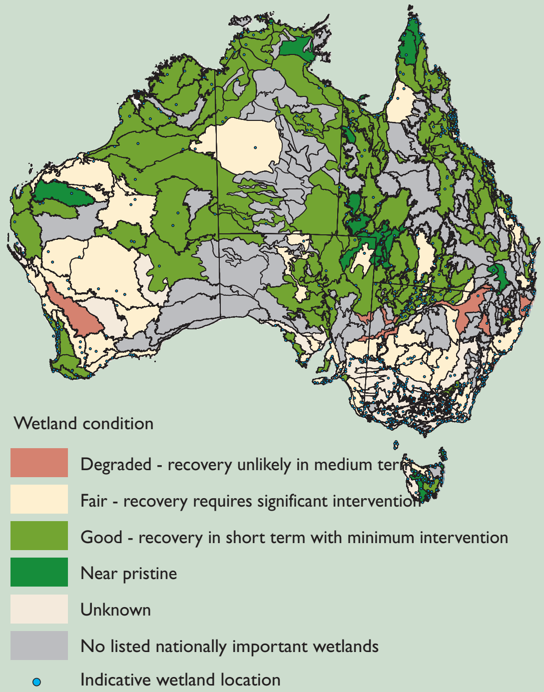


Figure 3.7 Condition of nationally important wetlands (median). Where subregions cross State and Territory borders, condition may not apply equally within each jurisdiction.

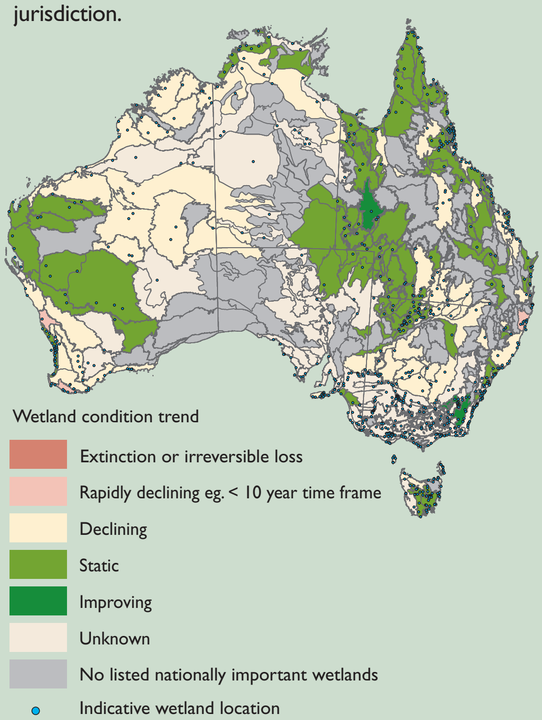
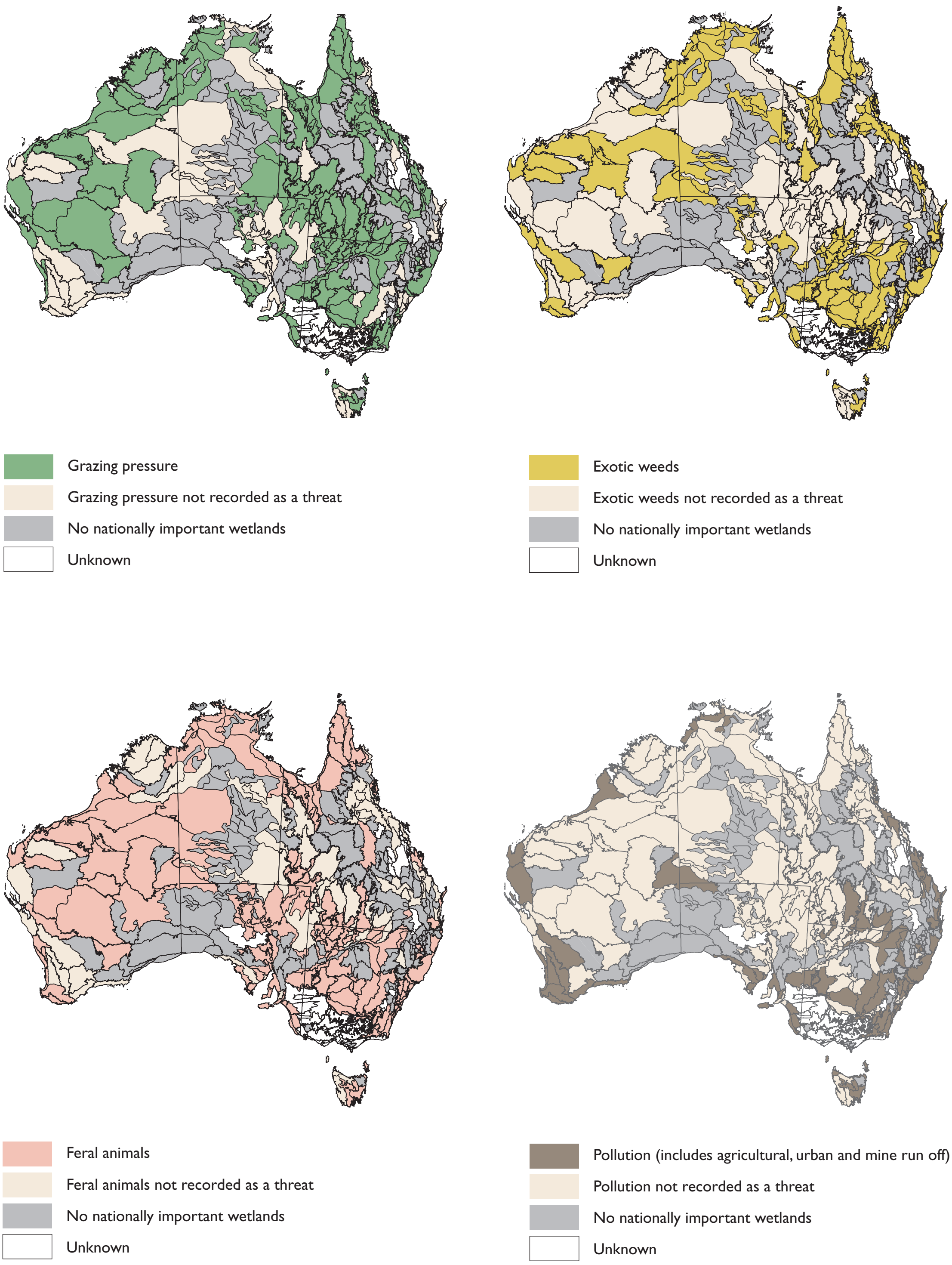


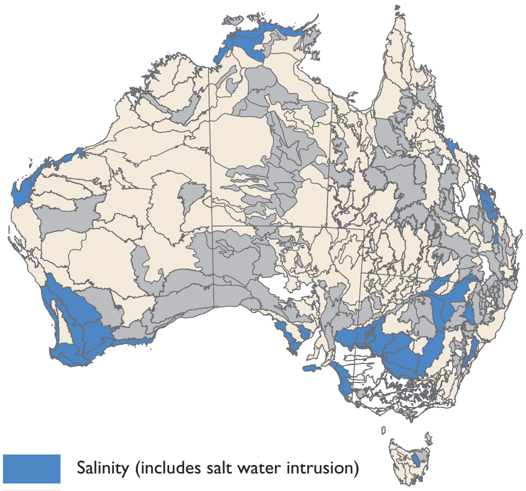
Figure 3.8 Trend in the condition of nationally important wetlands (median). Where subregions cross State and Territory borders, trend may not apply equally within each jurisdiction. Where trend information was available for less than 50% of wetlands, trend is classified as unknown.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Figure 3.9 Distribution of six major threatening processes for nationally important wetlands. Where subregions cross State and Territory borders, threatening processes may not apply equally within each jurisdiction. In some subregions, threatening processes were not recorded for all wetlands.



Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.



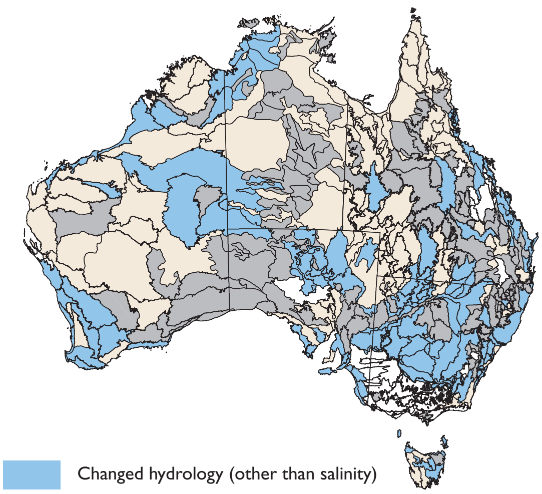


Table 3.2 An extract from the Australian Natural Resources Atlas on the nationally important wetlands of the Darwin Coast bioregion (Similiar information is available on the Atlas for regionally important wetlands).

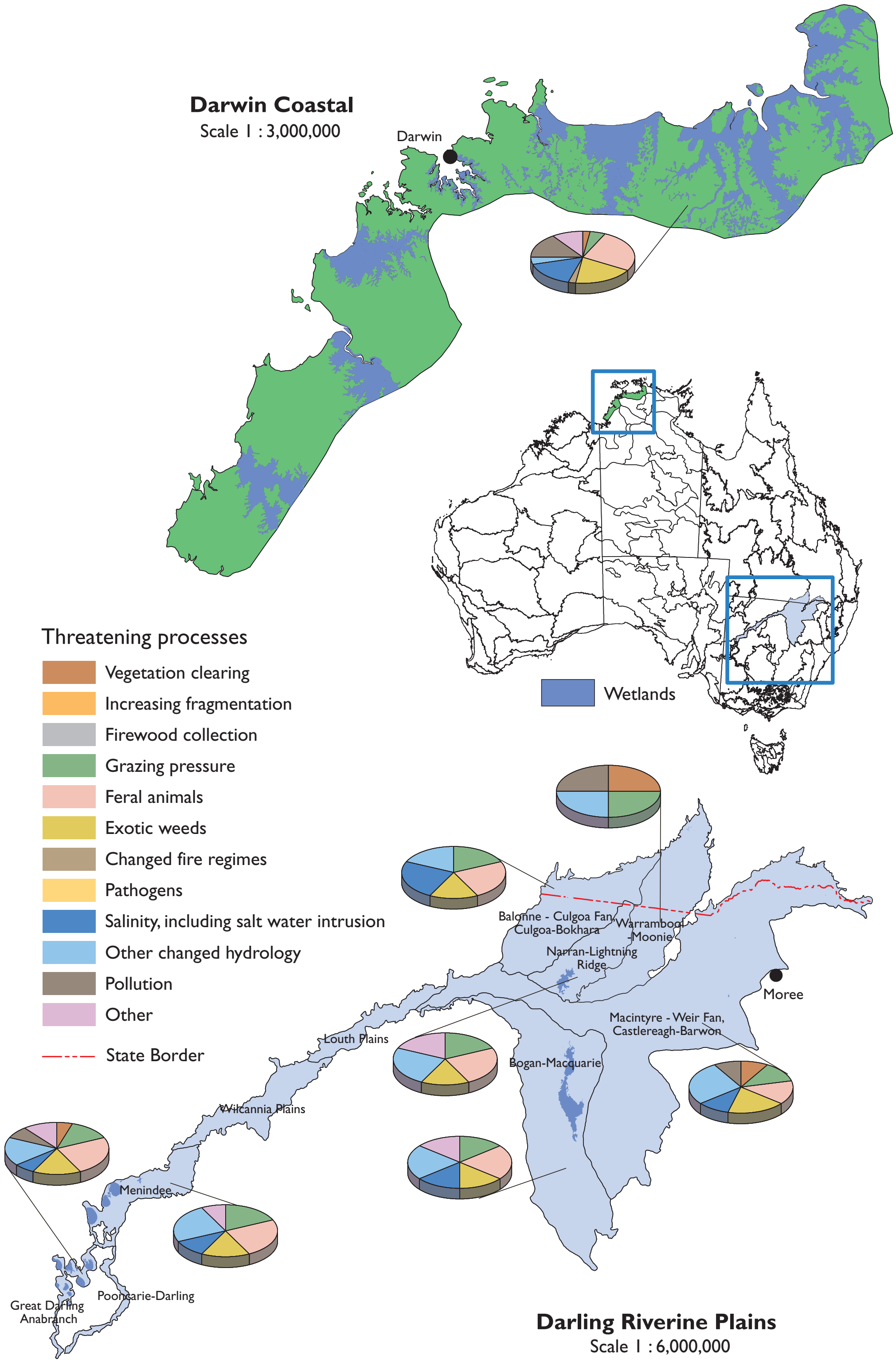
WETLAND NAME	RAMSAR WETLAND	CONDITION	TREND	THREATENING PROCESSES	THREATENING PROCESSES NOTES
Adelaide River Floodplain System (NT020)	No	Fair (Recovery requires significant intervention)	Unknown	Feral animals changed hydrology - salinity; exotic weeds	Extensive saltwater intrusion; large tracts of *Mimosa pigra*
Daly-Reynolds Floodplain-Estuary System (NT024)	No	Fair (Recovery requires significant intervention)	Unknown	Feral animals; pollution; changed hydrology - salinity; exotic weeds; grazing pressure	Potential from increased cultivation in catchment
Finniss Floodplain and Fog Bay System (NT025)	No	Good (Recovery requires little intervention)	Static	Grazing pressure; changed hydrology - salinity; exotic weeds; feral animals	
Moyle Floodplain and Hyland Bay System (NT027)	No	Near pristine	Unknown	Exotic weeds; changed hydrology - salinity	Potential *Mimosa pigra* and *Brachiara mutica*; potential saltwater intrusion

The Darwin Coastal and Darling Riverine Plains bioregions have been selected to demonstrate the type of information available on the Atlas (Figure 3.10). These regions are subject to a wide range of threats. The data represent the frequency of recorded threats rather than an assessment of relative importance.

Wetlands of regional significance were identified across Australia. In total, approximately 4700 regionally important wetlands were identified. Specific descriptions and an assessment for each wetland can be found in the Atlas. This listing represents a starting point for the identification and recording of regionally important wetlands. Their occurrence and values should be taken into account in regional and local planning, and natural resource management.
The identification of nationally important wetlands is not complete and large data gaps still remain.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Figure 3.10 Frequency of threatening processes for nationally important wetlands in the Darwin Coastal and Darling Riverine Plains bioregions. Pie charts do not convey relative importance of threatening processes, rather are an indication of frequency only.



Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Assessment of Riparian Zones

Increasing investment in the management of riparian areas reflects the increasing recognition of the fundamental role that rivers and their riparian zones play in ecosystem function. This assessment of riparian zones, including condition, trend and the processes threatening them, furthers the understanding of the status of these areas and the range of management practices needed.

Riparain zones were most commonly assessed as being in fair condition, where recovery will require significant management investment (38% of subregions) or degraded where recovery is unlikely in the medium term (31% of subregions) (Figure 3.11). Riparian zones in the highly cleared regions of southern and eastern Australia, assessed as degraded, coincide with the cereal regions of south-western Western Australia and western Victoria, as well as the intensively cropped floodplain systems in north-central New South Wales. In southern Queensland they occur across the Brigalow Belt, Mulga Lands and Channel Country bioregions. Many coastal lowland floodplain areas in southern and eastern Australia are degraded.

The riparian zones in many subregions dominated by pastoralism are in only fair condition or are degraded. This is principally due to the impact of stock grazing on riparian vegetation. Overgrazing also leads to increased nutrient and sediment loads, as detailed in the Audit's Australian Agricultural Assessment, (NLWRA 2001b). Very few subregions were classified as having near pristine riparian zones.

The trend in the condition of riparian zones shows that across most of Australia they are declining (73%) (Figure 3.12). Considerable effort is required at the national scale to arrest on-going riparian zone degradation.

The assessment of processes threatening riparian areas at the subregional scale provides some insights into the widespread decline of these systems, Figure 3.13.

The most commonly listed threats are:

- over-grazing;
- exotic weeds;
- changed hydrology;
- increased fragmentation;
- feral animals; and
- changed fire regimes.

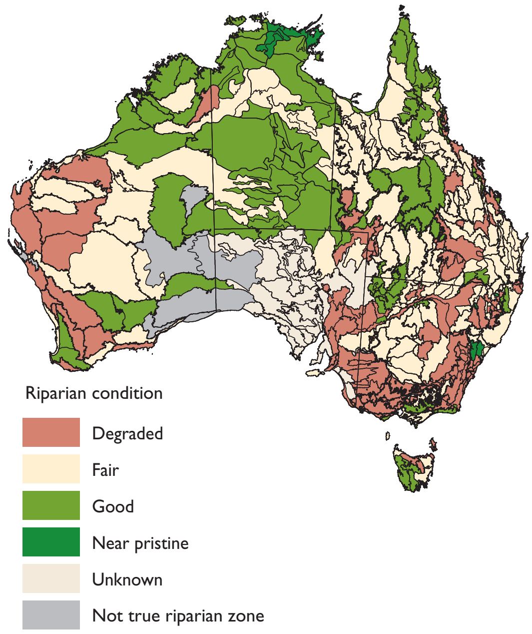


Figure 3.11 Average condition of riparian zones (all watercourses within subregion). Where subregions cross State and Territory borders, average condition may not apply equally within each jurisdiction.

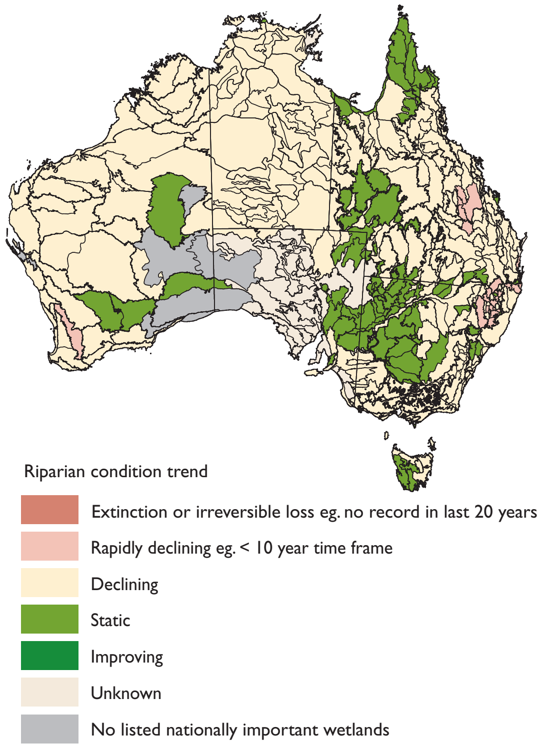


Figure 3.12 Average trend in the condition of riparian zones (all watercourses within subregion). Where subregions cross State and Territory borders, trend may not apply equally within each jurisdiction.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

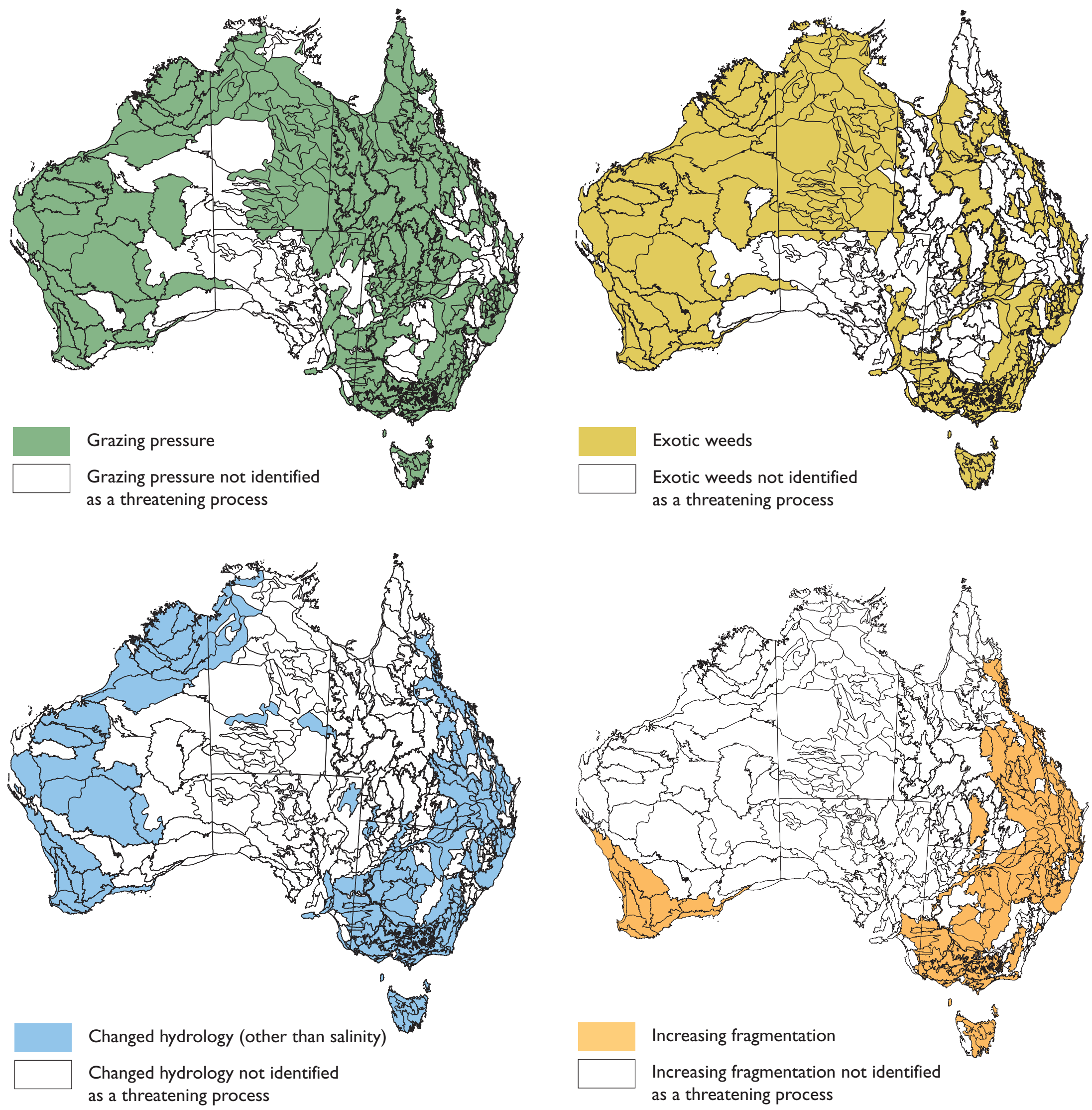
The wide distribution of these threatening processes, leading to a declining trend in riparian zones across 73% of subregions, means that additional targeted management initiatives are urgently required.

Rehabilitation would include changes to agricultural practices, replanting and weed control, rationalisation of barrages and levees, and the exclusion of stock and provision of off-stream watering facilities.

The Central Mackay Coast and the Mulga Lands bioregions have been selected to demonstrate the range of processes threatening riparian zones at the subregional scale (Figure 3.14). They provide a contrast between coastal and inland regions and demonstrate the value of a bioregional approach to assessing threats.

Along the Central Mackay Coast, vegetation clearance and fragmentation, changed fire regime and exotic weeds are the major threats identified, with grazing pressure and weeds identified as the key process threatening riparian zones in the subregion away from the coastal strip.

Figure 3.13 Distribution of six major threatening processes for riparian zones. Where subregions cross State and Territory borders, threatening processes may not apply equally within each jurisdiction.



Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
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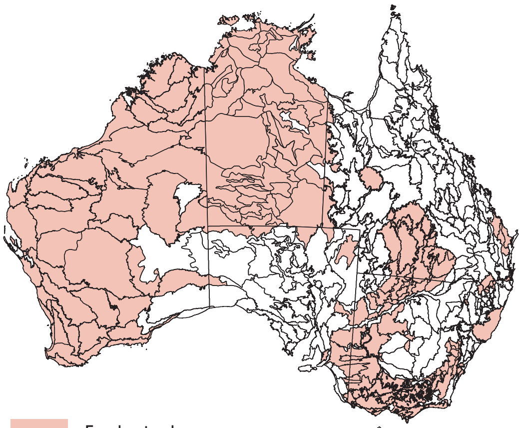
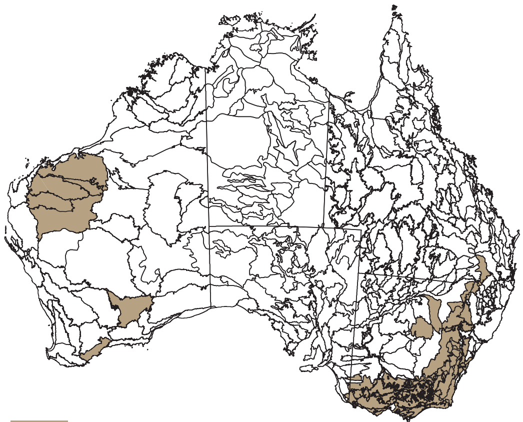




In the Mulga Lands, a wider range of threatening processes on riparian zones exist. Grazing pressure is a threat in all subregions in the Mulga Lands bioregion, with threats from vegetation clearance, feral animals and exotic weeds also widespread. Changed hydrological condition is identified as a threat in the south-east of the Mulga Lands bioregion.

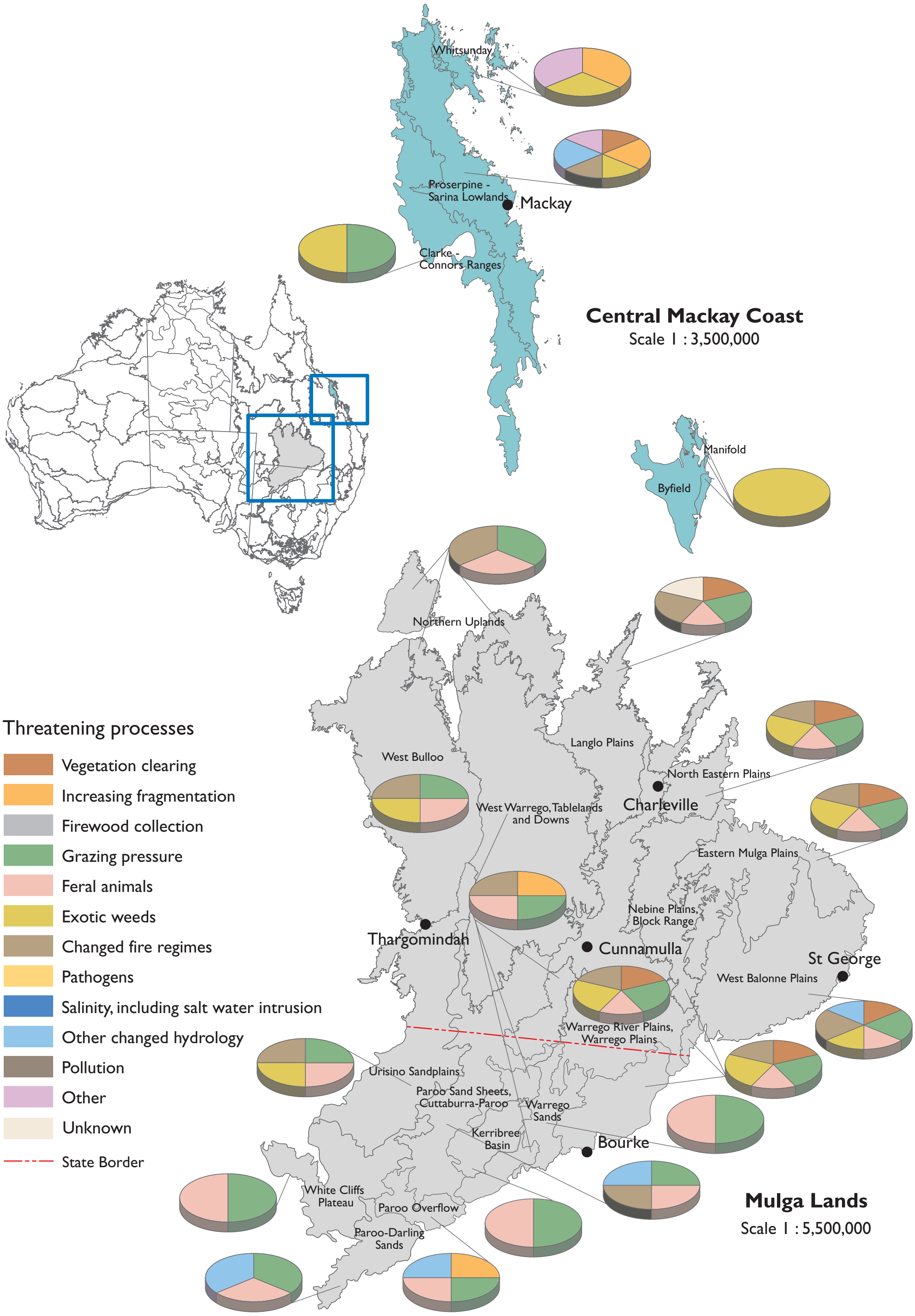
Table 3.3 gives an example of the detailed supporting information available on the Atlas. It shows for riparian zones across each subregion, their condition, trend and threatening processes. A reliability ranking of this assessment is also indicated.

Table 3.3 The average condition, trend and threatening processes for riparian zones in some subregions of the Wet Tropics bioregion. The reliability of the assessment is indicated.

SUBREGION	RIPARIAN CONDITION	RIPARIAN TREND	THREATENING PROCESSES	RELIABILITY OF ASSESSMENT
Herbert (WET1)	Fair (Recovery requires significant intervention)	Declining	Increasing fragmentation and loss of remnants; exotic weeds; changed hydrology	Quantitative and qualitative
Innisfail (WET3)	Fair (Recovery requires significant intervention)	Declining	Increasing fragmentation and loss of remnants; grazing pressure; changed hydrology; pollution	Quantitative and qualitative
Atherton (WET4)	Fair (Recovery requires significant intervention)	Declining	Increasing fragmentation and loss of remnants; pollution; changed hydrology;	Quantitative and qualitative
Paluma - Seaview (WET5)	Degraded (Recovery unlikely in medium term)	Declining	Increasing fragmentation and loss of remnants; changed hydrology; exotic weeds	Quantitative and qualitative
Bellenden Ker - Lamb (WET7)	Fair (Recovery requires significant intervention)	Declining	Increasing fragmentation and loss of remnants; changed hydrology	Quantitative and qualitative

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Figure 3.14 Frequency of threatening processes for riparian zones in the Central Mackay Coast and Mulga Lands bioregions. Pie charts do not convey relative importance of threatening processes, rather are an indication of frequency only.



Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

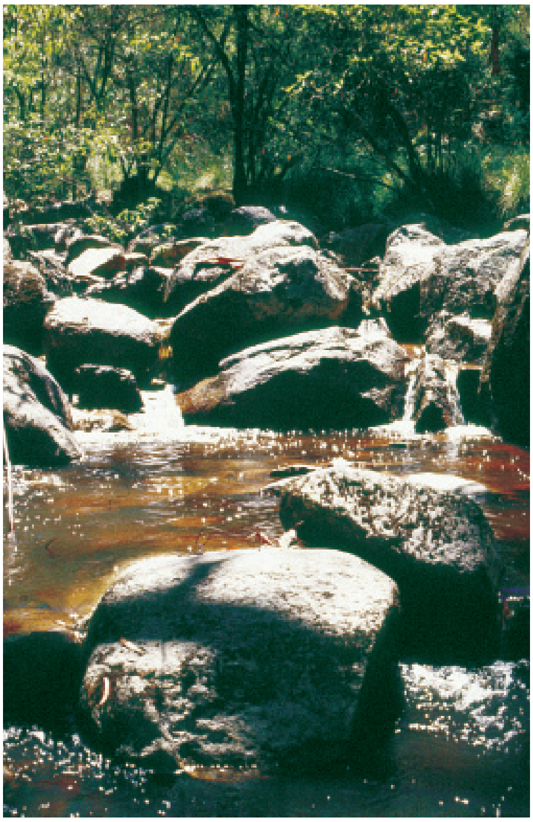
CONCLUSIONS

These assessments demonstrate the need for specific programs on rivers, estuaries, wetlands and riparian areas as an Australia-wide priority.

Management priorities and investment strategies will vary between regions and jurisdictions, but will need to include:

- programs for protection through reservation – such as the near pristine estuaries, river reaches and wetlands;
- rehabilitation activities – building on existing works and strategically designed to complement the areas reserved; and
- fine tuning of existing policies and new policies - ensuring a greater level of consideration, protection and integrated natural resource management at scales from local government through to Australia-wide.

Underpinning these strategies is the need for reliable information, and the assessment of the range of aquatic and related habitats here has indicated some of the deficiencies that exist. Continued investment in research and inventory work to document the values and increase awareness of the condition, threatening processes and management opportunities for these vital assets is needed.



Largely unmodified river in south-eastern Australia (CRC for Freshwater Ecology).

Artesian spring (R. Fensham).

4. Threatened ecosystems & species

Summary

Brigalow ecosystems stretching across the Arcadia Valley in the 1960s: Brigalow Belt South. It is now cleared and many ecosystems are threatened (R. W. Johnson).

SUMMARY

For the purposes of the Terrestrial Biodiversity Assessment, an ecosystem is defined as an integrated unit of vegetation, including dominant species and structural formation, underlying geology or soils and land form. The conservation status of ecosystems has been determined by comparing remnant extent and change in condition with pre-clearing extent across either the distributional range of the ecosystem or its bioregional occurrence. Threatened ecosystems include both endangered and vulnerable ecosystems.

Approximately 2891 threatened assemblages, including 2859 ecosystems and 32 other ecological communities, are identified in the first attempt to systematically determine the conservation status of Australia's terrestrial ecosystems. The scale of identification of threatened ecosystems varies across bioregions according to the ecosystem and vegetation mapping available.

In terms of the broad vegetation classes in which these threatened assemblages belong, 15% are eucalypt forests with a shrubby understorey, 12% are eucalypt woodlands with a shrubby understorey and 11% are eucalypt woodlands with a grassy understorey. Eucalypt woodlands are the most extensively cleared vegetation group in Australia.

Threatened ecosystems occur across much of Australia. Most bioregions (94%) have one or more threatened ecosystems. More than half of the total number of ecosystems in bioregions are threatened on the central east coast, the Darling Riverine Plains, the Murray Darling Depression, and other parts of New South Wales. This represents 16% of the 62 bioregions where information is available to calculate the percentage threatened in relation to the total number of ecosystems. A large proportion of bioregions (39%) have more than 30% of their total ecosystems threatened.

The number of threatened species of flora and fauna, including non-vascular and invertebrate species, ranges up to 236 per subregion, with the highest numbers in parts of the Murray-Darling Basin, the developed coastal parts of eastern and southern Australia, parts of Tasmania and in south-west Western Australia.

The most common threatening processes for threatened species are vegetation clearing, particularly in Queensland and New South Wales, continuing loss of native vegetation in Tasmania, increased fragmentation of vegetation remnants in New South Wales and south-western Australia, overgrazing and feral animals across much of central and western Australia, inappropriate fire regimes in northern Australia, and changed hydrology from various causes.

Similar processes affect threatened ecosystems. Vegetation clearing and increased fragmentation of vegetation remnants are the most significant threats in eastern Australia. Additional threatening processes are firewood collection in parts of southern Australia, salinity and other changed hydrology and exotic weeds.

The report to the Prime Minister's Science, Engineering and Innovation Council (Morton *et al.* 2002) recommended that reducing land clearing is one of the four areas of investment above all others that is likely to return greatest impact in heading off the diminishing values of Australia's natural systems and biodiversity.

This Biodiversity Assessment confirms that it is imperative that action be taken to limit vegetation clearing to ensure that regional biodiversity and hydrological objectives are not further compromised.

INTRODUCTION

Threatened species and communities receive considerable attention in the conservation debate. All States and Territories maintain lists of flora and fauna species that require special protection and have legislation to promote improved management. Generally, the objectives are to prevent extinction and to restore viable populations.

While it is important to manage individual threatened species in order to conserve the many components of biodiversity, including the thousands of species of invertebrates, non-vascular plants and micro-organisms, it is far more cost-effective to prevent species from becoming threatened by conserving them as part of viable and functioning ecosystems.

Recently, the focus on species conservation has broadened to the identification and conservation of threatened ecosystems. The governments of the Commonwealth, Australian Capital Territory, New South Wales, Victoria and Western Australia have enacted legislation to protect threatened ecological communities or ecosystems and Queensland has legislation to protect endangered regional ecosystems specifically from clearing. While detailed assessments of the conservation status of individual groups such as birds (Garnett & Crowley 2000) can be used to identify species that should receive special protection, no equivalent assessments have been available at the national level for threatened ecosystems.

One of the significant outputs of the Biodiversity Assessment is a list of threatened ecosystems across Australia together with a recommended conservation status of endangered or vulnerable. The trend of threatened ecosystems and species was also examined. Extensive information on threatening processes has been collated for both species and ecosystems at a subregional scale.

The threatened Striped Snake-lizard, *Delma impar* (J. Van Weenen).

THE ASSESSMENT

Threatened Ecosystems

For the purposes of the Terrestrial Biodiversity Assessment, ecosystems are described as integrated units of vegetation including the dominant species in the principal stratum and structural formation, geology or soils and landform. Each State and Territory was asked to identify threatened ecosystems across their bioregional distribution. Threatened ecosystems were recommended as either endangered or vulnerable as per criteria for assessing threatened ecological communities pursuant to the *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth).* The reliability of this assessment was recorded.

To assist in understanding the broad patterns of threatened ecosystems, the ecosystems were related to the 44 National Vegetation Information System (NVIS) Major Vegetation Sub-groups. This grouping will assist in the assessment of appropriate conservation measures for groups of threatened ecosystems. Any existing listings under State, Territory or Commonwealth legislation has been recorded.

The trend of the threatened ecosystem and what processes threaten each ecosystem has been assessed at a subregional scale. Trend for both threatened ecosystems and species was ranked in terms of six categories:

1. extinction, e.g. targeted research has not observed the species in recent times or no record of the species in the last 20 years
2. status/condition rapidly declining, e.g. less than 10 year time frame
3. status/condition declining
4. status/condition static
5. status/condition improving
6. unknown

Although threatened ecosystems were identified across most bioregions, it was not possible to calculate a percentage in all bioregions. Ecosystems have not been comprehensively mapped for some bioregions at the same scale as used in the identification of threatened ecosystems. The scale of vegetation mapping also varies across States and Territories and this has influenced the number of threatened ecosystems recorded in various bioregions.

Lists of threatened ecosystems were made for those bioregions which cross State and Territory borders by the jurisdiction containing the principal part of the bioregion and in consultation with the neighbouring jurisdiction. Cross-border issues arose in a number of locations where ecosystems were identified at different scales and further work is required to develop consistency in these situations.

The rare *Acacia peuce* (E. Anderson).

Threatened Species

Each State and Territory provided a description of the trend in status and condition of threatened species or groups listed by the Commonwealth, States and Territories. Threatening processes were identified for threatened species in each subregion where known. The reliability of the assessment of trend was ranked for each threatened species or group. To aid in recovery planning, it was proposed that threatened species be allocated to groups, either on the basis of similiar location, ecological requirements, or other factors that would enable the requirements for a group of species to be considered together. However, this could not be treated in a comprehensive way in this assessment.

The frequency of the 12 threatening processes on both threatened ecosystems and species was recorded for each subregion (see Figure 2.2 for the 12 threatening processes).

This extensive information on both threatened ecosystems and species is reported on the Australian Natural Resources Atlas for all bioregions and subregions.

Leafy greenhood (*Pterostylis cucullata*) is vulnerable (P. Lang).

FINDINGS

Threatened Ecosystems

There are 2891 threatened assemblages in Australia. Of those, 2859 are threatened ecosystems and a further 32 other ecological communities such as stygofauna communities are threatened. Ten bioregions have greater than 50% of ecosystems threatened - Central Mackay Coast, South Eastern Queensland, New South Wales North Coast, Nandewar, New England Tableland, Sydney Basin, South East Highlands, Darling Riverine Plains, Victorian Volcanic Plain and Murray Darling Depression (Figure 4.1).

These represent 16% of the 62 bioregions where data were available to determine a percentage of the total number of ecosystems occurring in a bioregion. The bioregions correspond to the extensively cleared parts of eastern Australia and within the Murray-Darling Basin with clearing still occurring in many of these bioregions. A further 14 (23%) of these 62 bioregions have between 30% and 50% of their total ecosystems threatened.

It is likely that with the availability of comprehensive bioregional data for South Australia and other parts, that additional bioregions will be identified as having a higher proportion of threatened ecosystems.

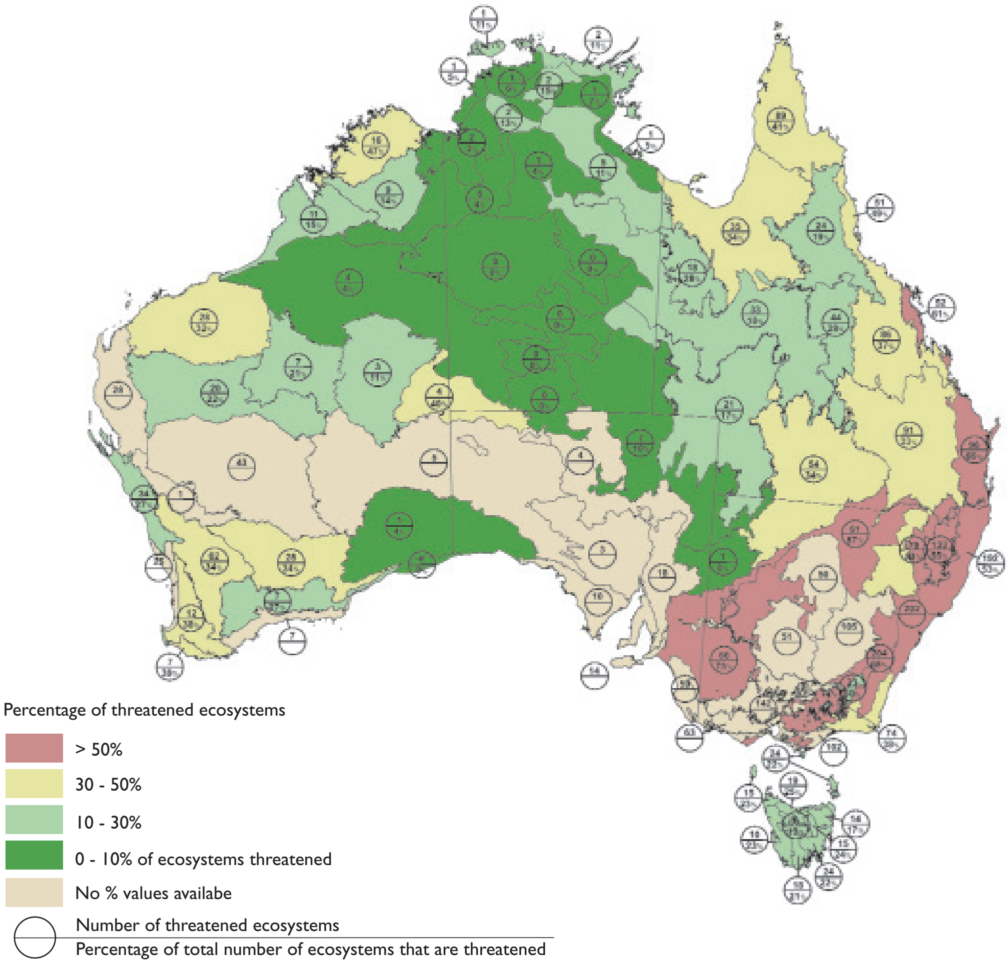


Figure 4.1 The number and percentage of threatened ecosystems and other ecological communities identified across bioregions. In some bioregions, the total number of ecosystems has not yet been determined to enable a percentage to be derived.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

In the more extensively used landscapes in northern and western Australia, large numbers of threatened ecosystems are identified primarily due to grazing pressure and changed fire regimes.

The extent of this biodiversity decline at an ecosystem level has major ramifications in terms of future species loss and impacts on ecological processes and ecosystem services.

Available on the Atlas is a comprehensive listing of all threatened ecosystems by bioregion. Table 4.1 is an extract from the Atlas and lists threatened ecosystems for the Riverina bioregion, the reliability ranking associated with their identification, the NVIS Major Vegetation Subgroup that each ecosystem belongs to, whether the ecosystem is already listed under State, Territory or Commonwealth legislation, their recommended status (endangered or vulnerable), and their trend in condition.

National Vegetation Information System

Each threatened ecosystem was matched to a Major Vegetation Subgroup of the National Vegetation Information System (NLWRA 2001c) in order to provide a picture of the types of ecosystems that are threatened across Australia (Table 4.2). This approach can help identify groups of threatened ecosystems and make conservation management more strategic.

The result of the matching is that eucalypt forests and woodlands are the dominant types of threatened ecosystems. One thousand, two hundred and thirty-eight of the threatened ecosystems (about 43% of the total) are eucalypt dominated forests or woodlands with a shrubby or grassy understorey.

Table 4.1 Extract of an Atlas table listing threatened ecosystems for the Riverina bioregion: their reliability of the identification, Major Vegetation Subgroup, current legislative protection, recommended status and trend. (E denotes endangered and V denotes vulnerable).

THREATENED ECOSYSTEM	RELIABILITY OF THE IDENTIFICATION	MAJOR VEGETATION SUBGROUP	EPBC LISTING	STATE LISTING	RECOMMENDED STATUS	TREND
Lignum Wetland	Quantitative and qualitative	Herbland, Sedgeland and Rushland		E	E	Declining
Pine Box Woodland	Quantitative and qualitative	*Eucalyptus* woodlands with a grassy understorey	E	E	E	Declining
Pine Buloke Woodland	Quantitative and qualitative	*Callitris* forests and woodlands	E	E	E	Unknown
Plains Grassy Woodland	Quantitative and qualitative	*Eucalyptus* woodlands with a grassy understorey		E	E	Declining
Red Gum Wetland	Quantitative and qualitative	*Eucalyptus* woodlands with a grassy understorey		E	E	Declining
Riparian Woodland	Quantitative and qualitative	*Eucalyptus* woodlands with a shrubby understorey		E	E	Declining
Riverine Escarpment Scrub	Quantitative and qualitative	Tall shrublands		Extinct	Extinct	Extinction
Riverine Grassy Woodland	Quantitative and qualitative understorey	*Eucalyptus* woodlands with a grassy		V	V	Declining
Sand Ridge Woodland	Quantitative and qualitative	*Callitris* forests and woodlands		E	E	Declining
Sedge-rich Woodland	Quantitative and qualitative	*Eucalyptus* woodlands with a grassy understorey		E	E	Declining

Table 4.2 The number of threatened ecosystems in each of the 44 Major Vegetation Subgroups identified in the National Vegetation Information System (NLWRA 2001c). Data was not available for 104 ecosystems and 61 ecosystems fell into the category of 'unclassified native vegetation.'

NATIONAL VEGETATION INFORMATION SYSTEM MAJOR VEGETATION SUBGROUPS	NUMBER THREATENED ECOSYSTEMS
Eucalyptus forests with a shrubby understorey	425
Eucalyptus woodlands with a shrubby understorey	344
Eucalyptus woodlands with a grassy understorey	318
Eucalyptus forests with a grassy understorey	149
Herbland, sedgeland and rushland	137
Tropical and sub-tropical rainforest + dry rainforest	136
Other tussock grasslands	123
Other grasslands	114
Tall shrublands	97
Heath + Banksia woodlands and shrublands	67
Brigalow (*Acacia harpophylla*) forests and woodlands	60
Other shrublands	51
Arid *Eucalyptus* low open woodlands with tussock grass	44
Eucalyptus tall open forest and *Eucalyptus* forests with a dense broad leaved understorey (wet sclerophyll)	43
Melaleuca forests and woodlands	44
Other *Acacia* forests and woodlands	43
Casuarina and *Allocasuarina* forests and woodlands	42
Other forests and woodlands	36
Tropical mixed spp forests and woodlands	32
Mixed Chenopod, Samphire and Forblands	45
Callitris forests and woodlands	28
Alpine and sub-alpine woodlands, shrublands, sedgelands and herbfields	28
Bare areas, rock, sand, claypan, salt lakes and lagoons	28
Mangroves, tidal mudflat and coastal samphire	27
Freshwater lakes	28
Arid *Acacia* low open woodlands and shrublands with chenopods	26
Mixed species arid *Acacia* woodlands and shrublands	25
Cool temperate rainforest	25
Chenopod shrublands	25
Mulga (*Acacia aneura*) woodland and low open woodland	23
Eucalyptus forests with a heath understorey	21
Other low open woodlands and shrublands with tussock grass	19
Mallee *Eucalyptus* low open woodlands	17
Arid acacia low open woodlands and shrublands with tussock grass	16
Arid *Eucalyptus* low open woodlands with hummock grass	12
Mallee heath and shrublands	7
Spinifex hummock grasslands	7
Arid *Acacia* low open woodlands and shrublands with hummock grass	5
Low tropical *Eucalyptus* forests and woodlands	4
Blue Grass (*Dichanthium*) and Tall Bunch Grass (*Chrysopogon*) tussock grasslands	2
Tropical *Eucalyptus* forest and woodlands with a annual grassy understorey	2
Mitchell Grass (*Astrebla*) tussock grasslands	1

Threatening Processes

The most widespread processes threatening ecosystems are vegetation clearing, fragmentation of remnant vegetation, grazing pressure, exotic weeds, feral animals, firewood collection, salinity and other changed hydrology, and altered fire regimes.

Clearing and increased fragmentation of remnants are the principal factors threatening ecosystems in eastern Australia and other locations (Figure 4.2). There are exceptions to these general patterns and therefore these threatening processes cannot be ignored in the rest of Australia. For example, clearing threatens ecosystems near Darwin and is related to developments for horticulture and improved pastures.

The legacy of broad-scale clearing in southern Australia is widespread land degradation and loss of biodiversity. In areas that have already been subject to clearing, increased fragmentation and removal of small patches of remnant native vegetation can have major impacts on the plant and animal species as habitat falls below critical thresholds.

Salinity and firewood collection are mainly affecting ecosystems of southern and eastern Australia (Figure 4.2). Recognition that firewood collection is a major threatening process has only occurred in the last few years (Wall 2000; Driscoll *et al.* 2000) and has led to the formulation of a national framework for managing its impacts on conservation values and air pollution (ANZECC 2001b).

Overgrazing threatens ecosystems across much of Australia (Figure 4.2) and can lead to irreversible loss of protective soil crusts, decline in perennial grasses, change in composition of functionally important flora and loss of soil fertility (Woinarski 2001). The Australian Collaborative Rangeland Information System (NLWRA 2001d) proposes a framework to monitor rangeland condition, including biodiversity. In regions where major soil loss and extensive floristic change has not occurred, grazing impacts can be more easily addressed compared with the major revegetation required in southern and eastern Australia. Strategic fencing and improved stock management may enable paddocks to be rested at critical times and grazing regimes could be altered to favour biodiversity values.

Feral animals are a major threat to native fauna (R. Brandle).

Changed fire regimes threaten ecosystems across Australia and is one of the principal threats in northern Australia (Figure 4.2). Fire monitoring using remote sensing is helping to refine the management of fire in northern ecosystems (Russell-Smith *et al.* 2002). However, no systematic framework exists for addressing fire regimes in the fragmented ecosystems of southern and eastern Australia (Bradstock *et al.* 2002) and the use of remote sensing is complicated by cloud cover and more complex topography. Possingham *et al.* (2002) estimated that implementing fire management regimes in native vegetation would save 95 species per $1 million spent and that large collateral benefits would result.

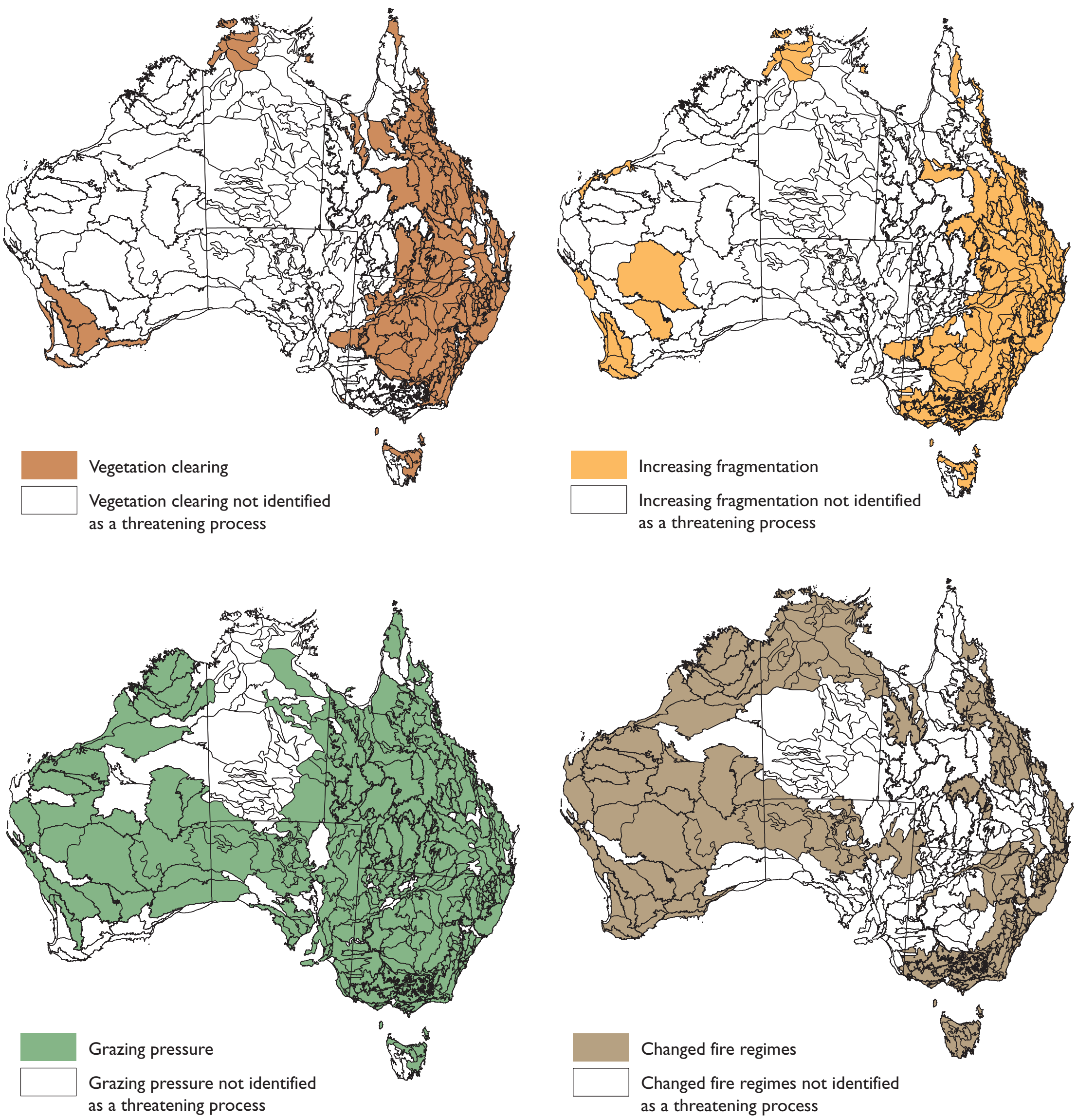
In the rangelands, the loss of the soil crust, compaction and the formation of hard pans have had major impacts on the flow of water, and water holding capacity is reduced (Figure 4.2). The loss of mammals that traditionally dug up soils, such as the Burrowing Bettong (*Bettongia lesueur*), also has had an impact on water balance in the landscape, as well as on other elements of environmental health and function (Noble *et al.* 1999). Changes in the fire regime can have negative impacts on surface water flow, which in turn can affect the habitat of endangered species such as the Giant Desert Skink or Tjakara (*Egernia kintorei*). Overall, the impact of land uses on soil characteristics and biota requires further study.

Exotic weeds and feral animals have an impact on threatened ecosystems across many bioregions (Figure 4.2). These threatening processes are difficult and expensive to manage across large areas.

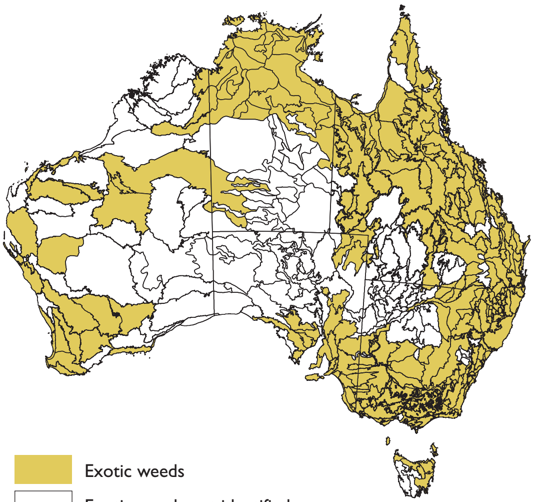
Available on the Atlas is detailed information on specific threatening processes for each threatened ecosystem in each subregion. Table 4.3 is an extract from the Atlas showing the level of data collated for each subregion.

Distribution of all threatening processes have not been mapped in Figure 4.2, however, some threatening processes may be regionally significant. For example, Jarrah dieback from *Phytophthora cinnamomi* is one of the significant threats to ecosystems at risk in south-west Western Australia.

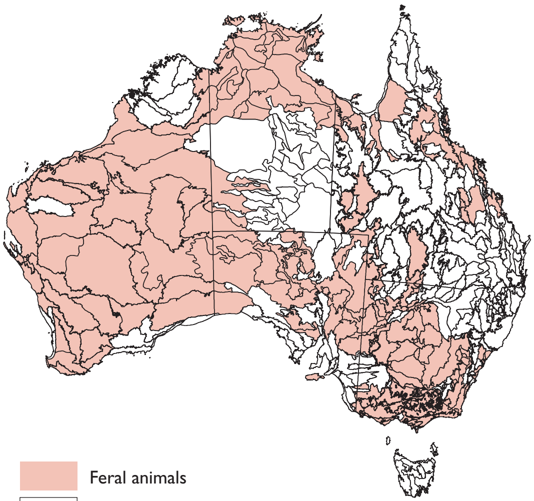
Figure 4.2 Distribution of the nine major threatening processes for threatened ecosystems. Where subregions cross State and Territory borders, threatening processes may not apply equally within each jurisdiction.



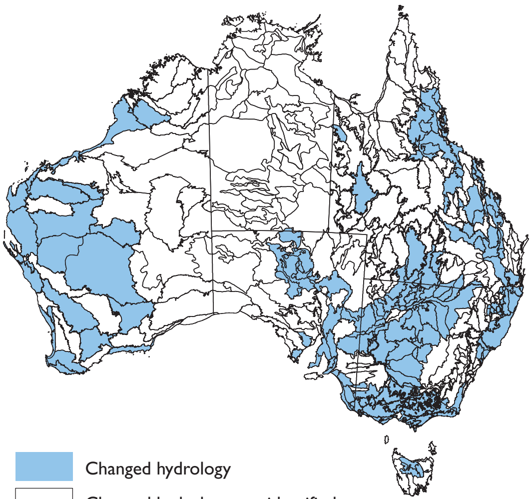
Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.



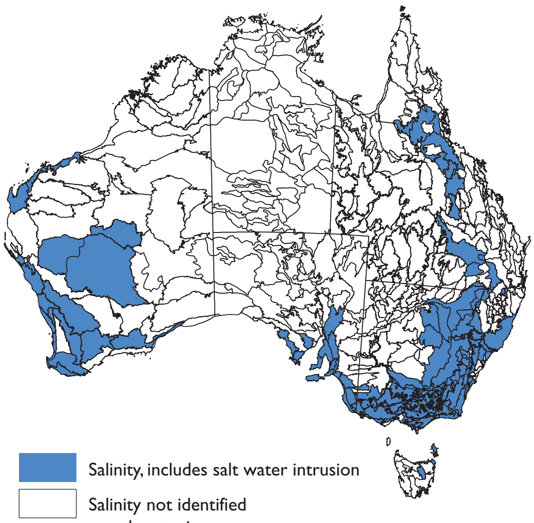
Exotic weeds
Exotic weeds not identified as a threatening process



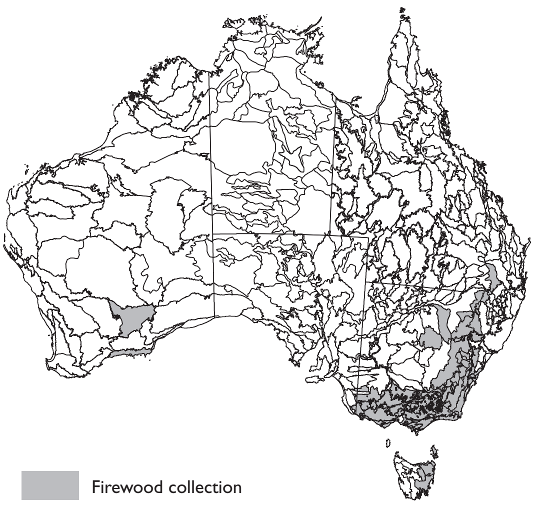
Feral animals
Feral animals not identified as a threatening process



Changed hydrology
Changed hydrology not identified as a threatening process



Salinity, includes salt water intrusion
Salinity not identified as a threatening process



Firewood collection
Firewood collection not identified as a threatening process

Overgrazing leading to severe soil erosion: Mt Isa Inlier (P. Sattler).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Table 4.3 Extract of an Atlas table listing threatened ecosystems in the Tasmanian West bioregion; their recommended status, and threatening processes. (E denotes endangered and V denotes vulnerable).

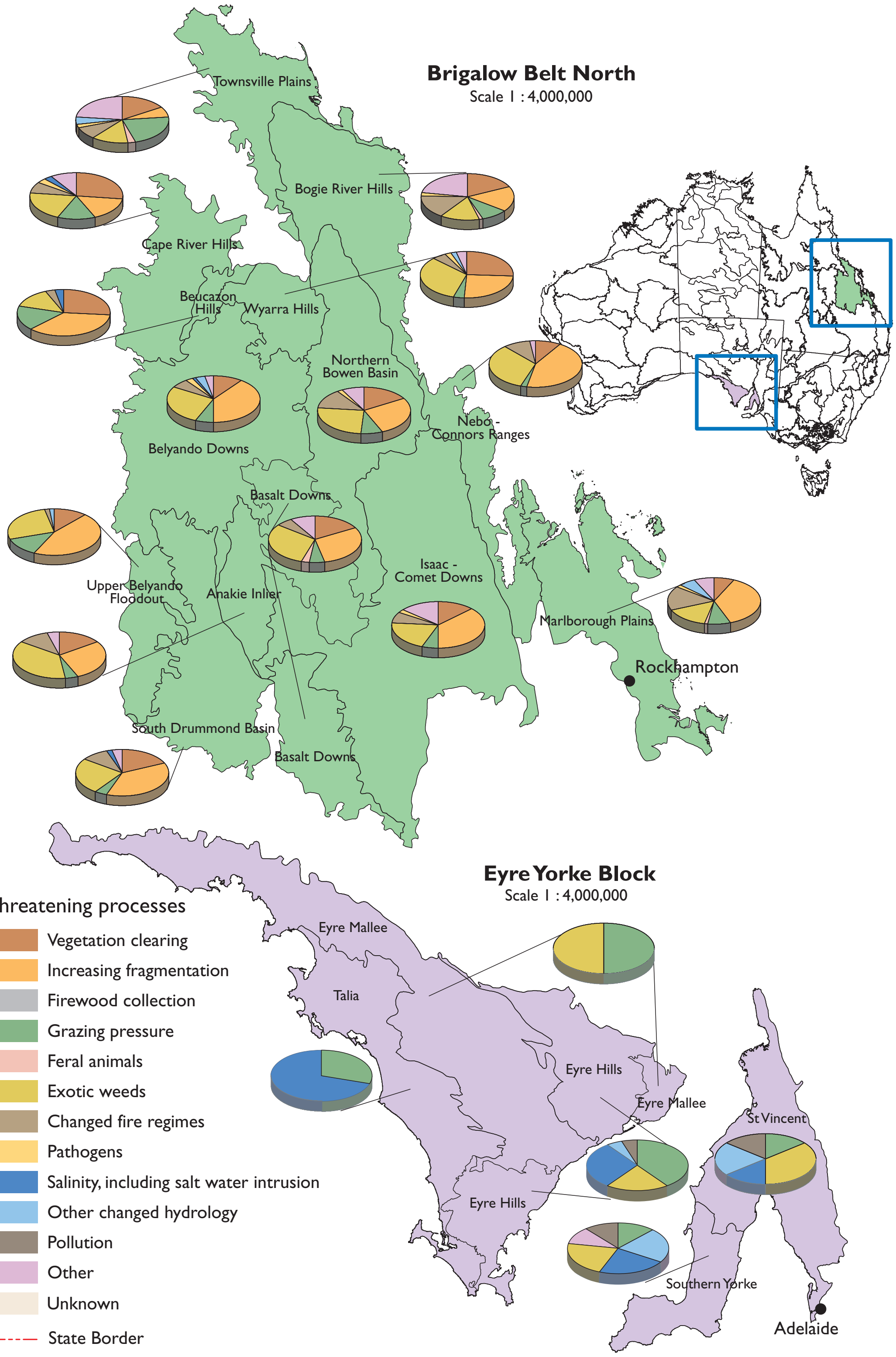
THREATENED ECOSYSTEM	RECOMMENDED STATUS	THREATENING PROCESS	NOTES
BA - Brookers gum wet forests	V	Other - describe	Clearing for forestry plantation establishment
F - king billy/pencil pine/ deciduous beech forest	V	Changed fire regimes	Ecosystem is fire sensitive
G - white gum/blue gum coastal forests on sands	V	Broad scale vegetation clearing	Clearing for agriculture or other purposes; weed invasion, dieback, inappropriate fire regimes, firewood collection
Ma - coastal saltmarsh	V	Grazing pressure	
Mg - coastal saline rushland/ sedgeland	V	Grazing pressure	
Ms - succulent coastal herbfield and saltmarsh	V	Grazing pressure	
NP - native olive/blanket leaf shrubberies	E	Changed fire regimes	Ecosystem is fire-sensitive
Sd - Sand dune vegetation	-	Changed fire regimes	
Waf - freshwater aquatic herbland	-	Increasing fragmentation and loss of remnants; grazing pressure; exotic weeds	
X - king billy/pencil pine forests	V	Changed fire regimes	Ecosystem is fire-sensitive

Frequency of Threatening Processes

To better understand the localised impact of each threatening process on ecosystems, the frequency of threatening processes recorded for each subregion was calculated. As it has not been possible in this assessment to indicate the relative importance of each threatening process on threatened ecosystems, these diagrams should only be interpreted as the frequency of threatening processes recorded.

Figure 4.3 shows the frequency of threatening processes recorded in two bioregions, Brigalow Belt North and Eyre Yorke Block. The remainder of the bioregions are available on the Altas. The two bioregions chosen to illustrate the range of processes impacting on threatened ecosystems provide an interesting contrast. In the Brigalow Belt North bioregion, vegetation clearance, increasing fragmentation of remnants, grazing pressure, changed fire regimes and exotic weeds have been identified as the main threats in all subregions. Salinity has only been noted as a minor component in two of the 14 subregions. In contrast, in the Eyre Yorke Block bioregion, where the history of development is much older, salinity has been recorded as a large component in four of the five subregions. Grazing pressure and weeds are common threats, reinforcing once again their widespread and pervasive nature.

Figure 4.3 Frequency of threatening processes for threatened ecosystems in the Brigalow Belt North and Eyre Yorke Block bioregions. Pie charts do not convey relative importance of threatening processes, rather are an indication of frequency only.



Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Threatened Species

As of June 2002, the total number of threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* was 1595, comprising 346 vertebrates, 8 invertebrates and 1241 plants. To effectively plan their conservation it is important to know their distribution and threats in different parts of the landscape. The approach taken was to consider the number of threatened species occurring at both the bioregional and subregional scale.

The number of species listed as threatened at the bioregional level has been collated from both State and Territory legislative listings and from the Commonwealth indicative distribution maps. This information is provided in the bioregional summaries on the Atlas. An example bioregional summary is given in Table 4.4. Of particular note is the difference between State and Territory listings and the Commonwealth listing. This difference arises out of the different methodologies, where the Commonwealth used expert-validated modeled distributions rather than actual point location records. Reference to both data sets is desirable in regional planning to assess conservation needs for threatened species located in that subregion or bioregion and to assess whether the species occurs in terms of potential distribution.

Table 4.4 Extract of Atlas information on threatened species in the Ord Victoria Plain bioregion. Threatened species are by major groups and as listed by the Northern Territory and identified in the Commonwealth indicative distribution maps (V denotes vulnerable and E denotes endangered).

SPECIES	COMMON-WEALTH LISTING	STATE LISTING
Mammals		
Lagorchestes conspicillatus conspicillatus (Spectacled Hare-wallaby (Barrow Island))	V	WA (V)
Macrotis lagotis (Greater Bilby)	V	NT (V); WA (V)
Rhinonicteris aurantius (Orange Leaf-nosed Bat)	-	WA (V)
Lagorchestes conspicillatus (Spectacled Hare-wallaby)	V	WA (V)
Macroderma gigas (Ghost Bat)	V	
Birds		
Erythrura gouldiae (Gouldian Finch)	E	NT (V); WA (E)
Geophaps smithii smithii (Partridge Pigeon (eastern))	V	WA (V)
Erythrotriorchis radiatus (Red Goshawk)	V	NT (V); WA (V)
Falcunculus frontatus whitei (Crested Shrike-tit (northern), Northern Shrike-tit)	V	NT (E)
Malurus coronatus coronatus (Purple-crowned Fairy-wren (western))	V	WA (V)
Reptiles		
Crocodylus johnstoni (Freshwater Crocodile)	-	WA (V)
Vascular plants		
Platysace saxatilis	-	NT (V)
Kohautia australiensis	-	WA (V)
Trianthema kimberleyi	-	WA (V)
Adiantum capillus-veneris (Dainty Maidenhair, Venus-hair Fern)	-	NT (V)

The number of threatened species recorded at the subregional scale is indicated in Figure 4.4. This is based on State and Territory listings of threatened species and ranged from 0 to 236 species per subregion. The highest number occurs in the Murray Mallee subregion in north-western Victoria. Other subregions in Victoria also have very high numbers of threatened species, particularly subregions of the Murray Darling Depression, Victorian Midlands, South East Highlands, Victorian Riverina, South Coast Plain and Victorian Volcanic Plains bioregions. These equate mostly with highly cleared regions, apart from Murray Darling Depression 4 – the subregion associated with the Big and Little Desert National Parks. South-east Tasmania and the New South Wales north coast also have greater than 150 threatened species per subregion.

The geographic patterns for threatened species are similar to those seen for threatened ecosystems. The subregions associated with the highly cleared areas of southern and eastern Australia have the highest numbers of threatened species. Only eight of the 384 subregions in Australia have no recorded threatened species.

This analysis gives no indication of whether a species was present in a subregion but is now extinct, a common situation in the more arid areas as discussed in the mammal chapter. Some locations with high numbers of threatened species may reflect historic refugia rather than the direct result of anthropogenic factors e.g., Cape York Peninsula.

Overall, the Murray-Darling Basin, coastal parts associated with intensive development, parts of Tasmania and the south-west of Western Australia are the areas most important in terms of threatened species.

Trend in Threatened Species

The trend in threatened species status or condition has been examined for species groups. Figure 4.5 shows the median trends for vascular plants, mammals, birds, reptiles and amphibians.
The status of threatened vascular plants is declining across much of the continent (177 of the 384 subregions), as are threatened birds (240 subregions) with extinctions in arid parts of Western Australia (14 subregions).

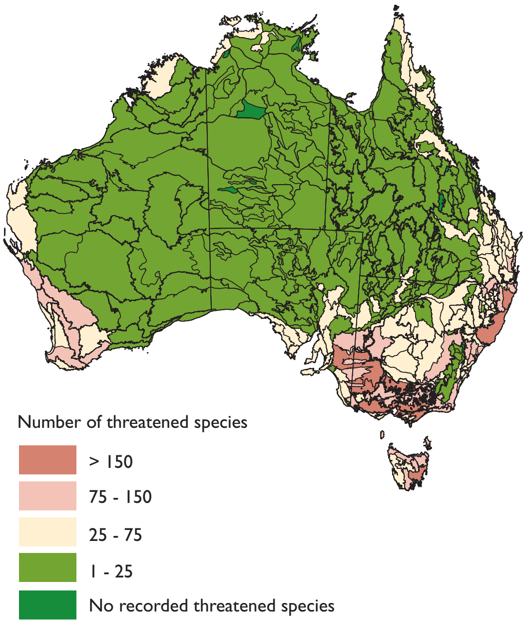


Figure 4.4 Total number of threatened species by subregion as per State and Territory listings.

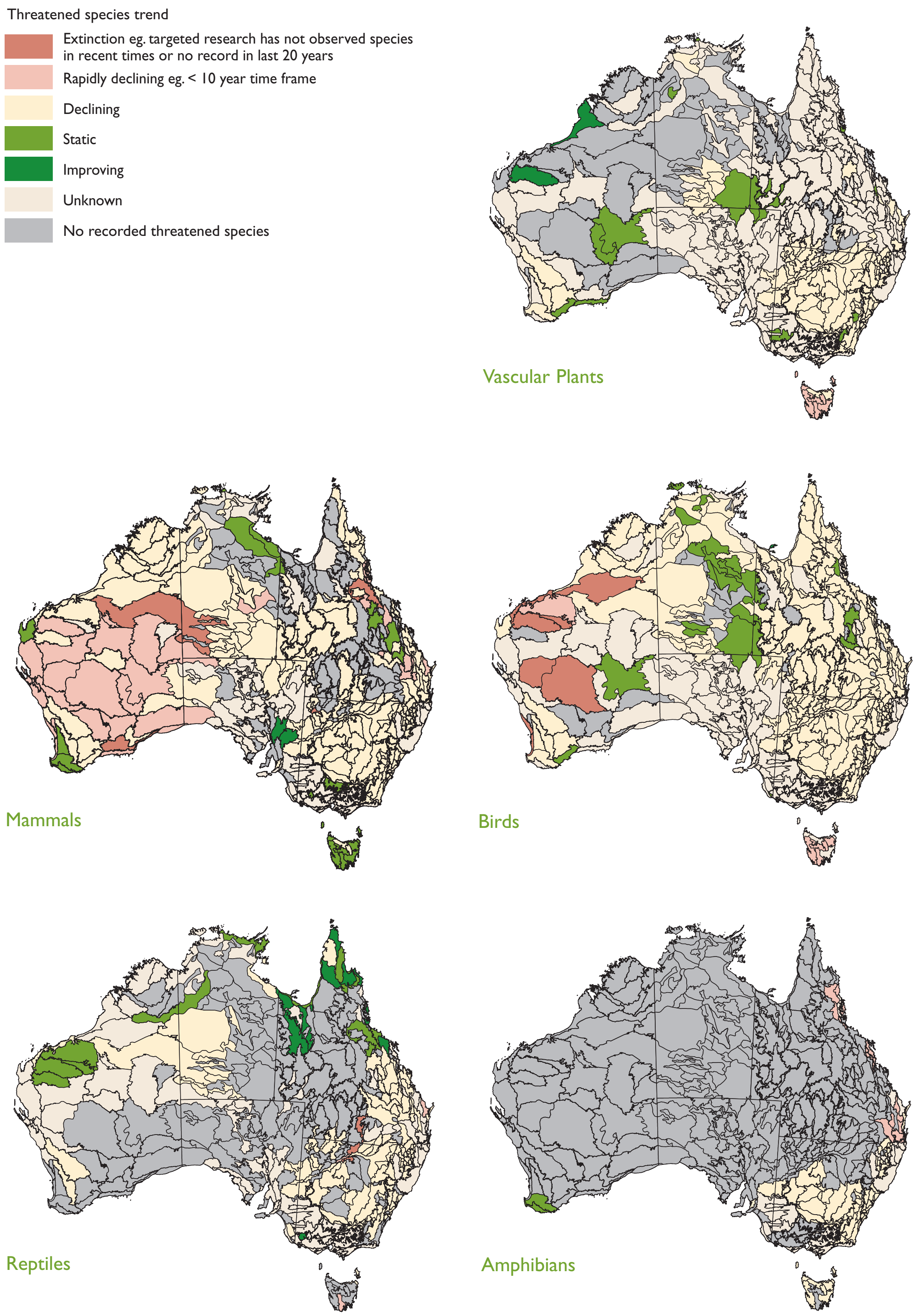
Threatened mammal species are rapidly declining in 20 subregions and declining in 174 subregions, particularly in arid parts of Western Australia. Reptiles are declining across 119 subregions. Threatened amphibians are declining in south-eastern Australia (65 subregions) and are rapidly declining in South East Queensland, Brigalow Belt South and Wet Tropics bioregions.

Little information was recorded for non-vascular plants and invertebrates reflecting not only the paucity of information but the limited protection afforded in State and Territory legislation.
For example, the decline in land snails in Tropical Savannas has not yet been reflected in State or Territory listings of threatened species. Where information was available, decline in status was recorded. These species groups should be more comprehensively assessed.

Threatened species, or groups, are recorded on the Atlas for each subregion together with their status, trend, threatening processes and a reliability ranking of the assessment of trend.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Figure 4.5 Threatened species trend (median) for vascular plants, mammals, birds, reptiles and amphibians.



Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Threatening Processes

With the extent of information collated on threatening processes impacting on the large number of threatened species, it has been possible to derive an overall map of the most common threatening processes by subregion (Figure 4.6).

This map illustrates the major biodiversity issues across Australia with:

- extensive vegetation clearing in Queensland, New South Wales and Tasmania;
- increased fragmentation of remnants in New South Wales and Western Australia;
- high continuing loss of native vegetation in Tasmania relative to its area;
- overgrazing in many parts of the pastoral zone;
- the widespread impact of feral animals in arid areas;
- changed fire regimes in northern Australia (being also significant on Cape York Peninsula);
- changed hydrology ranging from dams in Tasmania to the concentration of artificial watering points on the Barkly Tableland and to the impact on artesian springs in the Desert Uplands; and
- salinity emerging as the most common threat in parts of southern Australia.

The distribution of each threat contributing to the decline of threatened species in each subregion is detailed in Figure 4.7. These individual maps of each threat show the widespread nature of all 12 categories of threat identified as part of the template used in this assessment.

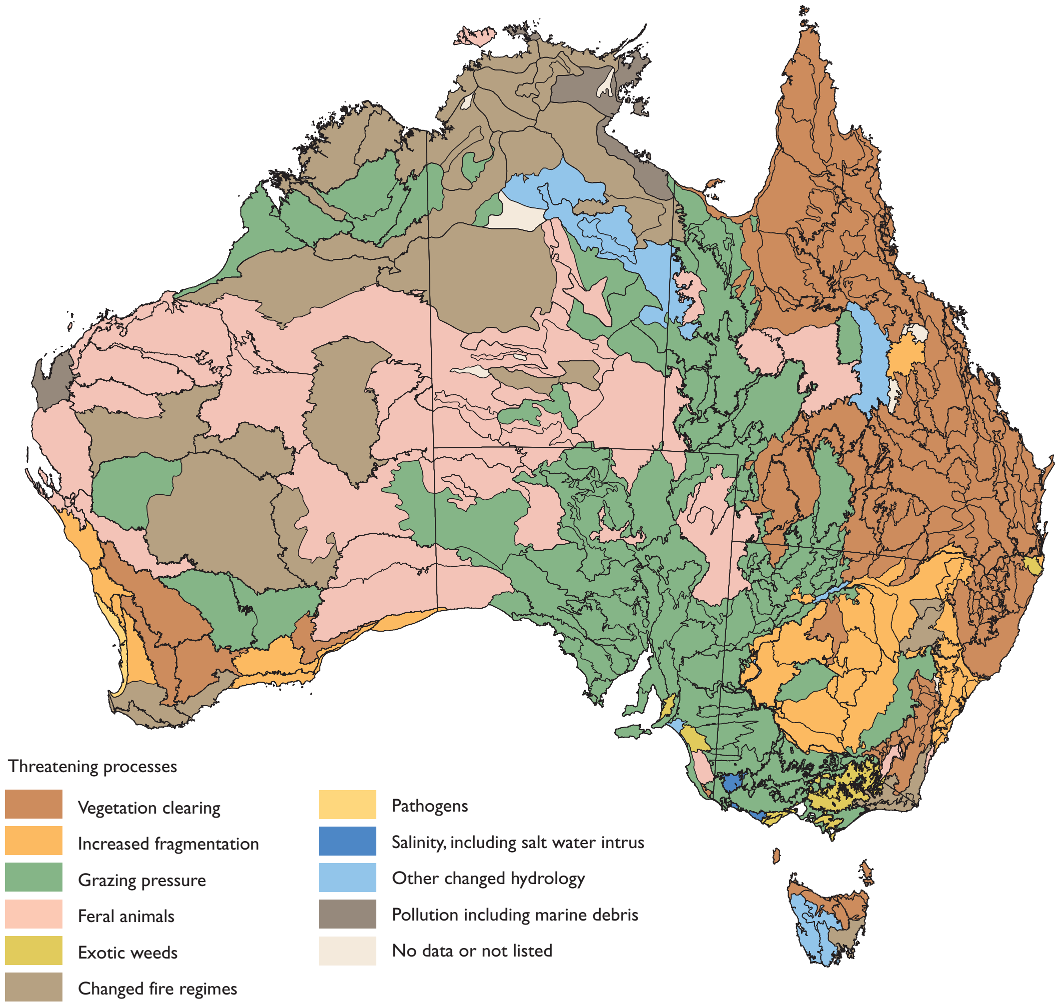
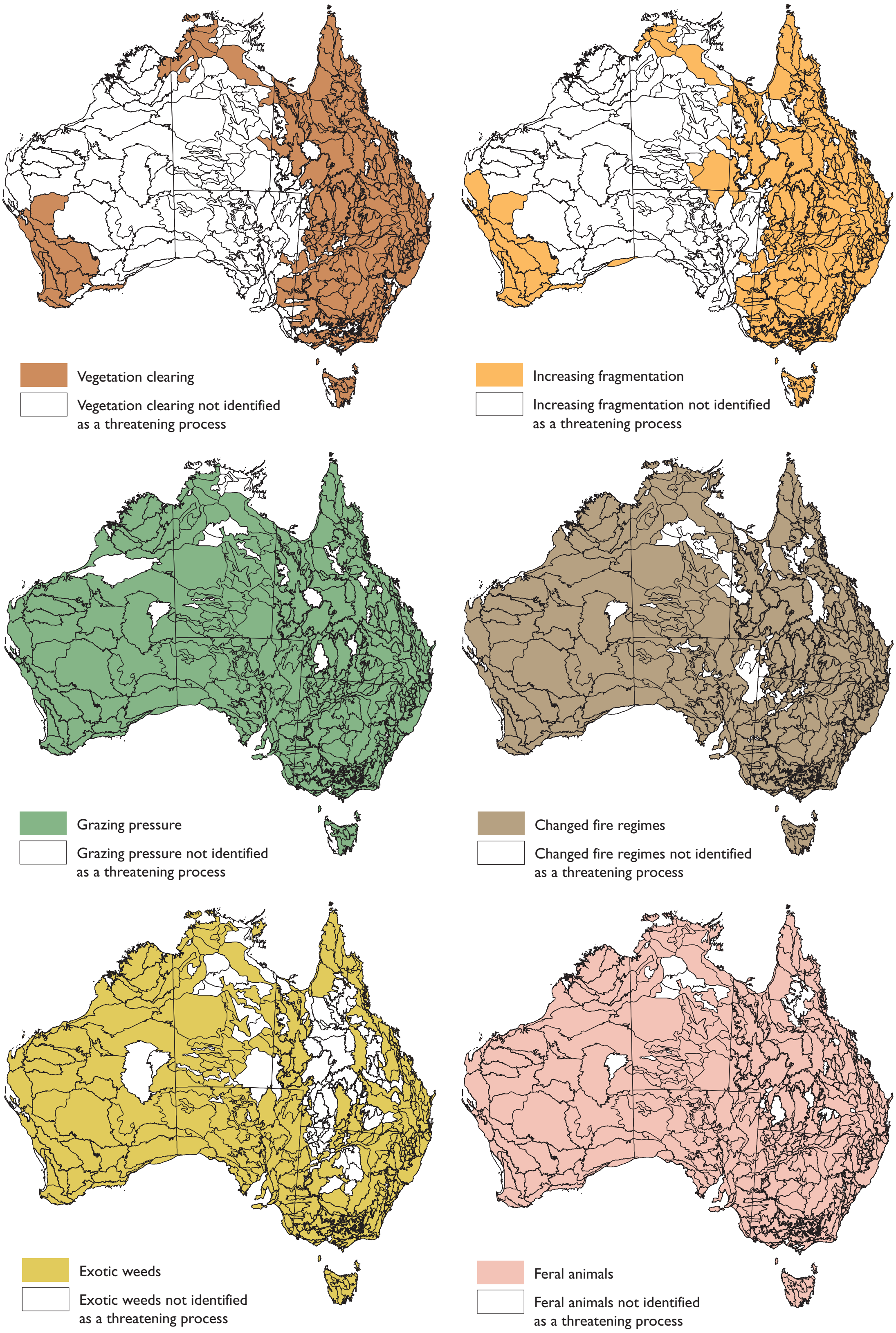


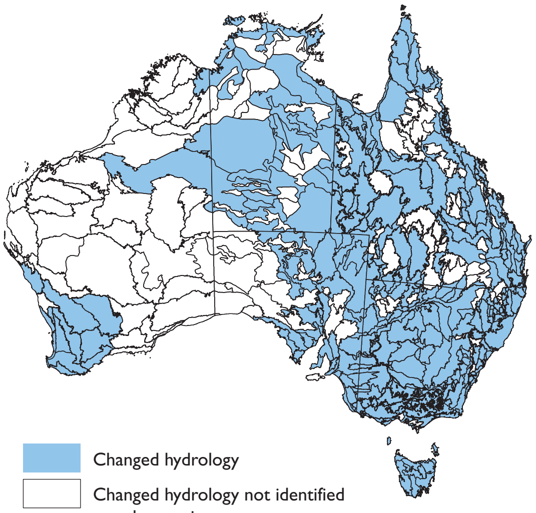
Figure 4.6 Distribution of ten most common threatening processes for threatened species by bioregion. Where subregions cross State and Territory borders, threatening processes may not apply equally within each jurisdiction.

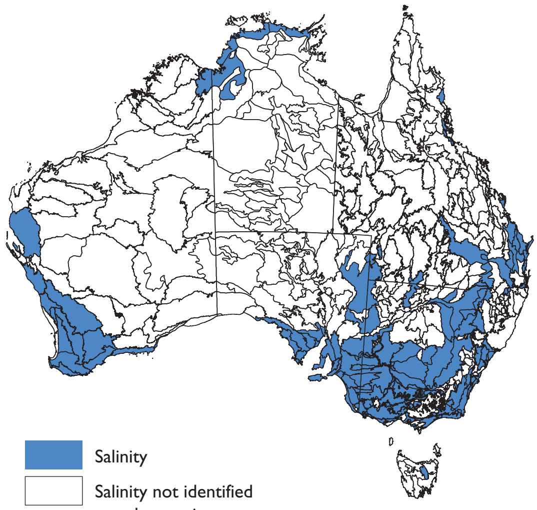
Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

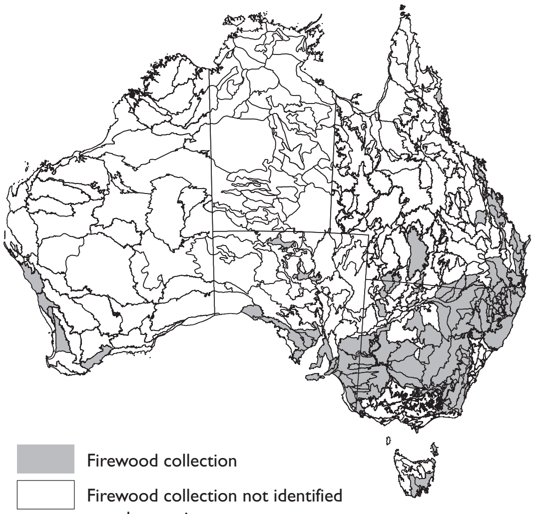
Figure 4.7 The distribution of twelve threatening process impacting on threatened species across subregions. Where subregions cross State and Territory borders, threatening processes may not apply equally within each jurisdiction. Clearing does not apply to the South Australian portion of subregions.

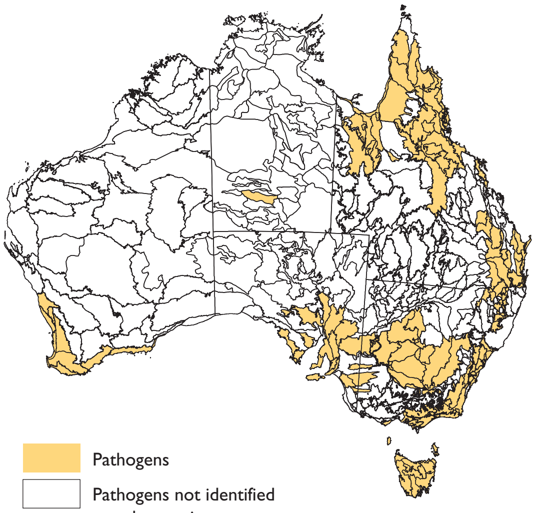


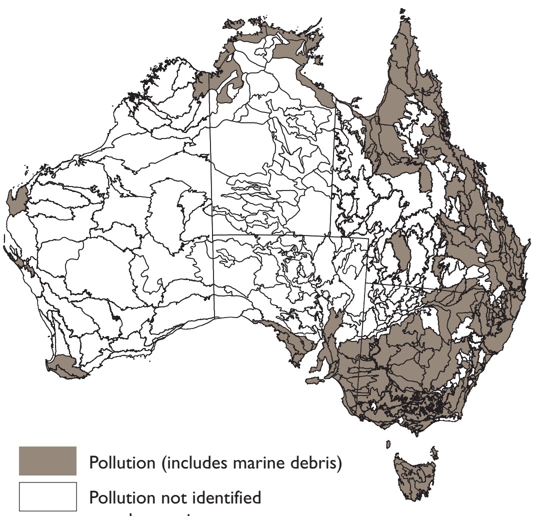
Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

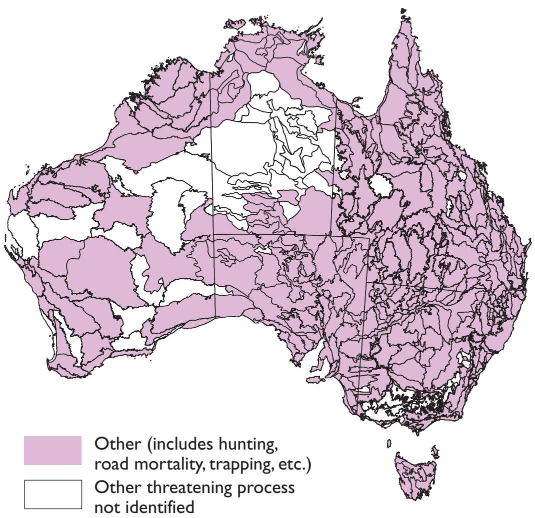












Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

The specific information behind these maps is available on the Atlas. An example of this information is given in Table 4.5, which shows the threatened species or species group in each subregion, their status, trend, threatening processes, subregional distribution of the species and a reliability ranking of the assessment of trend.

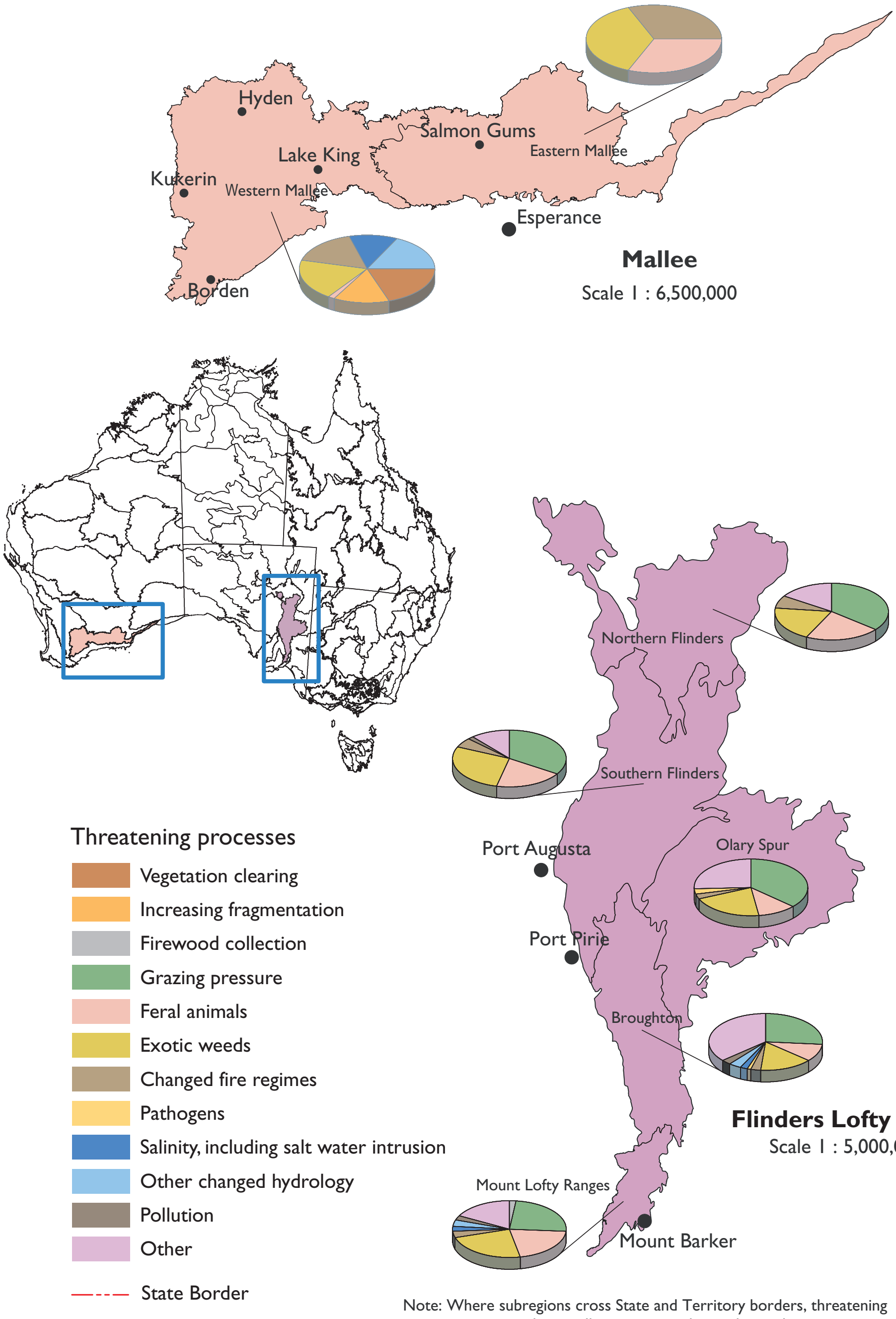
The interpretation of all maps should be carried out in consultation with these tables on the Atlas to more fully gain and understanding of the issues identified. For example, the identified impact of pollution on remote coastal parts of the Northern Territory refers to marine debris affecting threatened turtle species.

SPECIES	COMMON-WEALTH LISTING	STATE LISTING	RECOVERY PLAN	TREND	RELIABILITY ASSESSMENT	THREATENING PROCESS
Mammals						
Dasyurus geoffroii (Chuditch, Western Quoll)	V	V	No	Improving	Quantitative and qualitative	Broad scale vegetation clearing; increasing fragmentation and loss of remnants; feral animals
Macrotis lagotis (Greater Bilby)	V	V	No	Extinction		
Myrmecobius fasciatus (Numbat)	V	V	No	Unknown	Quantitative and qualitative	Broad scale vegetation clearing; increasing fragmentation and loss of remnants; feral animals
Birds						
Amytornis textilis textilis (Thick-billed Grasswren (western)	V	V	No	Extinction	Quantitative and qualitative	
Calyptorhynchus latirostris (Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo)	E	E	No	Declining	Quantitative and qualitative	Broad scale vegetation clearing; increasing fragmentation and loss of remnants; feral animals; changed hydrology - salinity and other
Vascular plants						
Acacia auratiflora (Orange-flowered Wattle)	E	E	No	Rapidly declining	Quantitative and qualitative	Broad scale vegetation clearing; increasing fragmentation and loss of remnants; feral animals; changed hydrology - salinity and other; changed fire regimes
Acacia depressa (Echidna Wattle)	V	E	No	Declining	Quantitative and qualitative	Broad scale vegetation clearing; increasing fragmentation and loss of remnants; feral animals; changed hydrology - salinity and other; changed fire regimes

Table 4.5 An extract from the Mallee 2 subregion table available on the Atlas. Threatened species, their status, trend and threatening processes. The reliability of the assessment of trend is indicated. V denotes vulnerable and E denotes endangered.

The frequency of threatening processes impacting on threatened species in each subregion has been collated and the Mallee and Flinders Lofty Block bioregions are used as examples (Figure 4.8).

Frequency pie diagrams of threatening processes are available for all 85 bioregions on the Atlas. As indicated for threatened ecosystems, these diagrams should not be interpreted as the relative importance of each threat.



Note: Where subregions cross State and Territory borders, threatening processes may not be equally common within each jurisdiction.

Figure 4.8 Frequency of twelve threatening processes contributing to the decline of threatened species in the subregions of the Mallee and Flinders Lofty Block bioregions. Pie charts do not convey relative importance of threatening processes, rather are an indication of frequency only.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

CONCLUSIONS

The extent of landscape modification in Australia means that 2891 ecosystems and other ecological communities are now threatened. These assemblages are a priority for conservation to protect the immense species diversity associated with them and for the protection of ecological processes.

The threatened ecosystems and other ecological communities identified in this assessment provide a basis for targeted initiatives in biodiversity management. It is imperative that conservation is approached in a cost-effective manner and this analysis of threats to ecosystems and species at both the continental and regional scale provides a basis for strategic approaches to threat abatement. Specifically, the detailed information on the Atlas is a vital resource for focusing regional planing and management.

There are many management responses to the conservation of threatened ecosystems. One response could be listing threatened ecosystems under Commonwealth, State or Territory legislation where such provisions exist. Should this course of action be chosen, the information on threatened ecosystems in this report needs to be value-added, including the desirable scale for grouping ecosystems, and to further assess the equivalency of ecosystems and status across State and Territory borders.

The report to the Prime Minister's Science, Engineering and Innovation Council (Morton *et al.* 2002) urges that we protect and maintain our natural systems rather than be faced with an ever increasing repair bill. The high number of threatened ecosystems identified in this assessment indicates how extensive the repair task will be unless comprehensive action is taken.

Rubber vine (*Cryptostegia grandiflora*) causes extensive degradation to habitat across northern Queensland: Gilbert River (QDNRM).

Grazing pressure is a widespread threatening process for both species and ecosystems: Mitchell Grass Downs.

In accord with the findings of the report to the Prime Minister's Science, Engineering and Innovation Council, urgent action is required to halt the clearing of all threatened ecosystems as well as broad-scale clearing within the Murray-Darling Basin. Priority areas should also include any subregion containing less than 30% remnant vegetation (see Chapter 9) and where the clearing of areas may threaten regional biodiversity values, including hotspots, and ecosystem function.

The wide range of threatening processes means that a variety of approaches to the protection of biodiversity is needed for different parts of the country. Protection and recovery both through protected areas and across the wider landscape is discussed later in this report.

Extensive salting beside a wheat paddock: Avon Wheatbelt (P. Sattler).

Clearing of endangered semi-evergreen vine thicket within a national park proposal north of Rockhampton: Brigalow Belt North (R. Melzer).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

5. Birds

Major Mitchell's Cockatoos, *Cacatua leadbeateri* (QEPA).

SUMMARY

This chapter examines a range of patterns and recent changes in bird species composition and abundance at both continental and bioregional scales. These patterns include species richness, endemism, threatened species, national and core habitat and the condition and trend of some of these attributes for both species and bird guilds.

The assessment relied principally upon the analysis of 6 million records of 744 bird species that were collected during two Bird Atlas periods, 1977-1981 and 1998-2001. As a consequence, only changes in distribution or abundance that occurred since the first Atlas survey are described in these analyses. Of the total number of records in the two Bird Atlases, there was adequate information for the detailed bioregional analysis of trends in 495 species (1.7 million records).

The analyses showed that there were considerable regional differences in the patterns emerging. Three principal interacting factors contribute to the observed trends: changes in landscape health (particularly in highly cleared areas), climatic fluctuations, and the biases resulting from changes in survey methods used between the two Atlases.

Many bird species appear sensitive to declining landscape health caused by broad-scale vegetation clearance, urbanisation, intensified agriculture and introduced predators. Overall, the clearing of land for agriculture appears to have had the greatest non-climatic influence on bird abundance.

Twenty-nine of the 497 species analysed in agricultural Australia showed significant decreases in reporting rates where increased proportions of the landscape have been cleared. Grassland, woodland and ground-nesting guilds were particularly affected.

Changes in fire regime (sometimes in association with intensification of pastoralism) have been implicated in the decline of some species, particularly the granivores.

Twenty-six species appeared to decline with decreasing landscape health, a measure that includes abundance of feral animals and weeds as well as intensification of primary production. There was a negative trend in reporting rate in 61 species in the intensive land use zone, when compared to Australia's rangelands, with at least part of this relationship being explained by climatic differences between survey periods. In contrast, species found in guilds that inhabit rainforest, temperate forest and mangrove systems showed significant increases in reporting rate. The reason for this trend is unknown but might be related to more intensive surveys in the second Atlas study.

Some native species are favoured in intensively developed landscapes. For example, the trend in reporting rates of 21 species increased with increasing land clearance and declining landscape health. Up to 15% of the bird fauna is exotic in south-eastern Australia, including eastern Tasmania, and in south-western Australia. This includes some native species that have been introduced outside of their natural range.

Long-term trends in bird abundance or distribution are much more difficult to identify in areas such as the tropical savannas of northern Australia and the arid zone. Separating the effects of climate in these regions from other factors is difficult because the climate, particularly the patterns of water availability across central Australia, differed greatly between survey periods. Two land use factors that vary within bioregions, and are therefore difficult to assess at a bioregional level, are rangeland grazing intensity and changed fire regimes. However, reporting rates of some grazing-sensitive species such as Singing Bushlark *(Mirafra javanica)* and Flock Bronzewing *(Phaps histrionica)* have declined.

Interacting with all of these factors were major differences in rainfall, and, in some regions, temperature, between the two Atlas periods. Significant changes in distribution (both increases and decreases) caused by different rainfall patterns were observed for around 6% of species. A number of other species were unusually common near the coast during the first Atlas, but appear to have contracted to the centre, particularly the Channel Country, in the second. However, a number of less mobile species probably increased and decreased at a local scale, resulting in a similar pattern of change.

Details of selected bird species and information on the special values, condition, trend and recommended management responses are provided for each bioregion on the Australian Natural Resources Atlas (www.environment.gov.au/atlas). On-going monitoring of key species identified for each bioregion will allow rapid appraisal of landscape and avian health. It will increase our understanding of the trends in bird distribution and abundance, and the processes affecting them, particularly over similar climatic conditions.

INTRODUCTION

Australia has over seven hundred species of birds, found across a diversity of habitats ranging from sub-alpine forest to the spinifex grasslands of central Australia. Birds have a special place in the hearts of most Australians, which is demonstrated by the large number of amateur bird watchers across the continent. Many of these individuals volunteered to collect survey data on birds for a nation-wide project coordinated by the Royal Australasian Ornithologists Union (now known as Birds Australia). The first 'Bird Atlas' survey was conducted between 1977 and 1981 and has been followed up by a second Atlas survey conducted between 1998 and 2001.

While there was a number of differences in the way birds were surveyed in the two Atlases, there is no comparable national scale data set for Australian birds or any other Australian taxa. This chapter uses the data from the two Atlases to examine a range of patterns and recent changes associated with bird species at both continental and bioregional scales. Features assessed include species richness, endemism, threatened species distribution, national and core habitat and the condition and trend in reporting rates of both species and bird guilds.

Similar 'audits' have been undertaken in the United Kingdom, where trends in the abundance of birds is considered one of the primary indicators of the health of the nation, along with the rate of unemployment and the gross domestic product. The broad analysis of the Atlas data presented in this chapter therefore provides significant insights into the environmental well-being of Australia.

THE ASSESSMENT

The data set used in this report was obtained from the Bird Atlas projects of Birds Australia. The Atlas projects surveyed the birds of the Australian continent and its near-shore islands from January 1977 to December 1981 (referred to as Atlas period 1) (Blakers *et al* 1984), and from August 1998 to August 2001 (referred to as Atlas period 2). This means that only changes in distribution that have occurred since the first Atlas survey are detected by these analyses. Approximately 41,000 record forms were used from those submitted in Atlas 1 and 47,000 for Atlas 2. Each record form contains one or more sighting. The analysed sheets contained a total of 768,000 sightings in Atlas 1 and 955,000 in Atlas 2. Overall, 6 million records were collected for 744 species during the two bird Atlas periods, 1977-81 and 1998-2001. Of the total number of records, there was adequate information to analyse for trends in 497 species (1.7 million records).

Because of the different ways data has been collected in the two Atlases, their analysis presents numerous challenges, as summarised in the detailed report on methods for this chapter (see the Australian Natural Resources Atlas for details).

Gang-gang Cockatoo, *Callocephalon fimbriatum* (G. Chapman).

The approach taken was to identify statistically significant patterns in the data, and then discuss which factors might contribute to these patterns. In doing so, correlations between changing reporting rates and environmental factors across the bioregions are considered more reliable indicators of the fate of a species than are the absolute changes themselves. The patterns identified are presented as relationships that are worthy of further investigation and highlight areas where more detailed analysis, both of the current data set, and of further specifically designed studies, is warranted.

The data sets were used to describe the distributional characteristics and trends for species at a national and bioregional level. Analysis of national reporting rate change was undertaken for bird populations across the continent. Using reporting rate enabled an unbiased comparison of trends in intensively surveyed areas like south-eastern Australia with those in more remote bioregions. Analysis of core bioregion reporting rate was undertaken for bioregions that are important for individual species only. Species were also grouped into guilds based on habitat and mode of feeding. Analysis of guilds assessed changes in bioregions at both Australia-wide and bioregional scales.

FINDINGS

Patterns in Bird Distribution and Abundance

Number of Species

The bioregions with the highest number of bird species occur along the length of eastern Australia, from Cape York Peninsula to Cape Otway in Victoria and inland through the lower Murray-Darling Basin (Figure 5.1).

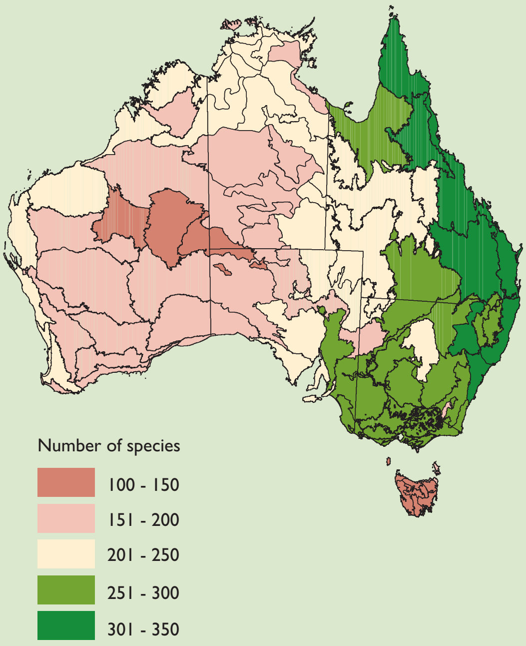


Figure 5.1 Total number of resident bird species

Within this band, the highest numbers of species have been recorded from south-eastern Queensland (429 species) and north-eastern New South Wales (428 species), followed by Sydney Basin (423 species) and the Wet Tropics (395 species). These numbers are inflated by seabirds, seasonal migrants that breed outside Australia, and vagrants. The highest numbers of species that breed in Australia (resident species) are found in the Brigalow Belt (BBN 332 species, BBS 342), Wet Tropics (325 species) and South East Queensland (330 species) bioregions. The last two of these bioregions are also in the top four for the total number of bird species, so make a particularly important contribution in terms of the overall number of species. The lowest number of species was recorded from Tasmanian bioregions (e.g. Tasmanian Central Highlands 129 species; Tasmanian Northern Highlands 140; Tasmanian Southern Ranges 151), the arid interior and western half of the continent (e.g. Gibson Desert 133; Little Sandy Desert 146; Central Ranges 151), although some of these bioregions were poorly surveyed.

Many Australian resident species also occur outside Australia, particularly in northern neighbouring countries. Correspondingly, the highest concentration of species only found in Australia is found in southern Australia, particularly inland. The semi-arid zone of southern Western Australia has the highest proportion of these most distinctive elements of the Australian bird fauna, which are adapted to harsh conditions. These are quite unlike species found elsewhere in south-east Asia or the Pacific.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Rarity

As elsewhere in the world, island species are disproportionately represented on the Australian list of threatened species. Both offshore islands under Australian jurisdiction, such as Christmas, Norfolk and Lord Howe, and nearshore islands, including Tasmania, have the highest levels of extinction and rarity in the country. For example, King Island has 13 threatened species, including four that are critically endangered and Kangaroo Island has 7 threatened species and 2 critically endangered. Some of the Tasmanian bioregions also have very high numbers of threatened species, particularly critically endangered species (Garnett & Crowley 2000) that are close to extinction eg. Tasmanian Southern Ranges - 9 threatened species, 2 critically endangered, Tasmanian West - 8 threatened, 2 critically endangered) (Figure 5.2).

The biogeographical effect of islands also occurs on the contintent proper. Patches of vegetation surrounded by crops or cleared land can be viewed as islands of habitat in a contrasting matrix. Bioregions where these land-use patterns are found include the Murray Darling Depression - 11 threatened, 1 critically endangered, Naracoorte Coastal Plain - 9 threatened, 1 critically endangered, the heaths and rainforest patches of South Eastern Queensland - 12 threatened, 2 critically endangered, NSW North Coast - 11 threatened, 2 critically endangered, and South East Coastal Plain - 13 threatened, 1 critically endangered. The south-western bioregions east of Albany (Esperance Plains, Jarrah Forest) would have had a higher threatened species score for birds but for the highly successful recovery programs that have been conducted in the area for Noisy Scrub-bird *(Atrichornis clamosus)*, Western Bristlebird (*Dasyornis longirostris*) and Western Whipbird *(Psophodes nigrogularis nigrogularis)*, which have recently been upgraded from endangered to vulnerable.

Azure Kingfisher, *Alcedo azurea* (G. Chapman).

Rainbow Lorikeet, *Trichoglossus haematodus*: there has been large increases in reporting rate including introduced populations in Swan Coastal Plain and the Avon Wheatbelt (G. Chapman).

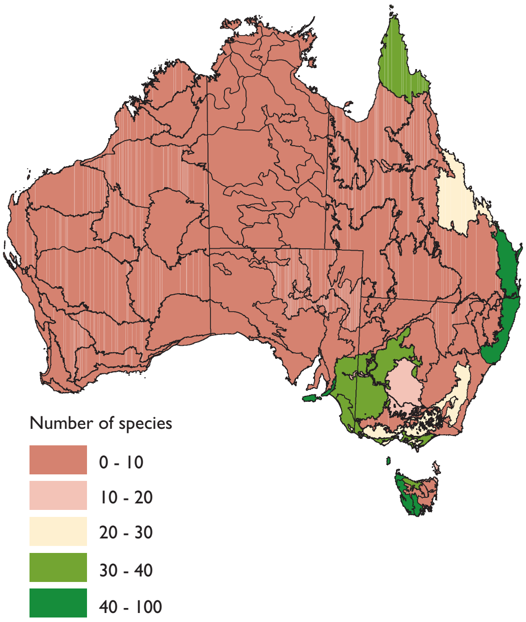


Figure 5.2 Relative importance of bioregions to threatened bird taxa, including those confined to nearby Australian islands, standardised against highest scoring bioregion, King Island

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Centres of Endemism

The number of species occurring in ten or fewer bioregions was considered the most appropriate measure of centres of endemism within Australia. Approximately 25% of the 555 resident species analysed are recorded from fewer than 10 bioregions (Figure 5.3). The largest numbers of these limited range species are found in Cape York Peninsula and the adjacent Wet Tropics.

Fourteen limited range species (ie. that occur in 10 or fewer bioregions) are found only on Cape York Peninsula, although all of them also occur across Torres Strait in New Guinea. The Wet Tropics has a higher number of Australian endemic species, with 13 species largely confined to its upland rainforests between Paluma and Big Tableland, only one of which, the Blue-faced Parrot-finch *(Erythrura trichroa)*, also occurs outside Australia. At a broader scale, over 30% of restricted range species are confined to the combined bioregions of north-eastern Queensland (Cape York Peninsula, Einasleigh Uplands, Gulf Plains and the Wet Tropics), with a further 14% extending down the east coast to north-east New South Wales. Three other areas also containing a disproportionately high number of restricted range species are: Tasmanian bioregions with 14 terrestrial and 4 marine species (12%), south-western Australia (Avon Wheatbelt, Coolgardie, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain and Warren bioregions) with 12 and 3 (10%), and the Top End and Kimberley (Arnhem Coast, Arnhem Plateau, Central Arnhem, Central Kimberley, Daly Basin, Darwin Coastal, Northern Kimberley, Ord Victoria Plain, Pine Creek and Victoria Bonaparte bioregions) with 10 terrestrial species (7%) and no marine species. These areas broadly coincide with the Endemic Bird Areas identified for Australia (Stattersfield *et al.* 1998).

Introduced Species

The relative abundance of introduced bird species is a measure of habitat alteration, which in turn has been related to changes in bird abundance and distribution. Large metropolitan areas are the main source of introduced species. The highest abundance of introduced species is found in southern Victoria, eastern Tasmania and parts of South Australia making up to 15% of all birds recorded (Figure 5.4).

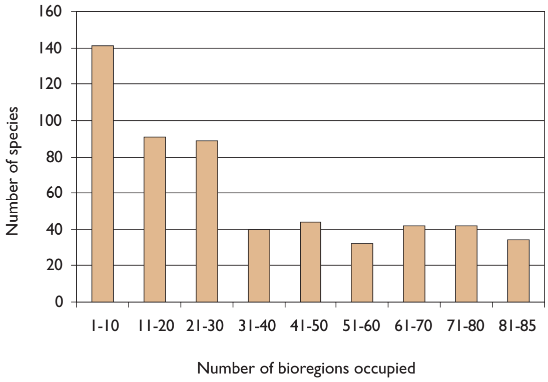


Figure 5.3 Patterns in the extent and distribution of Australian Birds

Most are species introduced from overseas, such as the Rock Dove *(Colombia livia)*, House Sparrow *(Passer domesticus)* and Common Starling *(Sturnus vulgaris)*. However, there have also been introductions of Australian species, like the Long-billed Corella *(Cacatua pastinator)* that now flourishes in nearly every capital city due to aviary-releases in the 1980s. Eastern Tasmania has a particularly high loading of native introduced birds, as has south-western Australia, particularly near Perth. One new species, the Barbary Dove *(Streptopelia risoria)*, has become established since the first Atlas.

Superb Parrot, *Polytelis swainsonii* (G. Chapman).

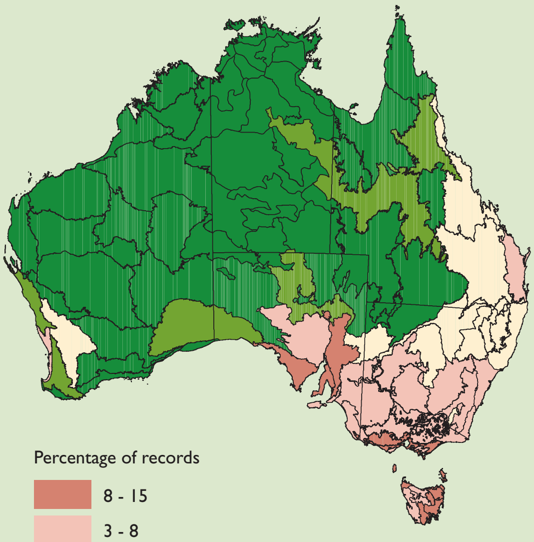


Figure 5.4 Percentage of records that are introduced species

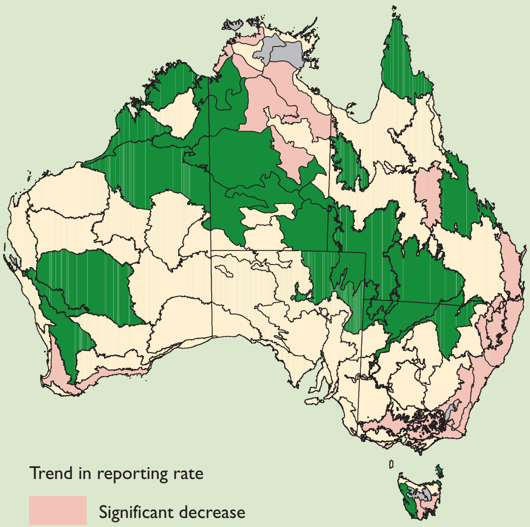


Figure 5.5 Trends in reporting rate of Australian breeding species between the first Atlas and the second Atlas

Trends in Abundance

The national reporting rate of 169 species increased, that of 68 species decreased and 219 species showed no net change. This generally positive trend was found despite a tendency for many species to be seen less frequently using the methods of the second Atlas.

This is demonstrated by the observation that for about 1.5% of species, there were no records during the second Atlas in bioregions that had been estimated to contain at least 10% of their population in the first Atlas. All but 5 of these (0.03%), however, were vagrant or cryptic birds or in poorly surveyed bioregions, suggesting these species were more likely to have been missed than absent. This figure is balanced by the 1.2% of species where greater than 10% of their population in the second Atlas was in bioregions where they had not been recorded in the first. Overall, there were greater apparent changes in abundance of bird species between the two Atlas periods than changes in their distribution.

For much of arid and semi-arid Australia, the overall reporting rate of Australian breeding species was relatively stable or rose more than 20% (Figure 5.5). This pattern contrasts with decreased reporting rates in the south-east and south-west of mainland Australia, eastern Tasmania, and much of the Top End of the Northern Territory.

Yellow Chat, *Epthianura crocea* (G. Chapman).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Trends among birds associated with different habitats varied greatly between guilds. Significant increases in reporting rate were recorded for rainforest, temperate forest, tropical and temperate woodland, and mangrove birds, although the reasons underlying this pattern are unclear. In contrast, significant decreases in reporting rate were detected for grassland birds and facultative woodland species.

Among grassland birds the greatest decline in reporting rate was in the south-east (Figure 5.6), despite relatively stable climatic conditions. There was a similar pattern of decline for woodland birds, with the greatest declines being where introduced birds are most prevalent. Overall, reporting rates of freshwater birds and migratory shorebirds also decreased.

Garnett (1992) identified two nesting guilds and two feeding guilds with higher than expected numbers of threatened species. Trends in reporting rates of these guilds were analysed here. Hollow-nesting species showed virtually no change in reporting rate, whereas the reporting rate of ground-nesting species decreased, again particularly in south-eastern Australia, but also in the Top End of the Northern Territory (Figure 5.7).

Obligate granivores were recorded at a higher rate in the second Atlas, particularly in semi-arid areas. However, ground-feeding insectivores decreased, again particularly in the south-east (Figure 5.8).

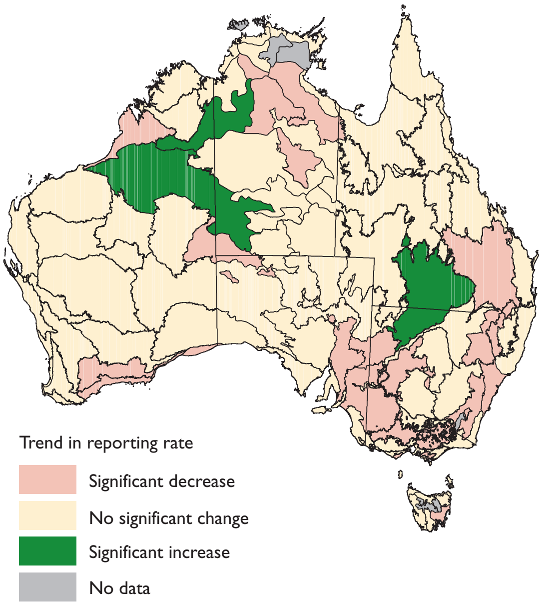


Figure 5.7 Trends in reporting rate of ground-nesting bird species between the first Atlas and the second Atlas

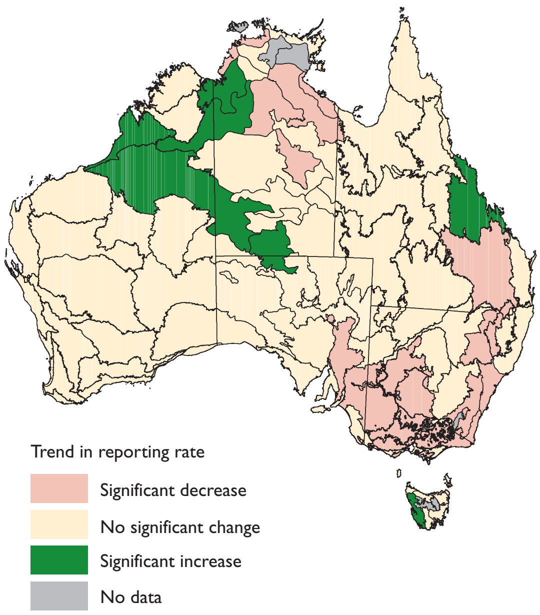


Figure 5.6 Trends in reporting rate of obligate grassland bird species between the first Atlas and the second Atlas

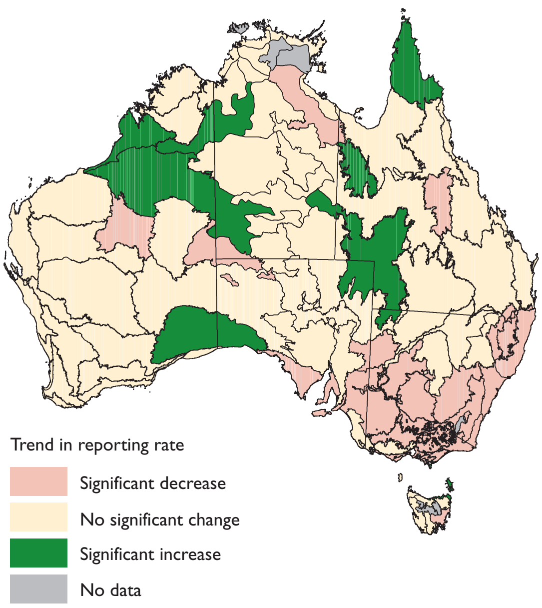


Figure 5.8 Trends in reporting rate of ground-feeding insectivore species between the first Atlas and the second Atlas

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

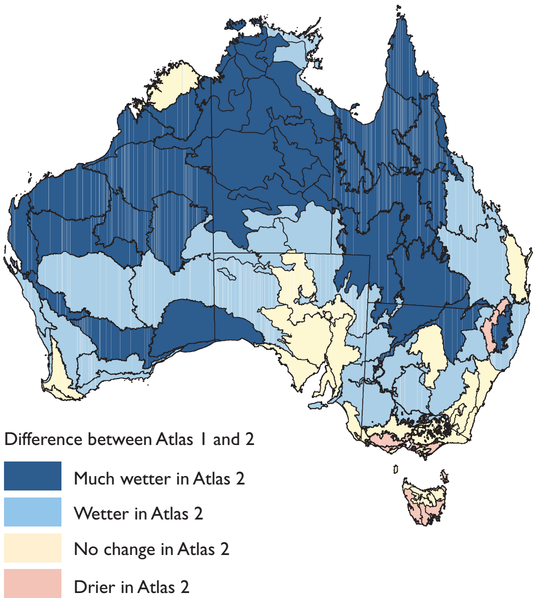
Jacky Winter, *Microeca fascinans* (G. Chapman).

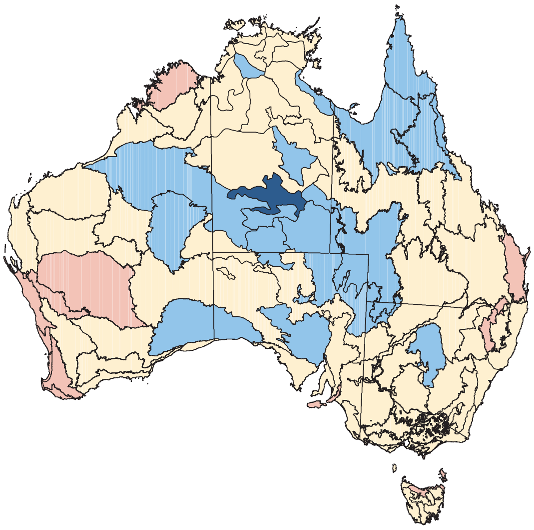
Factors that Contribute to Patterns in Bird Distribution and Abundance

Climate

At a continental level, both Atlas periods were wetter than average, with the second period wetter than the first. Only a few areas, particularly Tasmania and parts of Victoria, were drier in the second period (Figure 5.9). A number of species appear to have been advantaged by the wetter conditions, with fifteen species showing a significant increase in reporting rate with increasing rainfall.

The first two years of the first Atlas project coincided with an inland drought that had followed three years of exceptional inland rainfall. As a result, many mobile species, particularly waterbirds, had dispersed in large numbers as the inland dried out, thus inflating their numbers at the edges of the continent. A wet phase was underway during the second Atlas project, which did not include the subsequent drying of the inland. Twelve species showed a reporting trend that responded negatively to increasing rainfall.





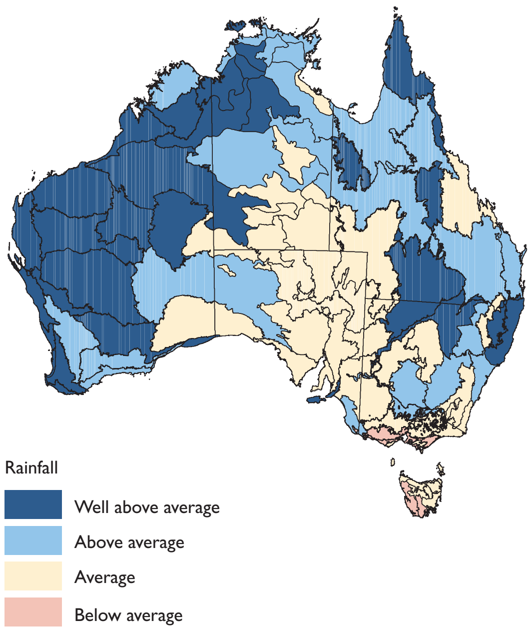


Figure 5.9 Rainfall patterns in the first Atlas (above), the second Atlas (right) and the difference between them (above right).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Diamond Firetail, *Stagonopleura guttata* (G. Chapman).

For many of the remaining 468 species for which no statistical relationship with rainfall was evident, distributional patterns of change suggest both an increase in wetter inland bioregions, particularly the Channel Country, and a decline, possibly back to more normal densities, along the eastern margin of the continent. During the first Atlas, arid zone bioregions were dry compared to the wetter period that had preceded the second Atlas. During the second Atlas the arid zone was wetter than the period before it. Populations of these species appeared to have increased near the coast during the first Atlas, and in the centre in the second. For the more mobile species, these changes can be accounted for by movement between regions.

In contrast, populations of some of the more arid-adapted species, such as Inland Dotterel (*Charadrius astralis)* and Gibberbird *(Ashbyia lovensis)*, which may also have increased during the mid-1970s, had lower reporting rates during the second Atlas period in bioregions where those of more wide-ranging species increased.

For more sedentary species, such as Hooded Robin *(Melanodryas cucullata)* or Jacky Winter *(Microeca fascinans)*, increased reporting rates inland and a decrease in the intensive use zone is likely to result from localised population changes, with the wetter climate producing favourable conditions in the inland, and more intensive land use closer to the coast being detrimental. Hence, the trends from the semi-arid zone appear to mainly reflect climatic variation, but those in the intensive use zone are more likely to be responding to changes in landscape health.

The decreased reporting rates for many freshwater birds and migratory shorebirds may also have been driven by climate. However, specialised surveys suggest that the decline may also be related to long-term declines in the health of many catchments. The decline in reporting rate of shorebirds, despite increased attention to shorebirds in recent decades, may be indicative of long-terms trends within the flyway and warrants more detailed analysis.

Another possible climatic effect is a decrease in reporting rate of several species with distributions centred on the uplands of south-eastern Australia. These trends are counter-intuitive given the protection of most alpine habitat and the adaptation of species like Flame Robins *(Petroica phoenicea)* and Gang-gang Cockatoos *(Callocephalon fimbriatum)* to agricultural and suburban landscapes during winter. Their apparent decline, therefore, may have been caused by a general increase in minimum temperatures in south-eastern Australia, a trend most likely to first affect species from the highest altitudes.

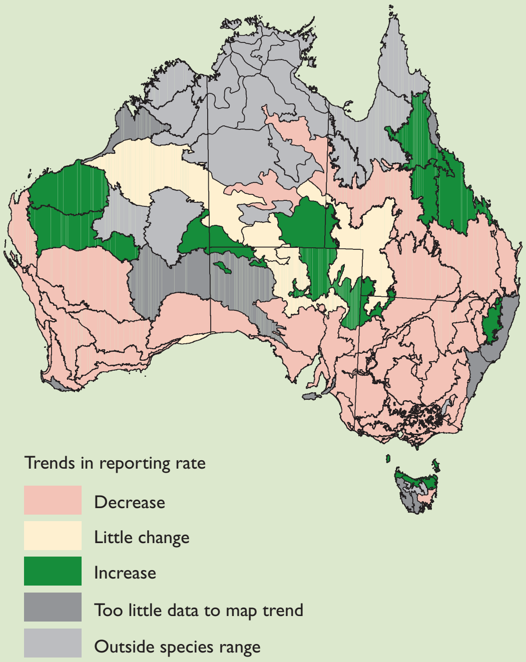


Figure 5.10 Trends in the reporting rate for Banded Lapwing *(Vanellus tricolor)* and its correlation with land use intensity between the first Atlas and the second Atlas

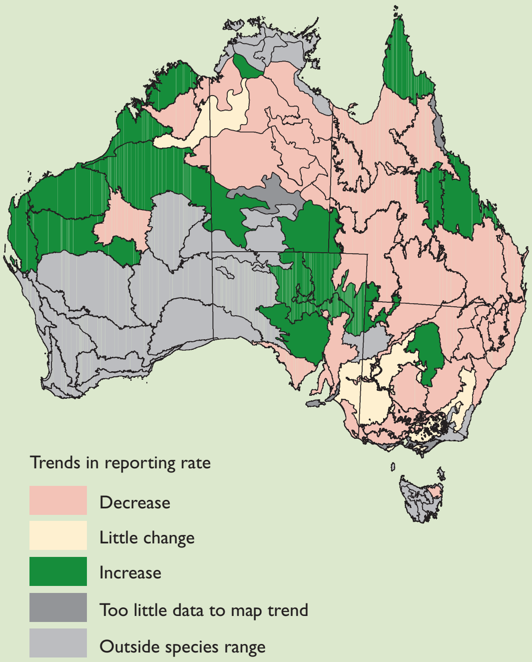


Figure 5.11 Trends in the reporting rate for Singing Bushlark *(Mirafra javanica)* and its correlation with land use intensity between the first Atlas and the second Atlas

Threatening Processes

In the agricultural regions of Australia, there is a range of responses to changes in type and intensity of land use. For 29 of the 495 species analysed, reporting rates decreased significantly with increased proportions of the landscape cleared. Overall, the clearing of land for agriculture appears to have had the greatest non-climatic influence on bird abundance in Australia. Some species have been lost as soon as habitat is destroyed, but others persist for decades in remnants. Species in the latter group will generally decline over time because of loss of habitat or lack of recruitment from other areas. These findings are consistent with the findings of Saunders & Ingram (1995) in south-western Australia and Robinson & Traill (1996) and Reid (1999) in south-eastern Australia who recorded major changes in the bird faunas of Australia's main agricultural regions.

In the case of grassland birds, the gradual effects of increases in land use intensity, including fragmentation, agricultural intensification, urbanisation and, possibly, an increase in introduced predators are all likely to have played a role in their decline. Land use intensification is also the most likely reason for the decline of ground-feeding insectivores and ground-nesting species, at least in south-eastern Australia.

Black-throated Finch, *Poephila cincta* (G. Chapman).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

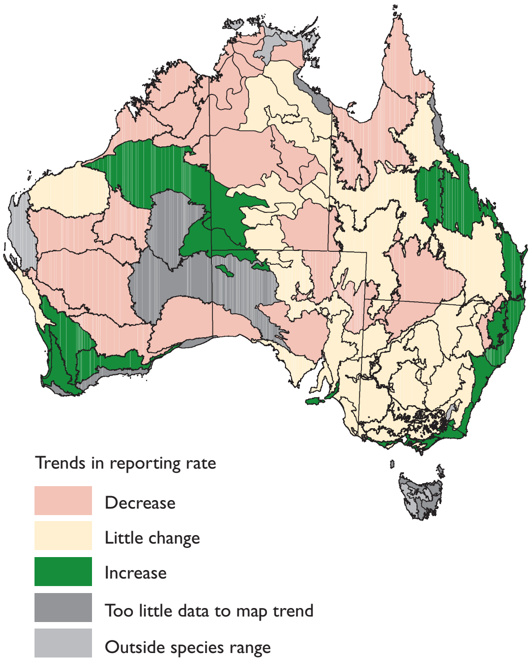


Figure 5.12 Trends in the reporting rate for Galah and its correlation with land use intensity between the first Atlas and the second Atlas

Twenty-six species showed a trend in reporting rate that responded negatively to decreases in landscape health (see Figure 5.10 for an example), a measure that includes abundance of feral animals and weeds as well as intensification of primary production. Sixty-one species had significantly lower reporting rates in the intensive land use zone compared to Australia's rangelands, with part of this relationship being explained by climatic differences between survey periods. Although the Atlas was not designed to determine trends in rare species, little correspondence was found between the areas of declining landscape health and the concentration of limited range species.

Two land use factors that vary within bioregions, and are therefore difficult to assess at a bioregional level, are rangeland grazing intensity and changed fire regimes. However, reporting rates of some grazing-sensitive species, such as Singing Bushlark *(Mirafra javanica)* (Figure 5.11) and Flock Bronzewing *(Phaps histrionica)* have declined, consistent with trends in grazing pressure on grasslands. Changes in fire regime (sometimes in association with intensification of pastoralism) have also been implicated in the decline of some species, particularly the granivores.

For a smaller suite of species, there was an increase in reporting rate with declining landscape health. Ten species increased with land clearance levels. Eleven species increased in regions with the worst continental stress class. Fifteen species also apparently fare better in the extensive use zone than in the intensive use zone. Many, like the Galah *(Cacatua roseicapilla)* had already expanded well into the agricultural areas at the time of the first Atlas (Blakers *et al.* 1984). By the time of the second Atlas, this movement towards the coast was complete (Figure 5.12). Other species, like Crested Pigeon *(Ocyphaps lophotes)* and Little Corella *(Cacatua sanguinea)*, still seem to be taking advantage of the change from woodland to fields of granivore food, although for others the links are less readily explained.

Flock Bronzewing, *Phaps histrionica* (G. Chapman).

Singing Bushlark, *Mirafra javanica* (G. Chapman).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

CONCLUSIONS

The analysis of Bird Atlas data has identified some important patterns in distribution and abundance of bird species and the factors that drive their condition and trend. For birds that range across the vast arid centre of Australia, climate is a key driver of their movements and abundance.

Centres of diversity, range restriction and rarity, lie along the perimeter of Australia, particularly in the east and south of the continent. These coincide with the main concentration of people in Australia and regions of intensive land use. Birds are responsive to the threats associated with these areas.

Many bird species appear to be sensitive to declining landscape health caused by broad-scale vegetation clearance, urbanisation, intensified agriculture and feral predators.

Overall, the clearing of land for agriculture appears to have had the greatest non-climatic influence on bird species, which is reflected in the reduced abundance of a number of species in the agricultural regions of Australia. The most urgent actions identified by this and other studies are to end the clearing of native vegetation, impose more appropriate fire regimes (see also Woinarski & Recher 1997), control feral and native animals whose presence threaten native species, and restore functional ecosystems.

Purple-crowned Fairy-wren, *Malurus coronatus* (G.Chapman).

Plumed Whistling Ducks, *Dendrocygna eytoni* (QEPA).

Actions are not only required in the more intensively used regions of Australia. Even though human settlements are sparse in areas such as the tropical and sub-tropical savannas of northern Australia, and the intensity of pastoralism is relatively low, altered fire and grazing regimes have major impacts on bird species (Franklin 1999). These land use factors vary within bioregions, and were therefore difficult to assess at a bioregional level in this study.

This analysis highlights a number of species that appear unable to tolerate landscape modification for agriculture, particularly clearing. More detailed analysis of the results of the two Atlases, particularly subdivision of guilds into increaser and decreaser species, and finer-scaled spatial analysis of individual species within core habitat, would further define the effects of threatening processes and lead to better management of our biodiversity.

Golden-shouldered Parrot, *Psephotus chrysopterygius* (QEPA).

6. Mammals

Summary

Tammar Wallaby, *Macropus eugenii* (D. Watts)

SUMMARY

Australia has 305 indigenous terrestrial mammal species (excluding those found in the External Territories) and 26 exotic species. Of the 305 indigenous species, 85% are endemic to Australia.

There has been a massive contraction in the geographical ranges and species composition of Australia's indigenous mammal fauna over the last 100+ years. One third of the world's extinct mammals since 1600 AD are Australian. Such a record is unparalleled in any other component of Australia's biodiversity, or anywhere else in the world.

Significant decline is still occurring. The continuing contraction in the distribution of species means that further extinctions are likely.

Twenty-two species of mammals are extinct in Australia, with eight other species remaining only on islands. A further two, possibly three, species have become extinct on Christmas Island, an Australian External Territory: *Rattus macleari, Rattus nativitatis* and possibly the shrew *Crocidura attenuata.*

The key findings are:

- mammals persist best in high rainfall bioregions;
- arid and semi-arid areas have lost a high proportion of their mammals;
- critical weight range mammals are most susceptible to extinction; and
- bats – the only mammals that can fly – demonstrate lower levels of decline and extinction.

Several new insights have also been identified through this study. In particular, the belief that the Top End of the Northern Territory and the North Kimberley are refugia for a range of mammal species appears to be misleading, as these regions are also experiencing declines in mammal numbers.

The study identified which biroregions are most important for the conservation of species that have disappeared from most of their ranges. These are Carnarvon, Avon Wheatbelt, Jarrah Forest and Esperance Plains in Western Australia, Stony Plains in South Australia, and Channel Country, which straddles the South Australia – Queensland border. Some species now rely on a single bioregion for their persistence.

Cape York is a key region as it is relatively undeveloped and still retains a large number of species that have limited distributions.

The recent appearance of the European Red Fox in Tasmania is cause for major concern, as it could precipitate the extinction of species that are already in decline such as the Eastern Quoll, Eastern Barred Bandicoot, and the Tasmanian Bettong. Exotic Polynesian Rats and Ferrets are also considered to be at high risk of increasing their range to the detriment of the indigenous fauna.

While mammal decline is being addressed in some parts of Australia through detailed species and fauna recovery programs, many areas and many species are not the subject of effective recovery programs. Detailed survey data are lacking for several bioregions. Unless Australia provides more resources to mammal conservation and is willing to address the continuing extensive changes to mammal habitat, species will continue to be lost.

INTRODUCTION

The purpose of the mammal component of the Biodiversity Assessment was to review the trend in condition of a key part of Australia's biodiversity where dramatic change has occurred within a relatively short time frame. This may provide an insight into the likely future impact of current environmental modification on other taxa where there may be a longer extinction lag.

The project developed a national database showing the original distribution of Australia's terrestrial mammals and their current status by bioregion, and analysed the database to reveal centres of endemism and patterns of decline. An attempt was made to correlate the patterns of mammal decline with environmental changes and with life history and behavioural attributes of mammals.

The database compiled for this study was contributed by State and Territory conservation agencies. It incorporates all information available including Museum data and information gained from extensive sub-fossil research.

THE ASSESSMENT

The first stage of the assessment was to list all Australian terrestrial mammal species. The list included well-recognised undescribed species but excluded endemic species found on the External Territories and oceanic islands and marine species. A conservation status was allocated to each species for each bioregion based on where it occurred at the time of European settlement and its change in extent and population (Box 6.1). This information was used to calculate a number of indices related to number of endemic species (both past and present) and regional patterns of decline and extinction of terrestrial mammals. Four independent variables were used to analyse the patterns of decline: landscape stress (NLWRA 2001a) which is a measure of environmental change; long-term average rainfall; the mean adult body weight of species and the ability of indigenous mammal species to fly. Detailed information on the methods used can be found in the project report that underpins this chapter and is available on-line from the Australian Natural Resources Atlas.

Box 6.1 Conservation status allocated to each species for each bioregion it occurred in at European settlement

- Persists in greater than 50% of former range within region;
- Declined by 50-90% of former range within region;
- Severe decline: extant within region but declined by greater than 90% of former range within region (range equates to 'extent of occurrence', not 'area of occupancy' (IUCN 2000);
- Extinct in region: when there is no reasonable doubt that the last individual has died;
- Range naturally expanded/ing into region during historical times
- Persists in greater than 50% of former range within region, translocated population(s) established for greater than 10 years.
- Declined, translocated population(s) established
- Severe decline, translocated population(s) established
- Extinct in the past, translocated population(s) established

A species was shown as translocated if it has been established in the wild for more than 10 years and is self-maintaining. (Self-maintaining includes conservation dependent populations where the species may disappear unless conservation management, (eg. fox control, fencing), is maintained.

Plains Mouse, *Pseudomys australis* (H & J Beste).

Squirrel Glider, *Petaurus norfolcensis* (QEPA).

FINDINGS

Number of Species

Australia's 331 mammal species includes 305 indigenous and 26 exotic species. Given the ongoing revision of the taxonomy of Australian mammals, it is likely that new species will be identified in the future.

Australian Endemism

Eighty-five per cent of the species in this study (258 of 305) are endemic to Australia. The remaining 47 species also occur in Papua New Guinea and/or nearby islands. Thirty of the species shared between Australia and islands to its north are bats.

Richness of the Original Faunas

Figure 6.1 shows the relative richness of Australia's regional mammal faunas as best we can re-construct them from a combination of modern, historical and recent sub-fossil specimens. The mesic regions of northern and eastern Australia had the faunas with the highest number of species, while the regions with the lowest number of species fell into two classes:

1. Cool temperate regions of Tasmania and the south-western tip (Warren bioregion) of Western Australia that are the smallest in area of Australia's bioregions, but also lack the rich array of small dasyurids and rodents found in semi-arid, arid and tropical Australia.
2. Remote and sparsely-settled regions in which only localised mammal surveys have been undertaken, and from which museums have received relatively few opportunistic records (Gulf Plains, Desert Uplands and Mulga Lands of Queensland and Yalgoo of Western Australia, in particular). Caution is needed in interpreting the analysis outputs related to these four bioregions. For example, current records indicate that the Desert Uplands is at least 30% poorer than similar bioregions around it, with only 25 known species.

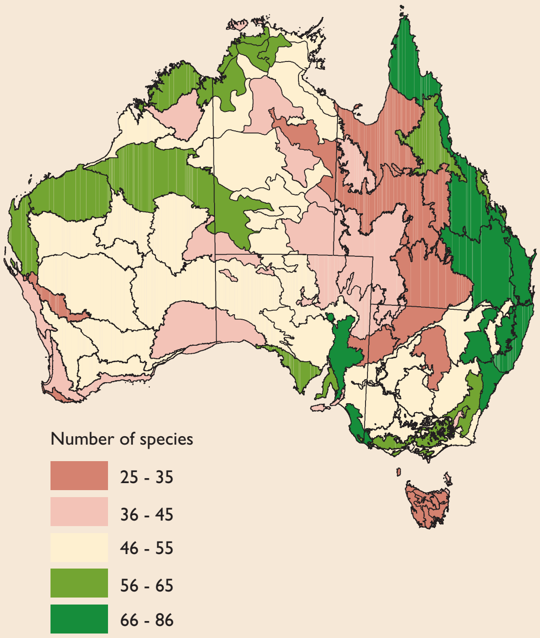


Figure 6.1 Species richness of the original mammal fauna in each bioregion.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Introduced Mammals

Twenty-six exotic species of mammals have established in the wild (Table 6.1). Dingoes *(Canis lupus dingo),* descendents of Asian wolves, are treated as an exotic species, having been introduced to Australia by humans about 4000 years ago. They have established in all 76 mainland bioregions. Some species are widespread, with *Felis catus* (Cat) occurring in all 85 bioregions, *Mus domesticus* (House Mouse) occurring in 76 bioregions, and *Vulpes vulpes* (European Red Fox) occurring in 60 bioregions. Others are highly restricted, for example *Funambulus pennantii* (Five-striped Palm Squirrel) occurs only in the Perth Metropolitan area near Perth Zoo. It previously occurred in Sydney suburbs near Taronga Park Zoo. *Rattus exulans* (Polynesian Rat) has been recorded only on islands of Australia's northern coastline (two bioregions), while *Mustela putorius* (Polecat; domesticated individuals are known as Ferrets) have established in four bioregions. Polynesian Rats and Polecats are at high risk of increasing their range to the detriment of the indigenous fauna. *Vulpes vulpes* (European Red Fox) is absent from tropical coastal and near-coastal regions of Australia and until very recently from Tasmania. These regions show the lowest levels of attrition of mammals.

Golden Bandicoot, *Isoodon auratus* (Pavel German).

Translocations

Nine species that were either regionally extinct or had very low numbers have been successfully translocated into 12 bioregions (Table 6.2). Many additional translocations have taken place in recent years (eg. Morris 2000) but have been established for less than 10 years.

Expanding Range

The range of three species was found to have naturally expanded into new regions during historical times: *Perameles gunnii* (Eastern Barred Bandicoot) has expanded into three Tasmanian bioregions (Ben Lomond, King and Tasmanian Southern Ranges), *Pteropus poliocephalus* (Grey-headed Flying Fox) has expanded into the Victorian South East Coastal Plain and *Rhinolophus megaphyllus* (Eastern Horseshoe Bat) has established in the Victorian Midlands bioregion. The expansion of the Eastern Barred Bandicoot can be attributed to land clearance opening up previously unsuitable habitat.

Faunal Change

Some species have contracted from more than 90% of the bioregions that they originally occupied (Figure 6.2). Regions whose faunas have been most susceptible to changes include: the arid and semi-arid regions of Northern Territory, South and Western Australia, particularly the desert and cereal crop regions.

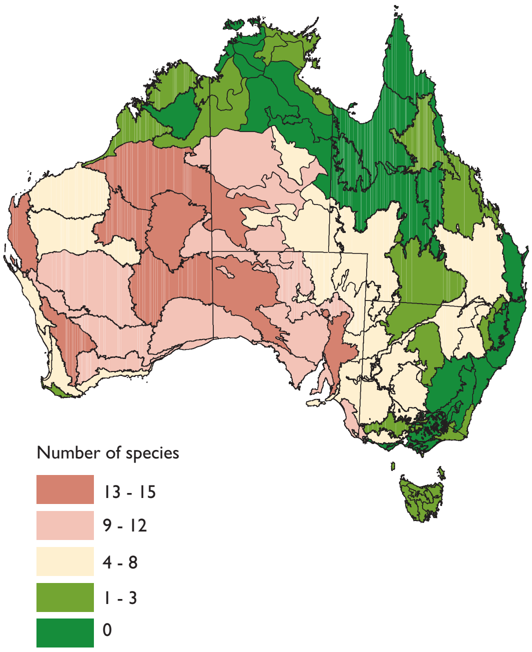


Figure 6.2 Range contraction: number of species in the pre-European fauna in each bioregion that have contracted from more than 90% of the bioregions that they originally occupied.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Table 6.1 Twenty-six exotic mammal species established in the wild and the number of bioregions affected.

SPECIES	NO. OF BIOREGIONS
RODENTIA	
Muridae	
Mus domesticus (House Mouse)	76
Rattus exulans (Polynesian Rat)	2
Rattus norvegicus (Brown Rat)	32
Rattus rattus (Black Rat, Ship Rat)	58
Sciuridae	
Funambulus pennantii (Five-striped Palm Squirrel)	1
CARNIVORA	
Canidae	
Canis lupus dingo (Dingo)	76
Vulpes vulpes (Red Fox)	60
Felidae	
Felis catus (Cat)	85
Mustelidae	
Mustela putorius furo (Ferret, Polecat)	4
LAGOMORPHA	
Leporidae	
Oryctolagus cuniculus (European Rabbit)	67
Lepus capensis (Brown Hare)	31
PERISSODACTYLA	
Equidae	
Equus caballus (Brumby, Horse)	59
Equus asinus (Donkey)	40
ARTIODACTYLA	
Suidae	
Sus scrofa (Pig)	51
Camelidae	
Camelus dromedarius (Dromedary, Camel)	21
Bovidae	
Bubalis bubalis (Water Buffalo)	13
Bos javanicus (Bali Banteng)	1
Bos taurus (European Cattle)	63
Capra hircus (Goat)	44
Ovis aries (Sheep)	48
Cervidae	
Dama dama (Fallow Deer)	21
Cervus elaphus (Red Deer)	16
Cervus timorensis (Rusa Deer)	15
Cervus unicolor (Sambar)	19
Axis axis (Chital)	2
Axis porcinus (Hog Deer)	3

Table 6.2 Successful translocations of Australian mammal species. Species are considered translocated if established in the wild for more than 10 years and self-maintaining.

SPECIES	BIOREGION WHERE TRANSLOCATED POPULATION(S) ESTABLISHED	FORMER STATUS IN REGION
Mrymecobius fasciatus (Numbat)	Jarrah Forest	extinct
	Avon Wheatbelt	declined
Isoodon obesulus (Southern Brown Bandicoot)	Avon Wheatbelt	severe decline
Macrotis lagotis (Bilby)	Eyre Yorke Block	extinct
Phascolarctos cinereus (Koala)	Naracoorte Coastal Plain	extinct
	South East Coastal Plain	severe decline
	South East Corner	severe decline
	Victorian Midlands	extinct
	Victorian Volcanic Plain	extinct
Pseudocheirus occidentalis (Western Ringtail Possum)	Swan Coastal Plain	severe decline
Bettongia penicillata (Brush-tailed Bettong)	Eyre Yorke Block	extinct
	Jarrah Forest	persists
Petrogale lateralis (Black-footed Rock-wallaby)	Avon Wheatbelt	severe decline
Petrogale rothschildi (Rothschild's Rock-wallaby)	Pilbara	persists
Leporillus conditor (Wopilkara,Greater Stick-nest Rat)	Eyre Yorke Block	severe decline
	Geraldton Sandplains	extinct


Proserpine Rock Wallaby *Petrogale persephone* (P.M. Johnson).

The species with major range contractions are hare wallabies, nail-tailed wallabies, rat kangaroos, Numbat, bandicoots and large rodents (*Notomys, Leporillus,* large *Pseudomys* and *Zyzomys*). All species had ranges centred on the continent's arid and semi-arid zone.

In general, bats and small mammals (<35g mean adult body weight) show little range contraction. High range contractions among species from Australia's medium to high rainfall bioregions were confined to *Conilurus albipes* (Paroo, White-footed Tree-rat), *Macropus greyi* (Toolache Wallaby), *Potorous platyops* (Broad-faced Potoroo) and the Basalt Plains Mouse, all of which had geographic ranges confined to regions that are now intensively settled or virtually cleared. *Thylacinus cynocephalus* (Thylacine) may be a special case, as it was a relatively large animal that became extinct in Tasmania, where it was selectively hunted (Smith 1981).

Figure 6.3 provides a comparison of levels of endemism at the time of European settlement and was derived by assessing the number of species

Rufous Hare Wallaby, *Lagorchestes hirsutus dorreae* (B. & B. Wells).

within each region's original mammal fauna that were confined to five or less of Australia's 85 bioregions. The highest number of species in this category were found in Cape York Peninsula and Wet Tropics. Many of these species have distributions that also occur outside of Australia, while other species show little or no range-contraction at region-to-region scales over the last 200 years.

To refine this view of regional values, a map showing bioregions with high relictual fauna value was derived (Figure 6.4). This identifies bioregions that have retained the greatest number of species that now occur in only a few regions (excluding translocated species). The bioregions with extant populations of the greatest number of these species (>5 species) are Carnarvon Basin, Avon Wheatbelt, Jarrah Forest and Esperance Plains in Western Australia, Stony Plains in South Australia, and the Channel Country, which straddles the South Australia – Queensland border. Ignoring translocations, some species rely entirely on a single bioregion for their persistence. These are:

- Carnarvon Basin (Western Australia): *Lagostrophus fasciatus, Lagorchestes hirsutus, Bettongia lesueur, Perameles bougainville* and *Pseudomys fieldi* (Barrow, Bernier and Dorre Islands);
- Jarrah Forest (Western Australia): *Potorous gilbertii* and *Myrmecobius fasciatus*;
- The Gulf Coastal Plain (Northern Territory) retains *Pseudantechinus mimulus* (Sir Edward Pellew Islands);

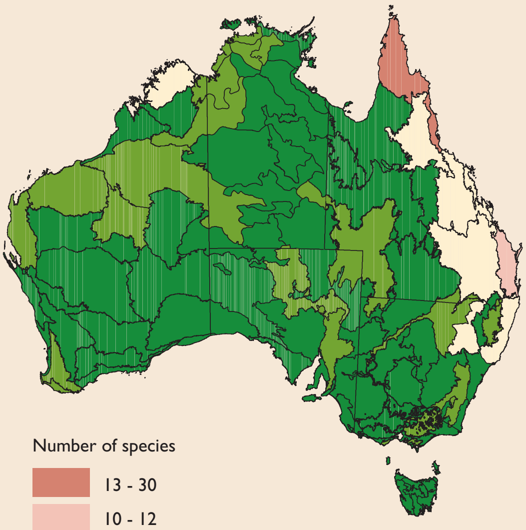


Figure 6.3 Endemism: number of species in each bioregion that were originally confined to five or less bioregions.

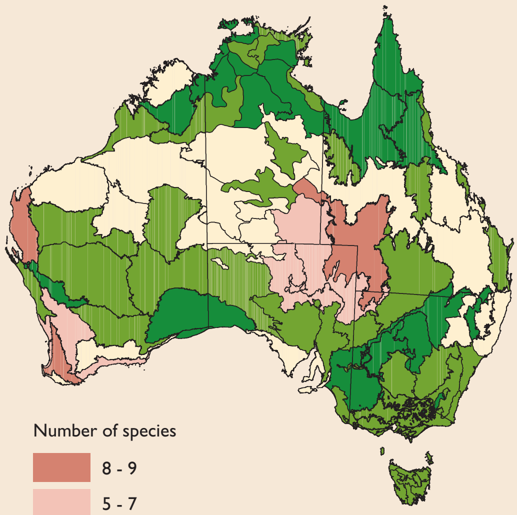


Figure 6.4 Bioregions of high relictual fauna value: number of species, ignoring translocated and extinct species, that are currently retained in each bioregion and have contracted from more than 50% of the bioregions they originally occupied.

Chapter 6

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

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- MacDonnell Ranges (Northern Territory): *Zyzomys pedunculatus*;
- Eyre Yorke Block (South Australia) *Leporillus conditor* (Franklin Island).
- Brigalow Belt North (Queensland): *Lasiorhinus krefftii* and *Onychogalea fraenata*
- Wet Tropics (Queensland): *Bettongia tropica*.

Islands are an important refuge for species that have contracted in their range (Burbidge 1999). The island of Tasmania (comprising nine small bioregions) is an important refuge for several species that have contracted in their range, including *Dasyurus viverrinus* (Eastern Quoll), *Bettongia gaimardi* (Tasmanian Bettong) and *Perameles gunnii* (Eastern Barred Bandicoot). The recent appearance of the European Red Fox in Tasmania is cause for concern as these species are susceptible to predation by the fox because of their body size.

Other species that have shown very significant contractions in their range, such as *Parantechinus apicalis* (Dibbler), *Bettongia penicillata* (Brush-tailed Bettong), *Notomys cervinus* (Ooarri, Fawn Hopping-mouse) and *Rattus* sp. (Central Queensland), now persist in only two bioregions.

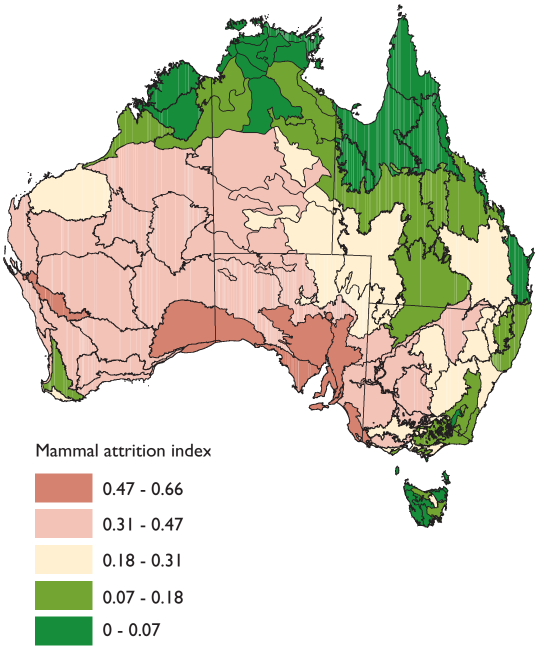

Figure 6.5 Attrition of Australia's regional mammal faunas. The numbers relate to the proportion of species in each bioregion that have disappeared from more than half the region (including locally extinct species).

Eastern barred-Bandicoot, *Perameles gunnii* (H. & A. Wapstra).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
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Bilby, *Macrotis lagotis* (QEPA).

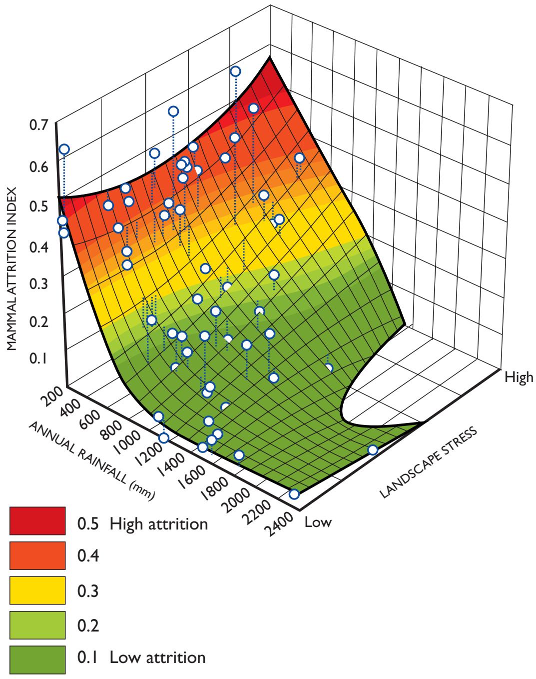


Figure 6.6 Scatter plot of mammal attrition index versus annual rainfall (mm) and landscape stress, with a contour surface fitted to data points.

The pattern of mammal attrition resembles rainfall patterns with higher levels of mammal decline in bioregions with lower annual rainfall (Figure 6.5). One visible modifier of this pattern is that the cereal-growing regions show higher-than-expected attrition indices.

Rainfall is closely related to the patterns of attrition in Australia's mammal fauna, with body weight, ability to fly and landscape stress (NLWRA 2001a) as significant interacting factors (Figure 6.6). 'Stress' in this context represents the cumulative effect of pastoral-use, changed fire regimes, vegetation clearance for cereal crops and related processes that impact on the soil A-horizon, coverage of indigenous plants, feral herbivores and predators, invasive weeds and salinity.

Stress explained around 12% of the variation in the data while 15% was explained by the body weights of the species comprising each region's fauna, and a further 15% was explained by the proportion of flying species in each region's fauna. Regional rainfall (herein used as an approximate surrogate of regional productivity) explained 39% of the variation. About 19% of the variation on the data was unexplained by the analyses.

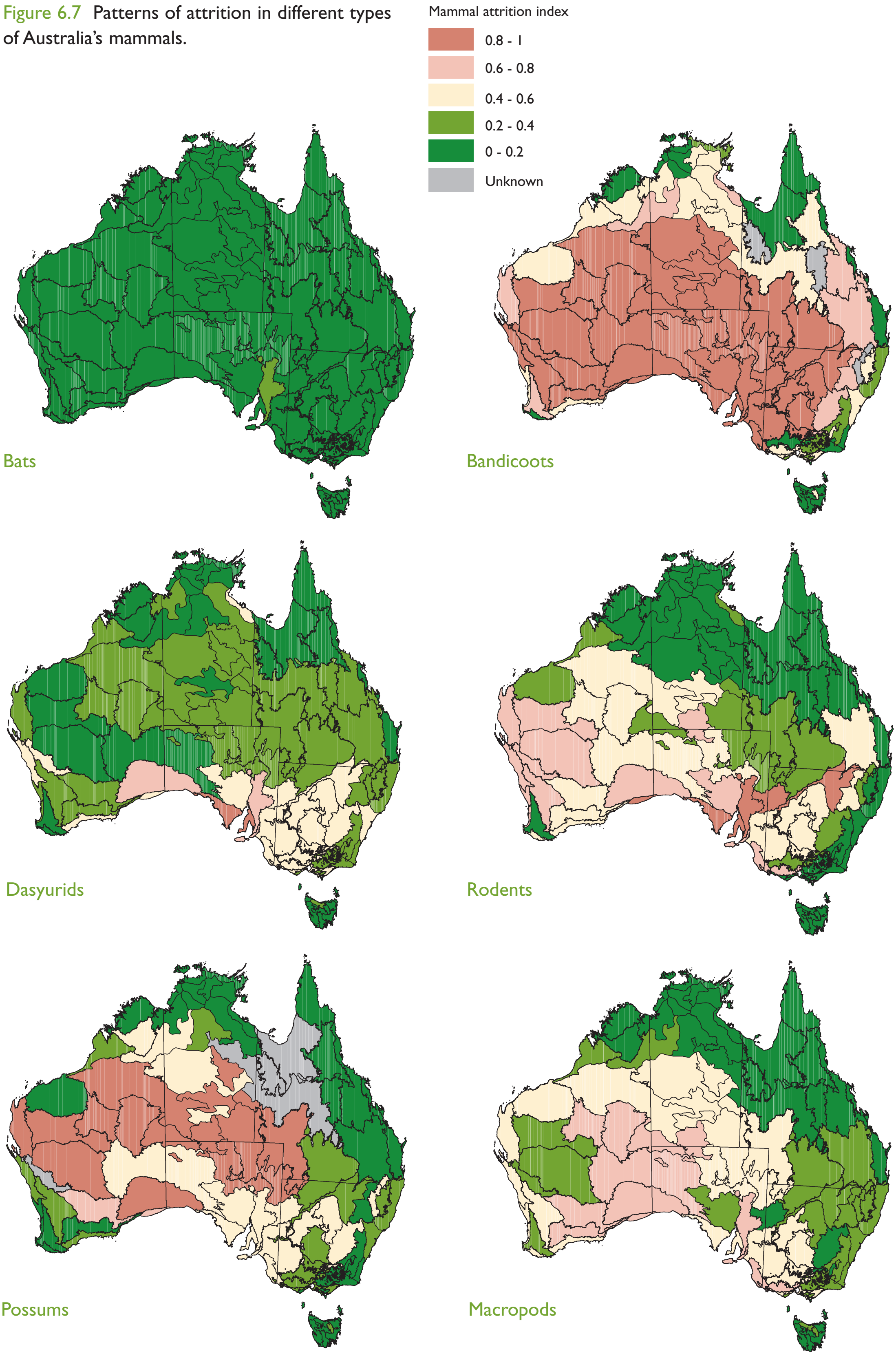
While body weight is considered to be a fundamental determinant of a species' ecology (e.g. Peters 1983), the inclusion of variables representing other biological characteristics would probably have accounted for more of the variation in the data.

In this study significant variation was accounted for by separating species into flying and non-flying foraging strategies. In an earlier study, significant variation was accounted for by separating species on whether they were confined to the ground's surface or not (e.g. arboreal, burrowing, rockpile-dweller), and whether they were carnivores/insectivores or omnivores/herbivores (Burbidge & McKenzie 1989).

The patterns of attrition for six different mammal taxa show some similarities (Figure 6.7). All taxa have persisted better on the high-rainfall margin of their former geographical ranges, but ground-dwellers such as bandicoots, most macropods, most rodents and most dasyurids show greater attrition than possums (mostly arboreal) and especially bats. The worst affected has been the bandicoots, although, when the large rodents were considered in isolation, similar patterns were evident.

Bats, which are the only mammals that fly, had the least attrition of all the taxa examined. There is a logical mechanism for this related to foraging efficiency in terms of energy cost per unit time (Calder 1984; Burbidge & McKenzie 1989).

Figure 6.7 Patterns of attrition in different types of Australia's mammals.



Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
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Table 6.3 Extinct Australian mammals and the number of bioregions they originally occupied.

EXTINCT AUSTRALIAN MAMMAL SPECIES	NUMBER OF BIOREGIONS FROM WHICH ORIGINALLY RECORDED
Thylacinus cynocephalus (Thylacine)	9 (Tasmania)
Perameles eremiana (Desert Bandicoot)	8
Chaeropus ecaudatus (Pig-footed Bandicoot)	21
Macrotis leucura (Lesser Bilby)	10
Bettongia pusilla (Nullarbor Dwarf Bettong)	3
Caloprymnus campestris (Desert Rat-kangaroo)	4
Potorous platyops (Broad-faced Potoroo)	9
Lagorchestes asomatus (Central Hare-wallaby)	5
Lagorchestes leporides (Eastern Hare-wallaby)	7
Macropus greyi (Toolache Wallaby)	2
Onychogalea lunata (Crescent Nailtail Wallaby)	19
Pteropus brunneus (Percy Island Flying-fox)	1
Conilurus albipes (Parroo, White-footed Tree-rat)	7
Leporillus apicalis (Djooyalpi, Lesser Stick-nest Rat)	25
Notomys amplus (Yoontoo, Short-tailed Hopping-mouse)	13
Notomys longicaudatus (Koolawa, Long-tailed Hopping-mouse)	20
Notomys macrotis (Noompa, Big-eared Hopping-mouse)	1
Notomys mordax (Payi, Darling Downs Hopping-mouse)	1
Notomys sp. (Great Hopping-mouse)	2
Pseudomys glaucus (Blue-grey Mouse)	1
Pseudomys gouldii (Koontin, Gould's Mouse)	6
Pseudomys sp. (Basalt Plains Mouse)	1

That is, in terms of the total area searched, flight is a far more energy efficient form of foraging than running on the ground.

Four variables explain 81% of the observed patterns in mammal decline and extinction in Australia. Variation in annual average rainfall between bioregions explained 39%, body weight and ability to fly each explained 15% and landscape stress explained 12%.

In general, these analyses confirmed the results of earlier studies (e.g. Burbidge & McKenzie 1989; Johnson, Burbidge & McKenzie 1989; Morton 1990; Short & Smith 1994; Smith & Quinn 1996; McKenzie, Hall & Muir 2000):

- mammals persist best in bioregions that receive high rainfall;
- arid and semi-arid areas have lost a high proportion of their mammals;
- Critical Weight Range mammals are most susceptible to extinction; and
- mammals that are unable to fly show a greater level of attrition than those that can (bats).

Ghost Bat, *Macroderma gigas* (QEPA).

Chapter 6

Table 6.4 Mammal species now extinct on the mainland but persisting on islands, ignoring translocations.

SPECIES NOW PERSISTING ONLY ON ISLANDS	BIOREGIONS IN WHICH ISLANDS OCCUR
Pseudantechinus mimulus (Carpentarian Antechinus)	Gulf Coastal
Perameles bougainville (Western Barred Bandicoot)	Carnarvon
Bettongia gaimardi (Tasmanian Bettong)	All Tasmania except King & Tasmanian West
Bettongia lesueur (Burrowing Bettong)	Carnarvon
Lagorchestes hirsutus (Rufous Hare-wallaby)	Carnarvon
Lagostrophus fasciatus (Banded Hare-wallaby)	Carnarvon
Leporillus conditor (Wopikara, Greater Stick-nest Rat)	Eyre Yorke Block
Pseudomys fieldi (Djoongari, Shark Bay Mouse)	Carnarvon

This study extended these hypotheses by demonstrating that landscape stress contributes to mammal decline - this is particularly evident in the cereal-growing, extensively cleared bioregions, such as Avon Wheatbelt (Western Australia) and Victorian Volcanic Plain.

The landscape stress attribute represents a number of distinct types of changes (cumulative effects of land-uses, exotic predators and herbivores, weeds, salinity, etc). In relation to mammal decline, more accurately-defined measures of environmental change are needed, in which these various disturbances are examined separately so that their different weightings in different bioregions can be taken into account. The Intensive and Extensive Land-use Zones used by the Landscape Health Assessment (NLWRA 2001a) could also be analysed separately, and the different components of landscape stress assessed individually.

These results also help put into perspective the impact of introduced mammals on indigenous species. Introduced mammals affect indigenous mammals by competing for resources, changing habitats or direct predation. In particular, foxes have been implicated in the decline of Critical Weight Range mammals (e.g. Kinnear, Onus & Bromilow 1988; Kinnear, Onus & Sumner 1998). However, wetter bioregions show lower attrition even if they have been colonised by foxes, and declines have been occurring in bioregions not colonised by foxes (eg. Central Kimberley). Furthermore, mammals were becoming extinct in the Carnarvon Basin of Western Australia's arid zone more than 20 years before foxes colonised that region (McKenzie *et al.* 2000). From a study in the Flinders Ranges of South Australia, Tunbridge (1991) reached a similar conclusion. This does not mean that foxes have not caused extinctions and that fox control is not necessary in order to conserve today's remnant populations—it means that other factors associated with land use have caused significant mammal declines and extinctions.

More of the variation in patterns of mammal decline and extinction may be accounted for if differences in species' habitats (eg. rock pile versus more fragile alluvial plains habitats) and diets (carnivore/insectivore versus omnivore/herbivore) are taken into account, as these attributes were shown to be significant for Western Australia by Burbidge & McKenzie (1989). Also, soil fertility and rainfall affect environmental resilience and carrying capacity, so a combination of these may provide a better measure of regional productivity than rainfall on its own.

Three key maps can be used to identify where strategic efforts for mammal conservation can be directed most effectively. Figure 6.5 shows the geographical pattern of attrition in terrestrial mammals, while Figure 6.2 shows the regional mammal faunas most affected. Figure 6.4 shows bioregions with the greatest number of relictual populations following range contraction. These figures identify the important bioregions for the conservation of threatened mammals.

CONCLUSIONS

Conclusion 1

There has been a significant contraction in the geographical ranges and species composition of Australia's indigenous mammal fauna. This is unparalleled in any other component of Australia's biodiversity, or anywhere else in the world.

This study confirms that Australia's terrestrial mammal fauna is particularly susceptible to declines and extinction. One third of the world's extinct mammals since 1600 AD are Australian (Baillie 1996). Twenty-two species of mammals are extinct in Australia (excluding External Territories) (Table 6.3), with eight other species remaining only on islands (Table 6.4). A further two, possibly three, species have become extinct on Christmas Island (Indian Ocean): *Rattus macleari, Rattus nativitatis* and possibly the shrew *Crocidura attenuata.*

Conclusion 2

Evidence suggests that the wave of mammal extinctions in Australia is continuing.

During the last two decades, all ground-dwelling Critical Weight Range mammal records in the North Kimberley have come from only the north-western fringe of the region, less than 20 km from its coast. Over the last 30 years this region has suffered significant changes in vegetation composition and structure due to increased fire frequency and the recent arrival of large exotic herbivores that have now penetrated to the coast. Recent trends indicate that with current land use some of the region's mammals will become extinct, while others will persist only on islands. Similar recent declines are evident elsewhere in Australia, for example *Myrmecobius fasciatus* (Numbat) and *Dasyurus geoffroii* (Western Quoll) have disappeared from the Avon Wheatbelt during the last 25 years.

The Top End of the Northern Territory and the North Kimberley have been considered to be refugia for a range of mammal species— based on this and other studies, this belief appears to be misleading. Woinarski *et al.* (2001) documented recent major declines in abundance of a variety of mammal species in the mesic regions of the Northern Territory and equivalent changes have been observed in the North Kimberley.

Addressing some of the threats in these regions could be more cost effective than for more intensively utilised bioregions, many of which require considerable human and financial resources. While mammal decline is being addressed in some parts of Australia through detailed species and fauna recovery programs, many areas and many species are not the subject of effective recovery programs. Detailed survey data are also lacking for several bioregions. Unless Australia provides more resources to mammal conservation and is willing to address the ongoing massive changes to mammal habitat, species will continue to be lost.

Spot-tailed Quoll, *Dasyurus maculatus* (QEPA).

7. Acacias and eucalypts

Summary

Rose Mallee, *Eucalyptus rhodantha*, is endemic to Western Australia and endangered (CSIRO)

SUMMARY

Analysis of the patterns of species richness, endemism and irreplacability of sites was undertaken for all species of *Acacia* and eucalypt (comprising the genera *Angophora, Corymbia* and *Eucalyptus).* This analysis used records held in Australian Herbaria.

For each subregion and bioregion of Australia, key attributes were collated:

- species richness (the total number of species);
- endemic species richness (the number of species that had more than 90% of all of their collection records in one region); and
- irreplacability (a measure of the degree to which the species in a region are represented in other regions).

Twenty-two bioregions have moderately high to high numbers of species (more than 150) of *Acacia* and eucalypt. There is a major centre of high species richness in the semi-arid south-west of Western Australia. Up to 222 species of *Acacia* and 160 species of eucalypt can be found in a single subregion. This includes the subregions of the Avon Wheatbelt, Mallee, Esperance Plains, Coolgardie and the Geraldton Sandplains bioregions.

The analysis reveals a number of other areas of significant diversity, including some desert bioregions of Western Australia (Murchison and Great Victoria Desert) and the Northern Territory (Tanami), and some of the bioregions of the tablelands and slopes of eastern Australia including Brigalow Belt South and the South Eastern Highlands.

Most subregions have some endemic species and a few subregions have high numbers of endemic species. For *Acacia* species, the subregions of high endemism are in the south-west of Western Australia (Avon Wheatbelt, Esperance Plains, Coolgardie and Mallee) and Northern Kimberley. For eucalypts, subregions with large numbers of endemic species also occur in the south-west of Western Australia (Coolgardie, Esperance Plains, Geraldton Sandplains, Mallee), in the Northern Kimberley, the Pilbara and the New South Wales North Coast.

Forty bioregions and 61 subregions have moderate to high irreplacability scores with concentrations occurring in the south-west of Western Australia, Great Victoria Desert, Pilbara, Kimberley area, and the coastal plains, ranges and western slopes of the Great Dividing Range from Cape York Peninsula to central Victoria.

The subregions and bioregions identified as important because of their endemic species and high irreplacability in south-west Western Australia and in the Murray-Darling Basin coincide with bioregions that are amongst the most extensively cleared, fragmented, and salinised in Australia based on the Landscape Health Assessment. This is of great concern for the on-going persistence of the *Acacia* and eucalypt species of special value in these regions and their associated ecological communities.

INTRODUCTION

Plants as a group are a significant component of the biological diversity of Australia. There are estimated to be 2,400 species of bryophytes (liverworts, hornworts and mosses), 2,500 species of lichens, and 15,000 species of flowering plants. About 80% of these are endemic to Australia. At the global scale, Australia has nine centres of species diversity, including two well-known regions of high plant diversity: south-west Western Australia and the Wet Tropics of north Queensland (Boden & Given 1995).

This assessment set out to more closely identify centres of species richness, endemism and irreplacability for *Acacia* and eucalypts. This analysis provides an example of flora biodiversity values that need to be fully recognised in conservation planning.

The Australia-wide analysis required plant groups that met the following criteria:

- comprehensively collected and studied across Australia;
- taxonomically resolved at species level;
- continent-wide distribution;
- consisting of large numbers of species; and
- available electronic database of records.

Only two major groups were able to fulfill these criteria - the acacias and eucalypts. These are two diverse groups of woody plants that are dominant in most Australian landscapes.

The results presented for acacias and eucalypts also provide reasonable surrogates for patterns in species richness for the communities of plants that are dominated by these woody sclerophyllous shrubs and trees. Changes recorded for the dominant plant species are likely to have major implications for many co-occurring species.

Mulga, *Acacia aneura,* and Western Bloodwood, *Eucalyptus terminalis,* woodland: Mulga Lands (P. Sattler).

THE ASSESSMENT

The analyses are based on the specimen records held by the major herbarium in each State or Territory of Australia. After extensive filtering of the herbarium records to remove duplicate, incorrect or imprecise records, data consisted of 95,685 records of 1,095 taxa of *Acacia* and 108,782 records of 1,090 taxa of eucalypt (comprising the genera *Angophora, Corymbia* and *Eucalyptus*).

The specimen point source location information was used to generate lists of species for each subregion to determine what proportion of all records of species occurred in particular subregions. This then allowed the following variables to be calculated:

- Species richness of each plant group in a subregion and bioregion.
- An Endemicity Score for each species in a subregion, using the proportion of all records for a species that came from a particular subregion.
- An Endemicity Index for a subregion, calculated as the sum of the squared endemicity values for each species in a subregion. The more species that are endemic (restricted) to a subregion, the higher the Endemicity Index for that subregion.
- An Irreplacability Score for a species in a subregion was calculated following Ferrier *et al.* (2000). A value from near 0 to 1 indicates how

significant that subregion is for the species. If a species is found in only one subregion (i.e., it is endemic to that subregion) the irreplacability score is 1 because it can be found nowhere else, hence, the population of the species in that subregion is irreplaceable.

- An Irreplacability Index for a subregion, which sums the irreplacability scores for species, was calculated following Ferrier *et al.* (2000).

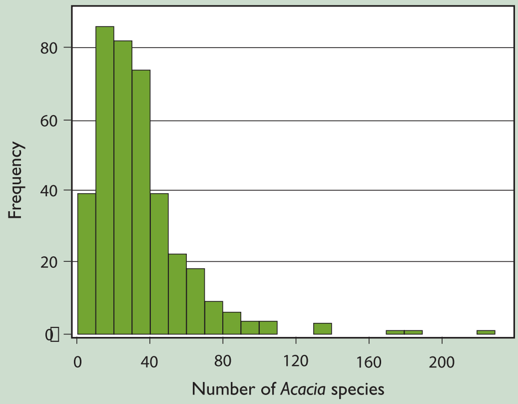
The more species in a subregion that have restricted geographic ranges, that is, occur in one or a few subregions, the higher the Irreplacability Index for that subregion.

- Landscape stress classes from the Landscape Health Assessment (NLWRA 2001a) were used for those subregions with high irreplacability indices to determine key threatening processes.

FINDINGS

Species Richness and Endemicity

Subregions of Australia support up to 222 species of *Acacia* and up to 160 species of eucalypt, with an average of 34 species of *Acacia* and 32 species of eucalypt per subregion, respectively (Figure 7.1). More than 80% of subregions have less than 50 species while a few subregions have 2 to 3 times this number.



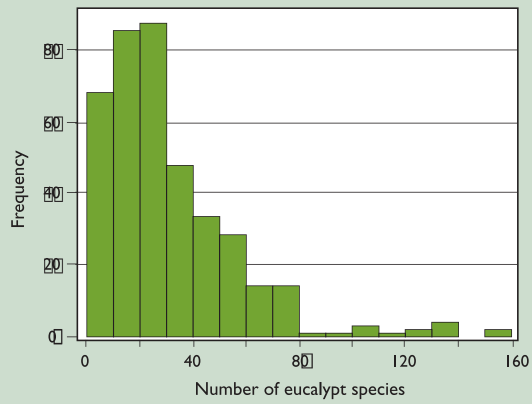


Figure 7.1 Frequencies of species richness values for all subregions.

Spatial patterns of species richness in subregions indicate similarities between acacias and eucalypts (Figure 7.2). There is a major centre of high species richness in the semi-arid south-west of Western Australia where up to 222 species of *Acacia* and 160 species of eucalypt are in a single subregion. This incorporates the subregions of the Avon Wheatbelt, Mallee, Esperance Plains and Coolgardie bioregions, for both groups, the Geraldton Sandplains for *Acacia*, and the Murchison subregion for eucalypts. Moderately species-rich bioregions occur throughout Western Australia, in the Kimberley, Arnhemland, Barkley Tableland, and the sub-tropical humid and temperate sub-coastal areas of eastern Australia.

When the species richness of acacias and eucalypts is combined (Figure 7.2) some of the centres of diversity coincide with those identified in other studies. For instance, south-western Western Australia, the Kimberley, the Top End and the Border Ranges were identified by Boden & Given (1995) using a wide range of plant taxa.

Eucalyptus beardiana is endemic to Western Australia and restricted to a small area of sand plain north of Perth between Murchison River and Shark Bay (CSIRO).

Chapter 7

The analysis in this chapter, using just two plant groups, reveals a number of other areas of significant diversity. These include some desert bioregions of Western Australia (Murchison and Great Victoria Desert) and the Northern Territory (Tanami), and various bioregions of the tablelands and slopes of eastern Australia (e.g., Brigalow Belt South, South Eastern Highlands).

Species richness is one measure of conservation significance but it does not take into account the set of unique species found in each subregion. That is, a bioregion or subregion can harbour large numbers of species but these may be mostly of species that are widespread, common, and maybe of lesser conservation concern than rare, narrowly distributed or endemic species.

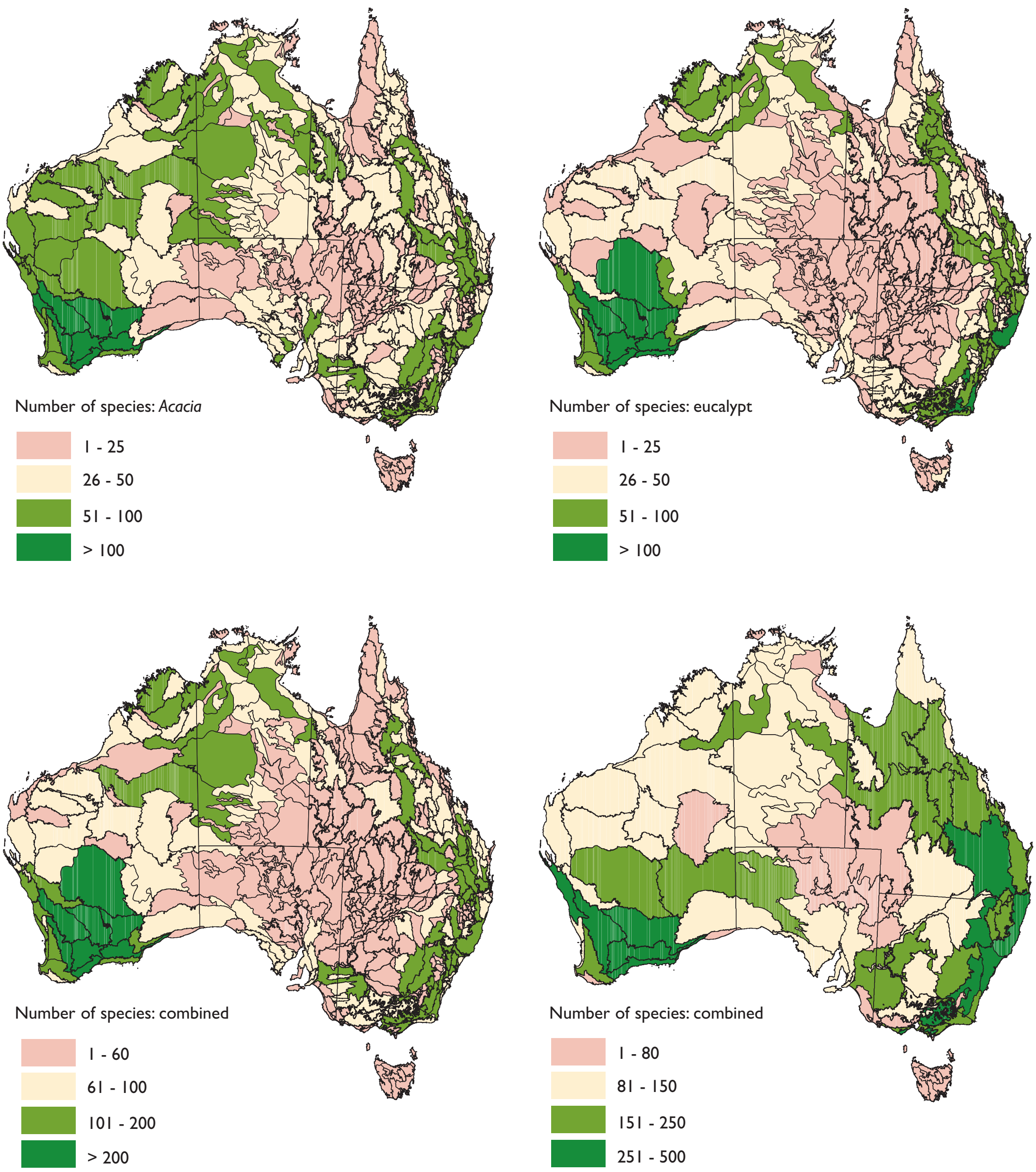


Figure 7.2 Species richness (clockwise from top left) of *Acacia* and eucalypt species occurring in each subregion, and combined species richness of acacias and eucalypts in bioregions and subregions.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database. Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Conversely, a modest number of species may be found in a subregion, but this may include unique species that are found nowhere else. Consequently, the subregion could be of relatively high biological and conservation significance.

The differences between subregions and bioregions that appear to be significant in Figure 7.2 illustrates this limitation. At the subregional scale, there are many locations in eastern Australia where a moderately rich flora of acacias and eucalypts are found, but none with very high numbers of species. However, when these species lists are aggregated to the bioregional scale, the overall species count for the bioregion is in the highest class of significance. This is because the subregions comprising a bioregion have each contributed some unique species to the bioregional total. For the purposes of this analysis it is more relevant to examine patterns of species distribution in relation to where endemic species occur, and particularly, to define where threats from land use coincide with endemic species as an insight to conservation management needs.

While there is a general trend for subregions with large numbers of species to also have large numbers of endemic species (Figure 7.3), there is variation in this relationship. Therefore species richness is not a reliable measure for predicting the number of endemic species in a region. It cannot be assumed that knowing the number of species in a bioregion or subregion will indicate the significance of that bioregion or subregion in terms of special biological features such as endemic species.

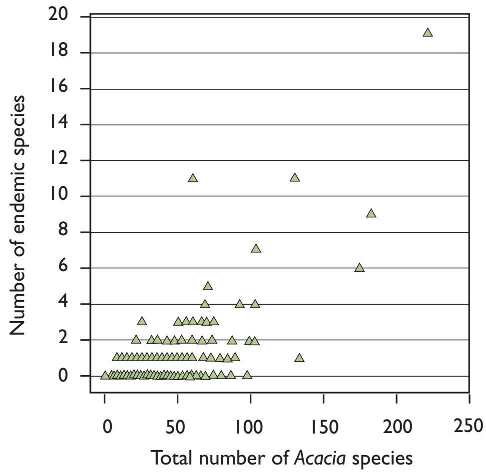
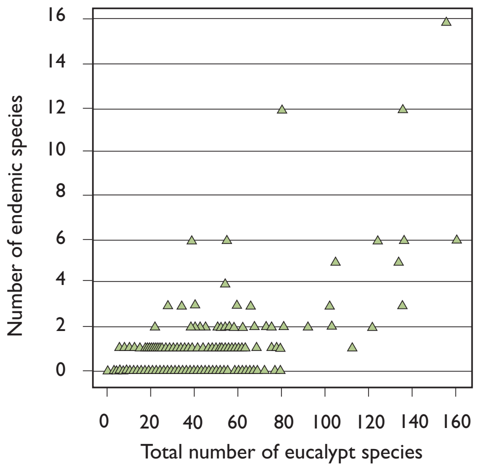


Figure 7.3 The number of endemic species in the subregion versus the total number of *Acacia* and eucalypt species in a subregion



Snow Gum, *Eucalyptus pauciflora,* is widespread from the edge of south-east of Queensland, through the Alps in New South Wales, the highlands of Victoria and central and north-eastern Tasmania (CSIRO).

Subregional and Bioregional Endemicity

Most subregions have only a few endemic species and a few subregions have high numbers of endemic species. For *Acacia* species, the subregions of high endemic richness are in the south-west of Western Australia (Avon Wheatbelt, Esperance Plains, Coolgardie and Mallee) and Northern Kimberley (Figure 7.4). For eucalypts, subregions with large numbers of endemic species also occur in the south-west of Western Australia (Coolgardie, Esperance Plains, Geraldton Sandplains, Mallee), in the Northern Kimberley, the Pilbara and the New South Wales North Coast.

Species richness and centres of endemism are two different measures of biodiversity and usually

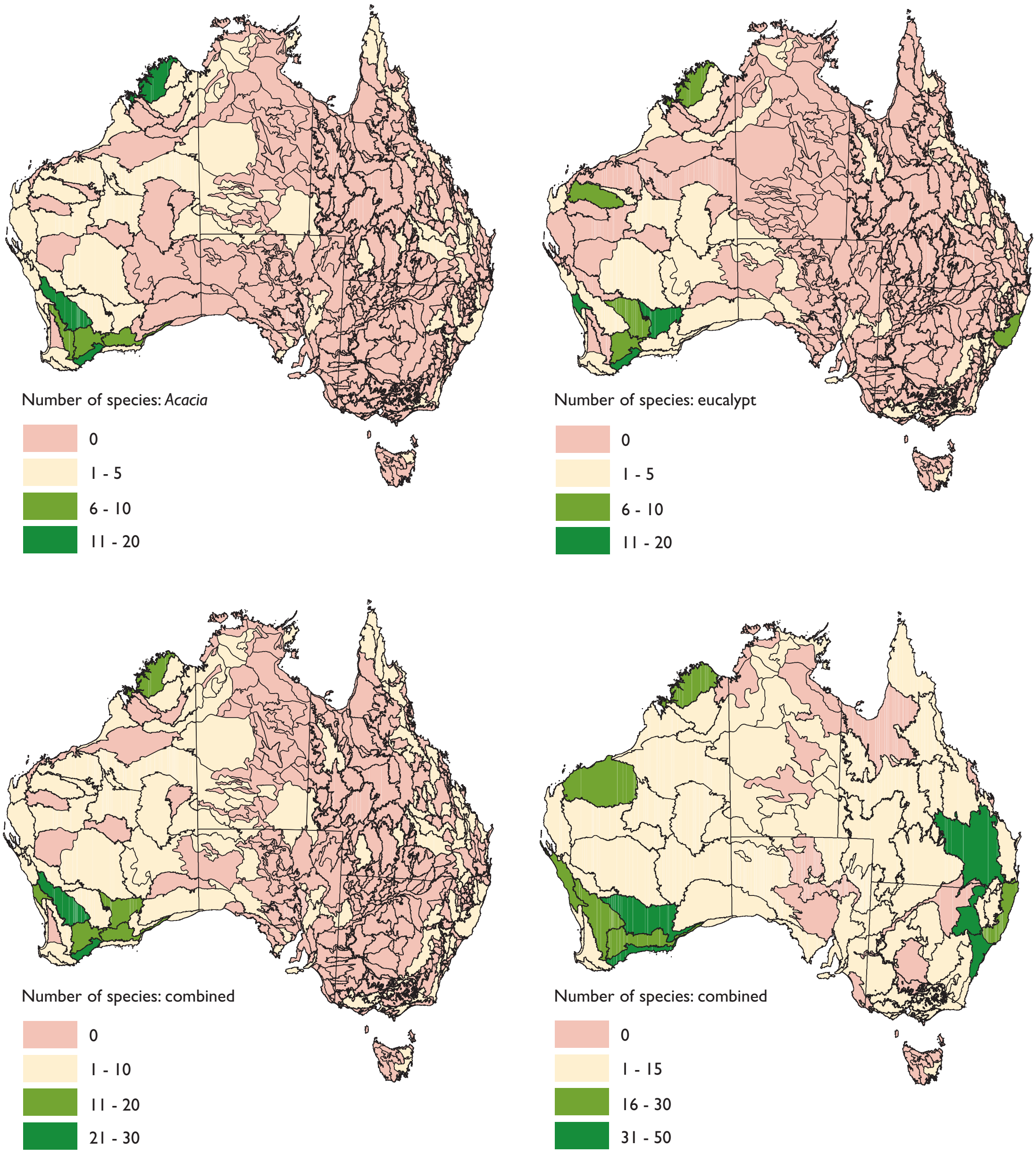
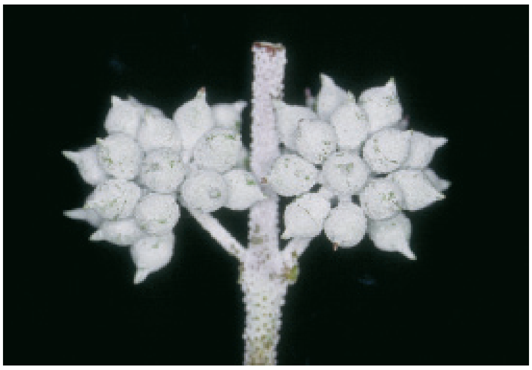


Figure 7.4 Numbers of endemic species (clockwise from top left) of *Acacia* and eucalypt species occurring in each subregion, and combined richness of endemic acacias and eucalypts in bioregions and subregions.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.



Eucalyptus crenulata, a rare small tree confined to swampy areas north and south of the Dividing Range, Victoria (CSIRO).

provide different levels of information. Comparing subregional data for *Acacia* and eucalypts shows that the centres of endemism occupy fewer adjacent subregions and are more restricted in area than the centres of species richness, although there is some overlap. This is to be expected since the number of species of restricted distribution is only a fraction of all the acacias and eucalypts in Australia.

The patterns of richness of endemic species for the combined *Acacia* and eucalypt data show that bioregions of high endemic richness are the Avon Wheatbelt, Esperance Plains, Coolgardie, Brigalow Belt South, and the Sydney Basin. Areas of moderately high endemic richness are the Geraldton Sandplains, Western Mallee, Pilbara, Northern Kimberley and New South Wales North Coast (Figure 7.4).

The number of endemic species in a subregion can be expressed by an index for endemicity. Bioregions and subregions that have higher values of this index have more species and more endemic species. By this method, those bioregions and subregions identified in Figure 7.4 remain highlighted and other bioregions and subregions emerge as significant (Figure 7.5 and Table 7.1) - the Jarrah Forests, Warren, Swan Coastal Plain, Carnarvon, Central Kimberley, Pine Creek, Arnhem Plateau, Cape York Peninsula, Einasleigh Uplands, Brigalow Belt North, South East Queensland, New England Tablelands, South East Coast and South Eastern Highlands, South East Coastal Plain, Victorian Midlands, Tasmania South East, Flinders Lofty Block, and Eyre Yorke Block. These bioregions are important because of the large numbers of endemic species they contain.

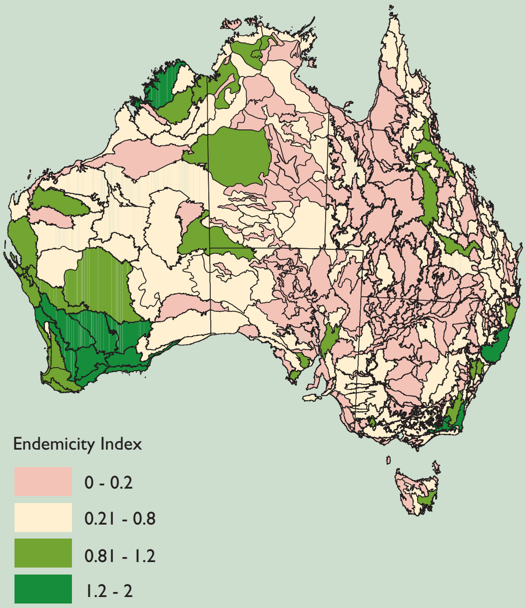
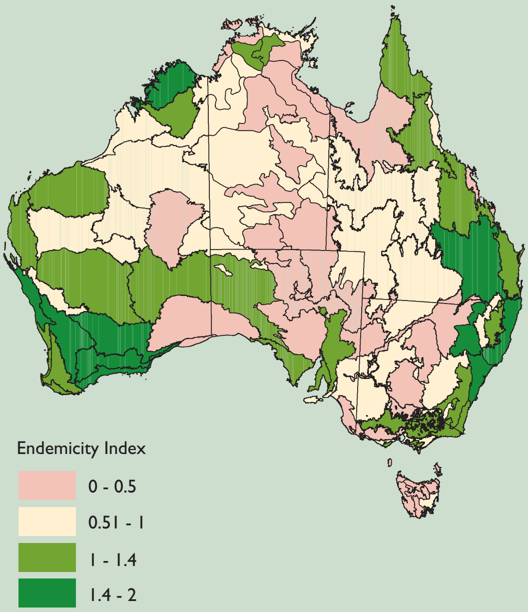


Figure 7.5 Endemicity Index for combined data of acacias and eucalypts in subregions (above) and bioregions (below).



Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
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Table 7.1 Summary and comparison of different metrics used to examine the patterns of species richness, endemism and irreplacability for *Acacia* and eucalypts in bioregions. Double stars indicate highest values for bioregions for the combined *Acacia* and eucalypt data; single stars indicate moderately high values.

BIOREGIONS	TOTAL NUMBER OF SPECIES	NUMBER OF ENDEMIC SPECIES	ENDEMICITY INDEX	IRREPLACABILITY INDEX
Arnhem Plateau			*	**
Avon Wheatbelt	**	*	**	**
Brigalow Belt North	*		*	**
Brigalow Belt South	**	**	**	**
Cape York Peninsula			*	**
Carnarvon			*	**
Central Kimberley			*	*
Central Ranges				*
Coolgardie	**	**	**	**
Dampierland				*
Desert Uplands	*			
Einasleigh Uplands	*		*	**
Esperance Plains	**	**	**	**
Eyre Yorke Block			*	**
Flinders Lofty Block			*	*
Gascoyne				*
Geraldton Sandplains	**		**	**
Great Victoria Desert	*			**
Gulf Plains	*			
Jarrah Forest			*	*
Little Sandy Desert				*
MacDonnell Ranges				*
Mallee	**	*	**	**
Mitchell Grass Downs	*			
Murchison	*		*	*
Murray Darling Depression	*			
Nandewar				*
New England Tableland	*			**
Northern Kimberley		*	**	**
N.S.W. North Coast	**	*	**	**
N.S.W. South Western Slopes	*			
Ord Victoria Plain	*			*
Pilbara		*	*	**
Pine Creek			*	*
South East Coastal Plain			*	*
South Eastern Highlands	**		*	**
South East Corner	*		*	**
South Eastern Queensland	*		*	**
Swan Coastal Plain			*	**
Sydney Basin	**			**
Tasmanian South East			*	*
Victorian Midlands			*	**
Warren			*	*
Wet Tropics				*
Yalgoo				*

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Red-flowering gum, *Eucalyptus ficifolia,* is restricted to an area south-east of Perth (CSIRO).

Irreplacability

Subregions with endemic species are important because they are the only places where these species are found. There are limitations with inferring conservation priorities from endemism. Importantly, endemicity is a scale-dependent attribute. For example, Figure 7.5 shows differences between areas of high endemism at the bioregional scale compared with the subregional scale. At the larger scales there will naturally be higher numbers of endemic species. To overcome this, an overall measure of irreplacability is assessed. This incorporates the significance of subregions in terms of both the number of species present and the proportion of those species that have restricted distributions.

The Irreplacability Index is a relative measure of the degree to which the species complement of a bioregion or subregion can be substituted for by another region or regions. Subregions with more endemic species will have a higher score of the index. Large numbers of species in a bioregion or subregion also contribute to a higher score. Both large numbers of species and the substitutability of the species are combined in the Irreplacability Index. This Index encapsulates both the importance of a location for irreplaceable species and for potentially high habitat diversity associated with large numbers of species.

Bioregions and subregions identified in Figures 7.4 and 7.5 all have a high Irreplacability Index. Additional subregions are highlighted (Figure 7.6, Table 7.1). For acacias, some subregions of the Murchison, Cape York Peninsula and the South East Corner become more prominent (Figures 7.4 and 7.6). For eucalypts, some subregions of the Murchison, Great Victoria Desert, Central Ranges, Ord Victoria Plain, Einasleigh Uplands, New South Wales South Western Slopes, and South East Corner become more prominent.

Comparison of the Irreplacability Index of the combined *Acacia* and eucalypt patterns at bioregional scale (Figure. 7.6) with the Endemicity Index (Figure. 7.5), shows that the same general patterns emerge (Table 7.1). The most significant bioregions are the Avon Wheatbelt, Esperance Plains, Coolgardie, Mallee, Geraldton Sandplains, Carnarvon, Pilbara, Northern Kimberley, Arnhem Plateau, Cape York Peninsula, Einasleigh Uplands, Brigalow Belt North, Brigalow Belt South, South Eastern Queensland, New South Wales North Coast, New England Tableland, Sydney Basin, South Eastern Highlands, Victorian Midlands, and the Eyre Yorke Block. Areas of moderately high irreplacability are the Jarrah Forest, Warren, Yalgoo, Murchison, Gascoyne, Little Sandy Desert, Central Ranges, MacDonnell Ranges, Dampierland, Central Kimberley, Ord Victoria Plain, Pine Creek, Wet Tropics, Nandewar, South East Coastal Plain, Tasmanian South East, and the Flinders Lofty Block.

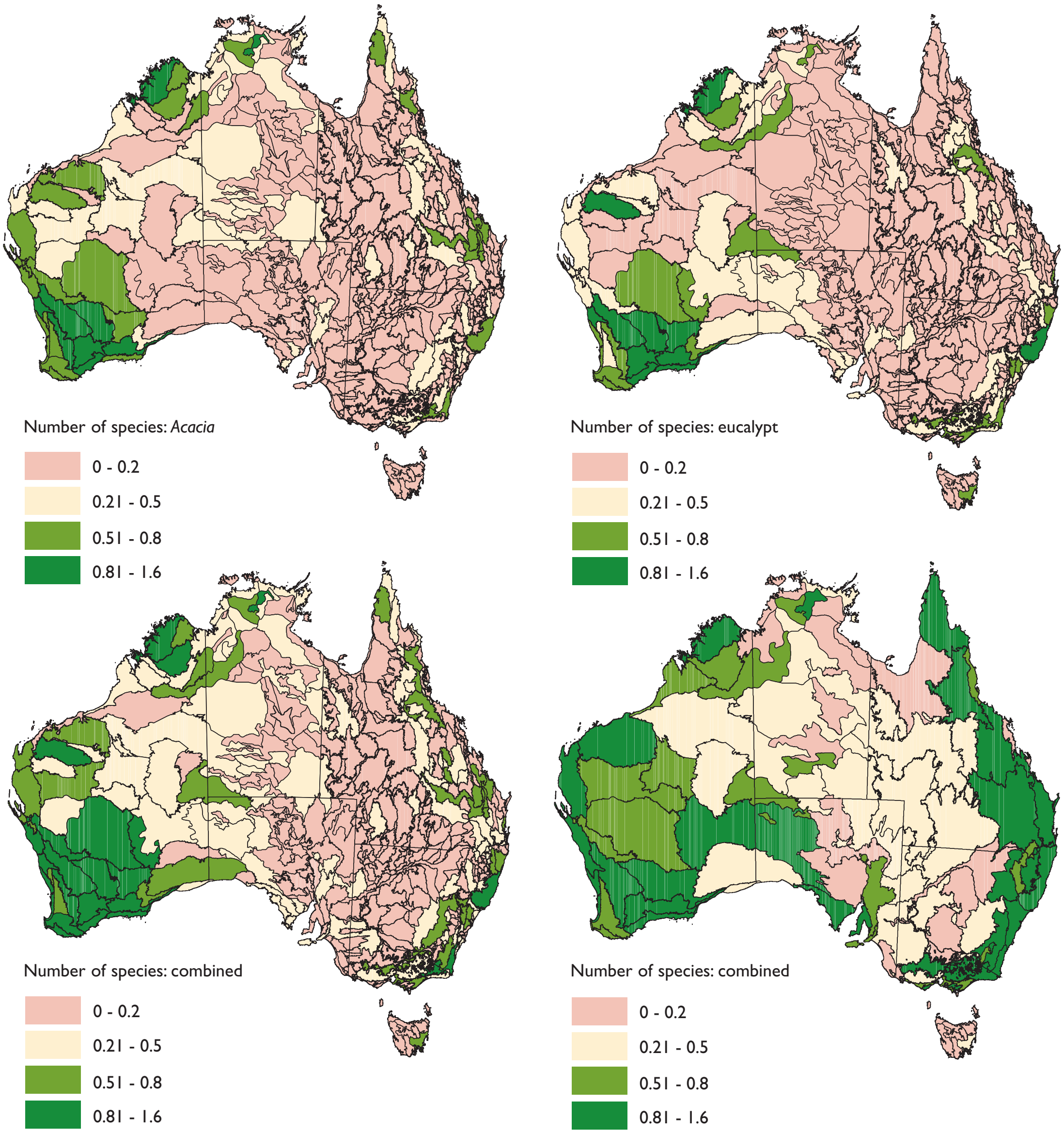


Figure 7.6 Irreplacability Indices (clockwise from top left) of *Acacia* and eucalypts in each subregion, and combined data of acacias and eucalypts in bioregions and subregions.

Condition and Trend of Bioregions and Subregions

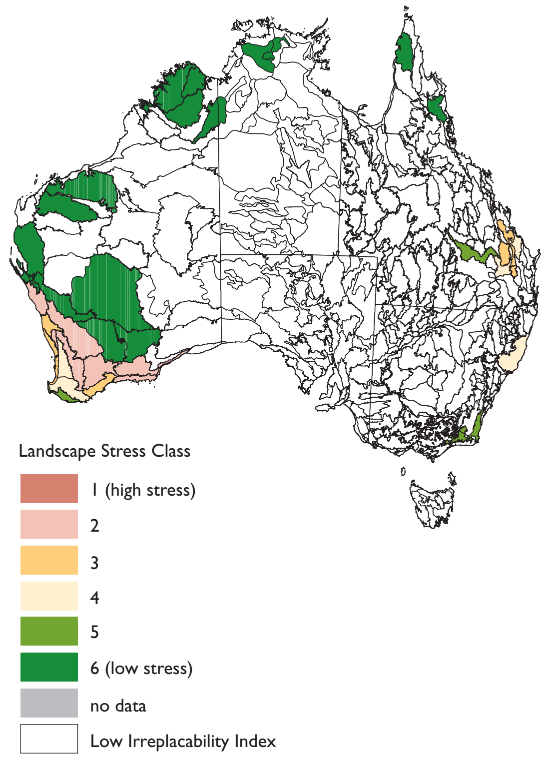
Subregions with high levels of endemism and irreplacability were examined in the context of the condition of their landscapes using the landscape stress classes developed by the Audit (NLWRA 2001a). This approach was used in lieu of an examination of condition and trend for each endemic species in a bioregion or subregion as this level of information is not yet available. Further assessment is required to link endemic species to ecosytems and identify the status, threatening processes and management needs for each ecosystem. The top two categories of the Irreplacability Index (greater than 0.5 in Figure 7.6) are shown with their stress class values in Figure 7.7.

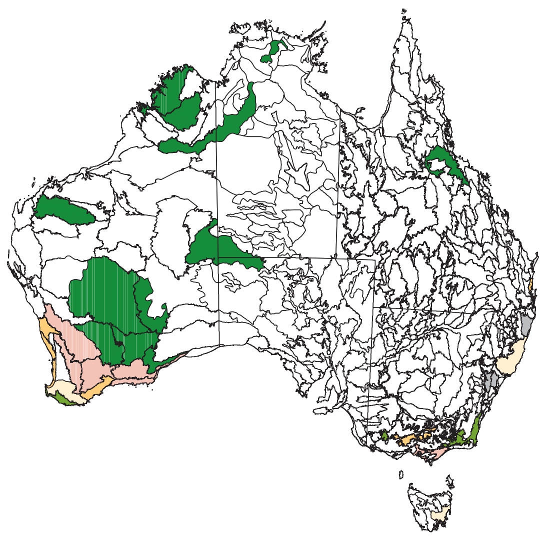
Many subregions of south-western Western Australia have a high level of irreplacability because they contain large numbers of *Acacia* and eucalypt species, and many endemic species of these taxa.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

This region is also amongst the most degraded in Australia. There is a general lack of data describing the population trends and conservation status of species in these subregions and bioregions. Nevertheless it seems likely that they would be under moderate to high threat because of the pressures from clearing and fragmentation of native vegetation, increases in salinity and other threatening processes. This deficiency in knowledge should be addressed to assist their conservation.

These bioregions and subregions are important for preserving the variety of *Acacia* and eucalypt species. Forty-two species of *Acacia* and 29 species of eucalypt occur only in these highly degraded bioregions and subregions in south-western Australia. Parts of the New South Wales South Western Slopes, Brigalow Belt North and South, and Victoria also have a moderate rating of irreplacability and species there are likely to be threatened when compared with the overall assessment of landscape health.





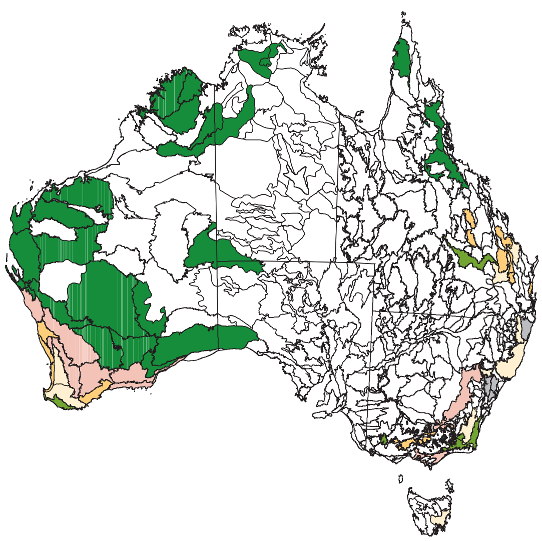


Figure 7.7 Subregions with Irreplacability Indices greater than 0.5 for acacias (top left) and eucalypts (top right), and for combined data of acacias and eucalypts (bottom) in subregions showing landscape stress classes.

Leafless rock wattle, *Acacia aphylla,* is listed as vulnerable and is endemic to south-west Western Australia near Perth (M. Fagg).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

CONCLUSIONS

This assessment using two key plant groups, reveals a number of areas of significant diversity in addition to the regions of high diversity for a broad range of plant groups recognised in previous studies.

It confirms that species with restricted ranges are not randomly distributed across the landscape, but are aggregated in bioregional centres (Figure 7.4). The most likely explanation for these patterns is that over evolutionary timescale, variable climatic regimes and changing geological and geomorphological systems result in events which fragment species distributions and initiate speciation processes.

The analysis shows that species-rich regions are only one indicator of conservation priorities. Because this measure does not indicate how species are distributed across the Australian landscape, indices of endemism and irreplacability have been used in this analysis to identify bioregions and subregions that are important for the restricted types of species they support.

Areas (or parts thereof) of south-west Western Australia, the Kimberley, the ranges in north-eastern New South Wales, south-eastern Queensland and the Sydney Sandstones were previously recognised as supporting significant numbers of endemic plants by Burbidge (1960) and more recently by Boden & Given (1995) and Crisp *et al.* (2001). The bioregions showing high levels of endemism for *Acacia* and eucalypts (Figure 7.5, Table 7.1) show some important differences from previous analyses.

Some bioregions that have not been recognised in the past, were found to support high species richness and endemicity of *Acacia* and eucalypts: the Pilbara, Carnarvon, Great Victoria Desert and

Eucalyptus erythrocorys occurs in subcoastal areas north of Perth (CSIRO).

Einasleigh Upland bioregions. The differences observed from previous analyses are most likely due to the wide range of plant taxa included in the datasets of the various analyses. Besides species of *Acacia* and eucalypt, rainforest taxa, rare and threatened species and other land cover groups have been included in the previous studies. The results of the current study also do not emphasise plant communities that are not dominated by *Acacia* or eucalypts, such as rainforests and heathlands. Hence, these results should not be seen as representing patterns for all Australian flora. Similar analyses should be repeated for other taxonomic groups as the information on these taxa becomes available.

Subregions of inland Australia that have high levels of irreplacability were found to have low landscape stress class values. This is not surprising as the stress class values are very strongly influenced by land clearing and fragmentation, primarily features of agricultural bioregions and subregions. In inland Australia, altered fire regimes and grazing by domestic stock are the primary variables driving species to the point of conservation concern, and these drivers of change are not fully delineated by stress class categories. Consequently, this analysis may understate the conservation issues occurring in inland Australia.

Indices of endemism and irreplacability have been used to identify bioregions and subregions that are significant for the numbers and types of *Acacia* and eucalypt species they support. These bioregions and subregions contain a complement of species that cannot be represented anywhere else on the continent and so are irreplaceable natural features.

Priorities for conservation need to also take into account the current status and threats to the species identified in this assessment. There is little specific information on the status and trends for acacias and eucalypts. This is also true for most other plant groups. Monitoring trends in key species and threatening processes in selected bioregions and subregions will build an understanding of the status of these elements of biodiversity at an Australia-wide scale, and greatly enhance the information required to support their conservation.

Sydney golden wattle, *Acacia longifolia,* occurs in eastern Australia (ANBG).

Gimlet, *Eucalyptus salubris,* is endemic to Western Australia (CSIRO).

8. Reserves

Summary

Cradle Mountain National Park (P. Sattler)

SUMMARY

Australia's protected areas are central to the conservation of biodiversity. As of June 2001, a total of 9.2% of the continent was in protected areas. Data on native ecosytems was only available for 68 of 85 bioregions and in these regions approximately 67% of the regional ecosystem diversity is protected by national parks and formal reserves (IUCN categories I – IV). An additional 5% of ecosystems occur in other protected areas that include covenants on private land (IUCN categories V – VI). Seventy-one subregions have no protected areas. These figures are a measure of the Comprehensiveness of the reserve system and demonstrate that the reserve system is incomplete or biased in terms of ecosystems reserved.

Analysis of the Comprehensiveness, Adequacy and Representativeness of protected areas and the degree of threatening processes suggests the following:

- 42 bioregions are of high priority to consolidate Australia's protected area system;
- 20 bioregions are of intermediate priority; and
- 23 bioregions are of lower priority.

The high priorities are predominantly more fertile lands, particularly in the semi-arid woodland, shrubland and grassland regions of Australia. At an ecosystem scale, 1500 ecosystems have been specifically identified as a priority for reservation.

The standard of protected area management is classed as fair for 53% of the 57 bioregions assessed. Whilst improved management is needed, there is not irretrievable resource degradation occurring in most protected areas. Systematic ecological monitoring of protected areas should be a component of enhanced management to improve management standards.

The status of biodiversity and extent of threatening processes detailed elsewhere in this report (particularly the large number of terrestrial ecosystems regarded as being threatened and the 57 subregions with less than 30% remnant vegetation) implies that there is an urgent need to implement a strategic plan for consolidating Australia's protected areas.

INTRODUCTION

The development of a Comprehensive, Adequate and Representative reserve system is the central strategy to conserve biodiversity in the *National Strategy for the Conservation of Australia's Biodiversity* (ANZECC 1996). To maintain ecosystem services and the conservation of the full range of biodiversity, reserves need to be complemented by ecologically sustainable management of other lands and waters. This chapter concentrates on the protected areas component of biodiversity conservation.

Protected areas such as nature reserves and national parks are cost-effective in terms of biodiversity conservation compared with the cost of maintaining biodiversity in developed landscapes (James *et al.* 1999). This is particularly relevant as large parts of Australia continue to become extensively modified.

The Commonwealth, State and Territory governments have successfully collaborated to expand protected areas in each State and Territory through a policy framework developed by ANZECC that is known as the National Reserve System. The goal of the National Reserve System is to establish a Comprehensive, Adequate and Representative system of protected areas.

More specifically, its priorities are to:

- sample all ecosystems identified at an appropriate regional scale;
- consider the requirements of rare and threatened species and ecosystems; and
- consider the conservation needs of special groups of organisms such as species with specialised habitat requirements (Environment Australia in prep.).

The biogeographic framework adopted for planning the expansion of the National Reserve System has been the Interim Biogeograhic Regionalisation of Australia (IBRA) (Thackway & Cresswell 1995). Since its inception, the regionalisation was updated and Version 5.1 developed. It now has 85 biogeographic regions or bioregions (Environment Australia 2000) and 384 subregions. Subregions represent a finer, more homogenous landscape unit that is closely associated with geomorphology and other environmental factors. Reservation across subregions provides a means of capturing any variation that might occur within ecosystems that have broad distributions.

Uluru – Kata Tjuta National Park protects one of Australia's icons (R. Lawson).

Previously, there has not been a quantitative assessment of the completeness of Australia's reserve system in terms of Comprehensiveness, Adequacy and Representativeness criteria. The only metric available was the macro-scale analysis of area reserved per bioregion and subregion together with additional contextual information derived from the extent of remnant vegetation using the Audit's Landscape Health Assessment data (Cummings & Hardy 2001). An earlier review, using the best available data at the time, was undertaken by Specht *et al.* (1974).

Comprehensiveness, Adequacy and Representativeness criteria in this assessment are defined as:

- Comprehensiveness: the degree to which ecosystems identified at an appropriate regional scale are captured in the reserve system across each bioregion. This is recorded as the percent reserved.
- Adequacy: the area (hectares and percent of the area of the bioregion) reserved in each bioregion, recognising that this does not address the complex issues of viability particularly for rare and threatened species and ecosystems, and other special organisms.
- Representativeness: the degree that the inherent variation within an ecosystem is reserved. This is assessed by the degree to which ecosystems are captured in protected areas across their geographic range as measured by their representation across subregions. This information is presented as a proportion of ecosystems that are represented across their whole subregional range (ie. 100% of their subregional range) and the proportion of regional ecosystems that are represented across 50% or more of their subregional range.

Cooloola National Park (P. Sattler).

THE ASSESSMENT

This assessment has provided a review of the Comprehensiveness of Australia's reserves. This includes both national parks and formal reserves (IUCN reserve categories I – IV) and other protected areas including covenants on private lands (IUCN reserve categories V – VI).

The priority ecosystems for reservation have been identified in each bioregion within the constraints of available information. These chiefly represent those unreserved or poorly reserved ecosystems (< 5% of their pre-European extent) that are also threatened or have special values.

Representativeness information is only available for some parts of Australia, as the coarse scale or inadequate mapping of vegetation or ecosystems does not allow for meaningful analysis within some subregions (eg. in northern South Australia) and in Tasmania subregions are not identified.

These criteria, together with the extent of threatening processes, have been used by the States and the Northern Territory to determine the priority bioregions for consolidating the National Reserve System and to assess the relative subregional priorities within each bioregion. This prioritisation builds upon an earlier analysis of the National Reserve System program priorities by Environment Australia (Cummings & Hardy 2001).

This prioritization, based on relative area reserved per bioregion, categorized:

- Priority 1 as <2% reserved
- Priority 2 as <5% reserved
- Priority 3 as <10% reserved
- Priority 4 as <15% reserved
- Priority 5 as >15% reserved

The priorities assigned to bioregions have been reviewed and increased if significant threatening processes exist or if the protected area system was biased in terms of Comprehensiveness, Adequacy or Representativeness criteria.

Reserve management is a critical factor for biodiversity conservation. In addition to the above gap analysis, the States and the Northern Territory, using the criteria shown in Figure 8.1, have assessed the standard of management of protected areas across bioregions.

i) Poor eg. high visitor impact and/or other threatening processes that are not managed and are leading to permanent resource degradation in a number of reserves.

ii) Fair eg. biodiversity values and or management issues are poorly identified; resource degradation is occurring, though retrievable.

iii) Good eg. major biodiversity issues effectively managed

iv) Very good eg. high proportion of reserves have management plans, ecological monitoring programs in place and key biodiversity issues are being addressed.

Figure 8.1 Management classes used to categorize the standard of protected area management across each bioregion.

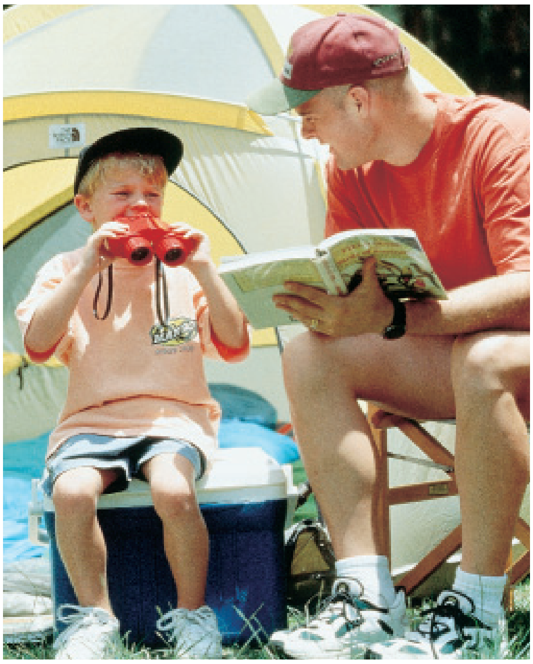
FINDINGS

Current Reservation Levels

Approximately 9.2% or 71,390,486 hectares of the Australian continent is gazetted as protected areas as at June 2001 (Figure 8.2). This includes 50,650,860 hectares (6.6 %) in IUCN reserves I – IV and 20,191, 011 hectares (2.6 %) in IUCN reserves V – VI. Information collated on protected areas in this assessment includes gazettals since the Collaborative Australian Protected Area Data Base (CAPAD) 2000 as well as private protected areas, such as South Australian heritage agreement areas that were not included in CAPAD 2000 (Hardy 2001).

The bioregional framework was used to assess the broad distribution of protected areas. Forty-six bioregions have less than 10% of their area in reserves, 16 bioregions have less than 2%, and two have no protected areas.

Only 67% of Australia's ecosystems are sampled within national parks and formal reserves. An additional 5% are sampled in other protected areas or protected by covenants on private lands.



Reserves are places to learn about nature (QEPA).

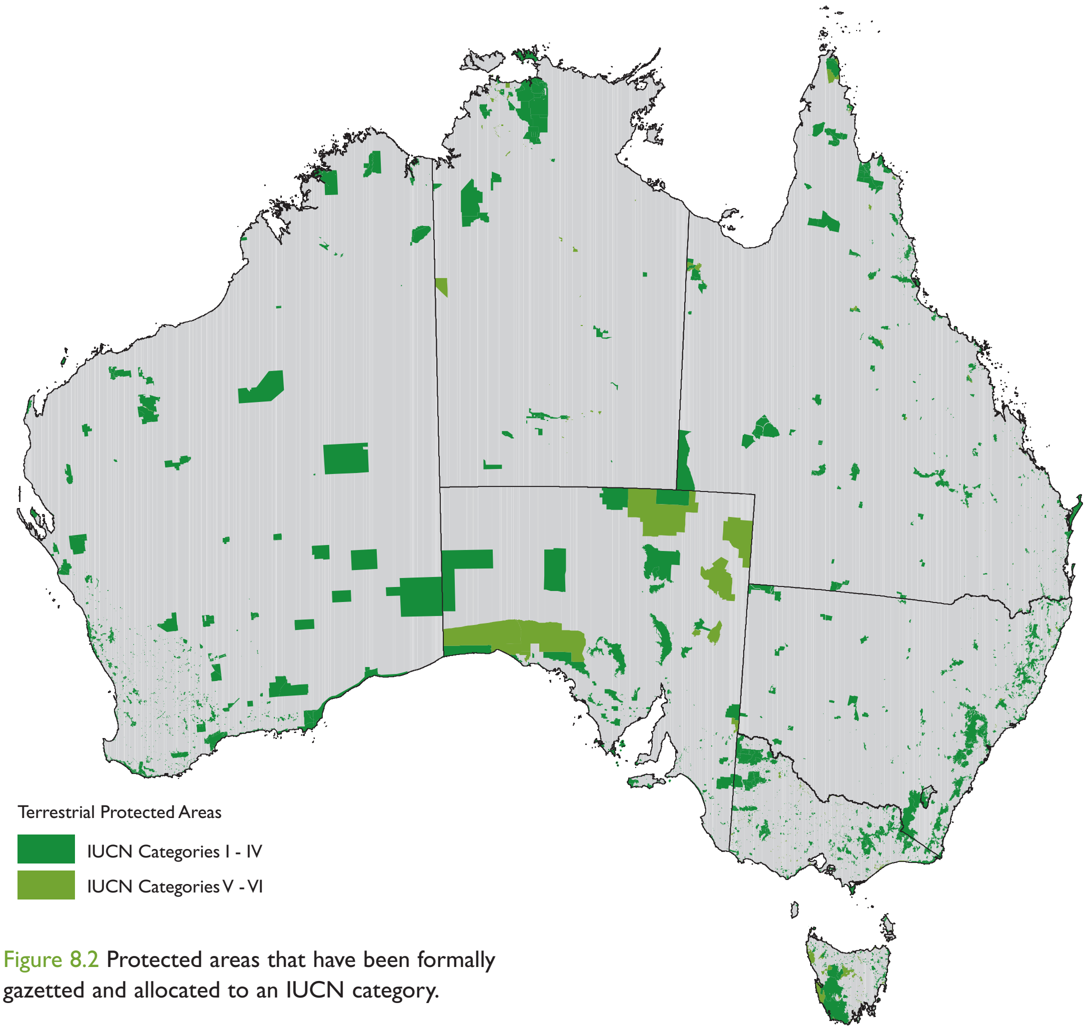


Figure 8.2 Protected areas that have been formally gazetted and allocated to an IUCN category.

This analysis of Comprehensiveness is constrained as it is based on an assessment of 68 of the 85 bioregions. Those bioregions not assessed contain a similiar proportion of reserved land but it can not be assessed how representative the protected area system is in these bioregions. The availability of only a broad scale description of ecosystems in many parts of the continent means that a finer classification is likely to show additional gaps and a more conservative estimate of Comprehensiveness.

Each State and the Northern Territory has determined the priority ecosystems in each bioregion for reservation. These amounted to over 1500 ecosystems Australia-wide requiring reservation. A number of these are identified at a broader scale than the ecosystems identified as threatened in Chapter 4.

Representativeness values are not available Australia-wide to ascertain the degree to which ecosystems are sampled across their subregional range.

In terms of a macro-scale analysis, 71 of the 384 subregions have no reserves. Specific information on Representativeness is available for some bioregions and this is presented on the Australian Natural Resources Atlas.

Lizard Island National Park (QEPA).

Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Setting Priorities for the Further Consolidation of Australia's Protected Areas

Figure 8.3 and Table 8.1 show the bioregional priorities for consolidating Australia's protected area system on a 1 to 5 priority scale (1 being the highest priority). Forty-two bioregions are poorly reserved (less than 5%) and/or are under significant threat leading to the irreversible loss of opportunities for a fully Comprehensive, Adequate and Representative reserve system (priorities 1 and 2). Twenty-one bioregions are identified as priority 3 where there is either some level of reservation (5 - 10%) or where the level of existing degradation or threatening processes are not yet as extensive as for priority 1 and 2. Twenty-three bioregions are classed as priority 4 or 5 where reasonable levels of reservation occur (>10%).

Within these bioregions, some subregions may have particular reservation needs owing to the disproportionate level of threat or the number of ecosystems or species requiring protection through reservation.

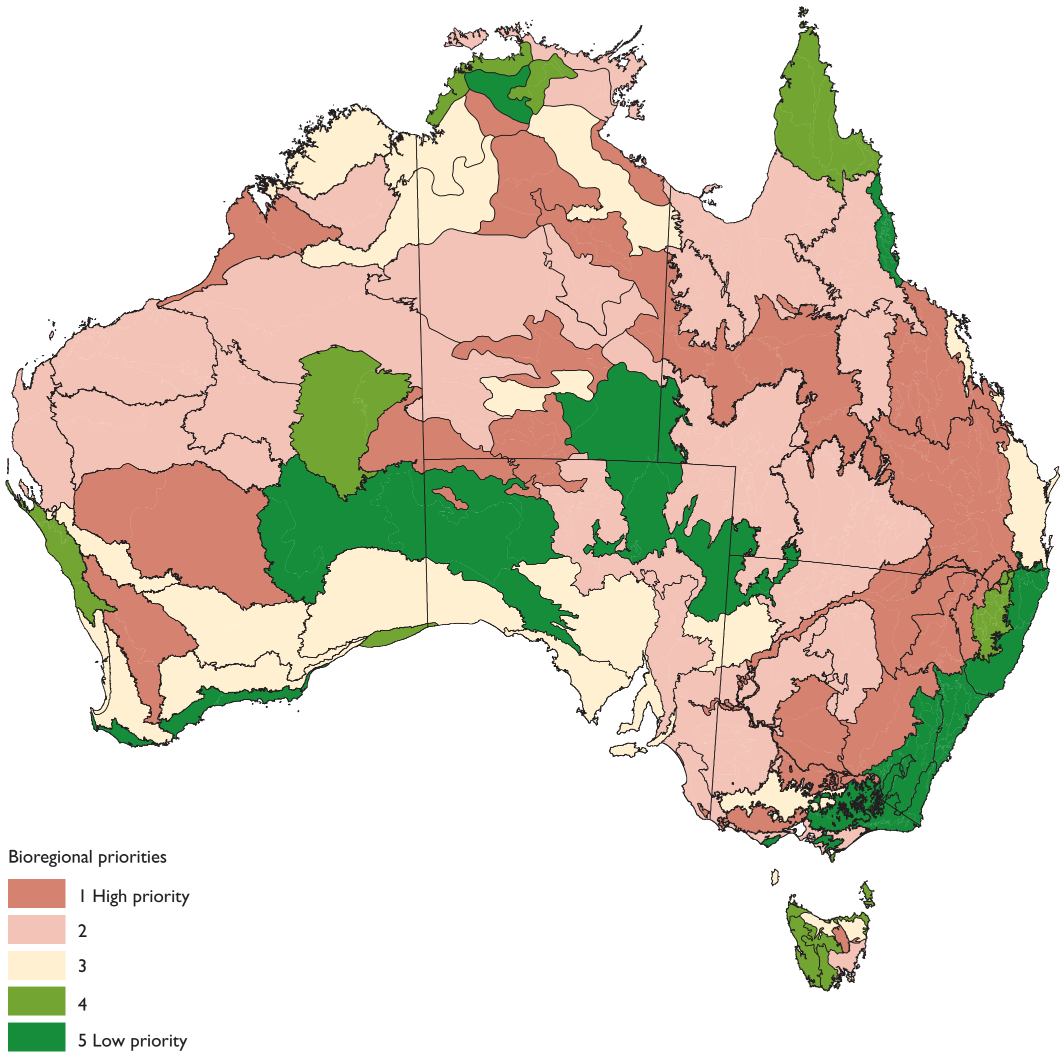


Figure 8.3 Bioregional priorities for consolidating Australia's protected area system.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Table 8.1 Bioregional priorities to consolidate Australia's protected area system.

Reservation Priority 1 (Highest)	Reservation Priority 2	Reservation Priority 3	Reservation Priority 4	Reservation Priority 5 (Lowest)
Avon Wheatbelt	Arnhem Coast	Ben Lomond	Arnhem Plateau	Australian Alps
Brigalow Belt North	Central Arnhem	Broken Hill Complex	Cape York Peninsula	Esperance Plains
Brigalow Belt South	Carnarvon	Central Mackay Coast	Darwin Coastal	Great Victoria Desert
Burt Plain	Channel Country	Coolgardie	Flinders	NSW North Coast
Central Ranges	Central Kimberley	Eyre Yorke Block	Gibson Desert	Pine Creek
Daly Basin	Cobar Peneplain	Gawler	Geraldton Sandplains	Sydney Basin
Dampierland	Desert Uplands	Gulf Fall and Uplands	Hampton	South East Corner
Darling Riverine Plains	Davenport Murchison Ranges	Jarrah Forest	New England Tableland	South Eastern Highlands
Finke	Einasleigh Uplands	Kanmantoo	Tasmanian Central Highlands	Simpson Strzelecki Dunefields
Gulf Coastal	Flinders Lofty Block	King	Tasmanian Southern Ranges	Warren
Mitchell Grass Downs	Gascoyne	MacDonnell Ranges	Tasmanian West	
Murchison	Great Sandy Desert	Mallee	Wet Tropics	
Nandewar	Gulf Plains	Northern Kimberley		
NSW South Western Slopes	Little Sandy Desert	Nullarbor		
Riverina	Murray Darling Depression	Ord Victoria Plain		
Sturt Plateau	Mount Isa Inlier	South Eastern Queensland		
Tasmanian Northern Midlands	Mulga Lands	Swan Coastal Plain		
Victorian Volcanic Plain	Naracoorte Coastal Plain	Tasmanian Northern Slopes		
	Pilbara	Victoria Bonaparte		
	South East Coastal Plain	Victorian Midlands		
	Stony Plains	Yalgoo		
	Tanami			
	Tiwi Cobourg			
	Tasmanian South East			

Figure 8.4 shows the subregional priorities which should be considered within their bioregional priority context. They are classed as high, medium and low priority.

An example is the Wet Tropics biroregion which is classed overall as having a bioregional priority of 4. This bioregion contains extensive national parks and the World Heritage Area occuring over the upland subregions. However, the limited reservation, number of threatened species and ecosystems and degree of threatening processes throughout the lowlands identity these subregions as high priority for expanded reservation compared with low priority for a number of the upland subregions. Additional reservation of lowland alluvial ecosystems also will contribute significantly to the protection of wetlands and fisheries.

In parts of Australia, the opportunity to implement a Comprehensive reserve system has been lost or is rapidly diminishing. An indication of this is given by the findings of the Landscape Health Assessment (NLWRA 2001a) which found that within the intensive land use zone 57 subregions (31%) had less than 30% remnant vegetation and in 88 subregions (48%), connectivity of vegetation remnants had broken down.

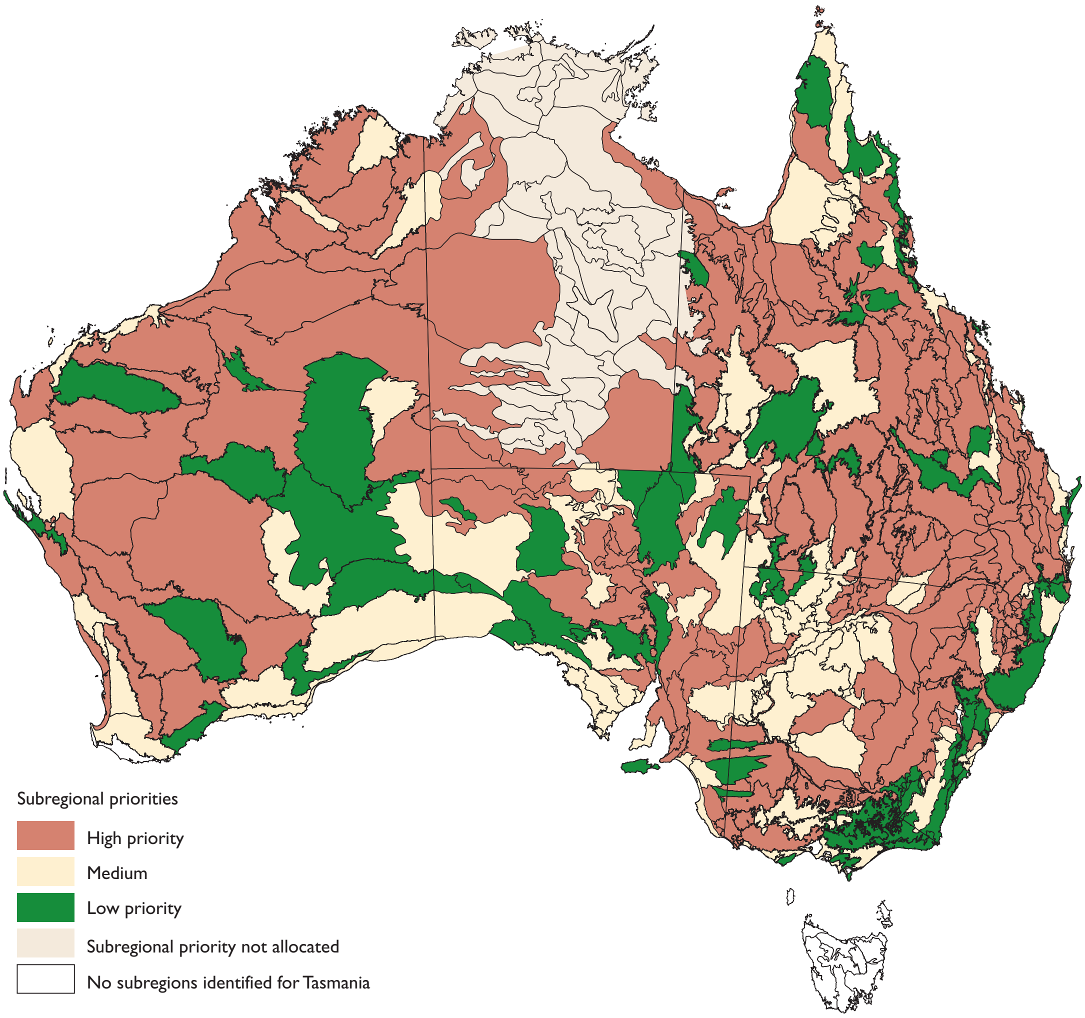


Figure 8.4 Subregional priorities within their bioregional context for consolidating Australia's protected area system.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Surveying for the acquistion of Welford National Park: Mulga Lands (P. Sattler).

Bioregional priority	1
Area of bioregion	26,926,569 ha
Comprehensiveness	54 %
Adequacy (I-VI)	2.8 %
Representativeness (all subregions)	27 %
Representativeness (>50% subregions)	39 %
Reserve management standard rank	Fair

Table 8.2 Comprehensiveness, Adequacy and Representativeness (CAR) of protected areas within the Brigalow Belt South bioregion and a ranking of reserve management standard. The bioregional priority for consolidating the protected area system is based on this CAR analysis and threat.

As an example of the assessment made for each bioregion, the Brigalow Belt South (extending across Queensland and New South Wales) has 2.8% of its area reserved (Table 8.2). In terms of Comprehensiveness, only 54% of its ecosystems are reserved. As an indication of Representativeness, 27% of its ecosystems are fully reserved across their subregional range with 39% reserved across half of their subregional range. This reflects that the largest areas reserved within the bioregion are located within only a few subregions on its northern extremity around the Carnarvon Range.

The limited area reserved, the bias in ecosystems sampled and the degree of threatening processes means that this region is classified as priority 1 for consolidation of the protected area system.

Regional priorities for reservation in this bioregion must now focus on those poorly reserved ecosystems associated with the clay and alluvial plains. Unfortunately, the extensive clearing of these fertile areas means that the opportunities for a fully Comprehensive, Adequate and Representative reserve system in this bioregion no longer exists.

An example of the detailed information on the priorities for reservation that is available on the Atlas is shown for the Gawler bioregion in South Australia. Table 8.3 shows the subregional and ecosystem priorities for reservation together with the constraints for reservation.

BIOREGIONAL PRIORITY	SUBREGION PRIORITIES	ECOSYSTEM PRIORITIES	ECOSYSTEM PRIORITY NOTES	CONSTRAINTS
4	GAW1 (medium) GAW2 (medium) GAW3 (low) GAW4 (high) GAW5 (high)	*Acacia aneura* Low Woodland on sand plains (SA0034)	Poorly conserved. Regeneration threatened by grazing	Competing land use
		Acacia calcicola Low Woodland on calcareous soils of breakaway tablelands (SA0036)	Threatened by camel and rabbit grazing. Occurrences few, small, thinly spread and widely scattered.	Competing land use
		Alectryon oleifolius spp. canescens Tall Shrubland on alluvial soils of plains (SA0040)	Very little regeneration occurring due to rabbit and stock grazing, and understorey severely degraded.	Competing land use

Table 8.3 Bioregional, subregional and ecosystem priorities to consolidate the protected area system and associated constraints: Gawler bioregion. Bioregional priorities are based on a scale of 1 to 5 (1 is the highest) and subregional priorities based on high, medium and low.

Reserve Management

Australia's national parks and other protected areas are its premier investment in biodiversity conservation. Adequate management of these areas (and adjoining lands) is essential. The assessment of protected area management standards (Table 8.4) has indicated that reserves across 12% of assessed bioregions have a very good standard of management where a high proportion of reserves have management plans and ecological monitoring programs in place. However, the standard of management of most of Australia's protected areas indicates that more can be done. In most bioregions (53%), the standard of management is only fair though any resource degradation is retrievable, and in 14% it is poor where permanent resource degradation is occurring. In 21% of bioregions reserve management is good and the major biodiversity issues are being addressed, though not necessarily in a structured context where systematic ecological monitoring programs are in place.

In Canada, the monitoring of parks' natural integrity is a legislated requirement. This represents a desirable precedent to ensure park management incorporates the protection of biodiversity values as part of the enhanced effort required to improve overall park management standards.

Management standard	Very good	Good	Fair	Poor
Number of bioregions	7 (12%)	12 (21%)	30 (53%)	8 (14%)

Table 8.4 Protected area management standards within Australia's bioregions (based on 67% of bioregions assessed).

Kosciuszko National Park (NSW NPWS)

CONCLUSIONS

The incompleteness of Australia's protected area system in reserving the full range of biota, as indicated by 42 bioregions being of high priority (priorities 1 and 2) for reservation and Comprehensiveness assessed at 67% for IUCN reserves I – IV, means that a major commitment is required to consolidate the reserve system. Such action should build on the work of the successful National Reserve System initiative and other efforts to achieve secure protective status on private lands. Additional effort is also required in terms of reserve management to protect Australia's premier investment in biodiversity conservation.

The degree of threatening processes as indicated by 57 subregions now having less than 30% remnant native vegetation, means that action to consolidate the reserve system is urgent. In many parts of Australia the opportunities for a fully Comprehensive, Adequate and Representative reserve system no longer exist and elsewhere, particularly associated with areas being rapidly cleared, the options are rapidly diminishing.

Consolidation of the reserve system is an integral component of any bioregional conservation strategy together with off-reserve conservation and integrated natural resource management. This is demonstrated through the case studies carried out for this Biodiversity Assessment (Chapter 10) where reserve consolidation is identified as a key part of the mix of the required conservation actions in all studies.

Reporting on the improvement in the Comprehensiveness of Australia's protected area system and the reduction in number of priority bioregions should be undertaken as part of Australia's State of the Environment reporting every five years.

Litchfield National Park (P. Sattler).

Mt Kaputar National Park (NSW NPWS).

9. Biodiversity conservation across the wider landscape

Summary

Integrating wildlife conservation with agriculture (QEPA).

SUMMARY

There are two broad groups of management responses for delivering biodiversity conservation. The first is protective management - across both public and private lands. This is the most cost-effective management strategy because preventing degradation is easier than repair. The second management response is rehabilitation to recover threatened species and repair threatened ecosystems and ecological processes. This strategy is costly, but necessary in parts of Australia. Both groups of management responses rely upon effectively integrating biodiversity conservation into natural resource management.

To assess where integrated natural resource management might effectively deliver conservation outcomes, subregions were assessed in terms of existing constraints and community capacity. The assessment indicated that capacity for integrating biodiversity conservation into natural resource management is severely constrained in 14% of Australia's IBRA subregions. Major constraints include the extent of degradation, socio-economic issues and limited community capacity. In a further 33% of subregions, significant constraints are identified. There is an identified capacity to integrate biodiversity conservation as part of natural resource management activities in 29% of subregions and natural resource management actions are achieving conservation outcomes in 21% of subregions. Conservation is considered to be well integrated into production systems in only 1.5% of subregions.

The specific measures required to deliver biodiversity outcomes as part of integrated natural resource management vary widely across Australia and need to be tailored to regional circumstances. Existing activities and opportunities for integrated natural resource management to achieve effective biodiversity conservation have been reviewed for each subregion.

Compared to the high numbers of threatened species, only 338 Commonwealth, State and Territory recovery plans exist (approximately 20% of Commonwealth listed species) and the implementation of many of these is not funded. Given the size of the task of redressing this situation, threatened species recovery across Australia requires a more strategic approach that goes beyond planning and addresses implementation.

Bioregional and subregional planning strategies and works that focus on multiple species may provide an appropriate mechanism for addressing recovery of threatened species. To assist in these activities, this assessment has identified recovery actions for threatened species in each subregion. Further work is needed to identify groups of threatened species for multiple species recovery, to foster links with other natural resource management initiatives and facilitate management orientated ecological research.

Recovery planning for threatened ecosystems and other ecological communities has received relatively little attention. Notable exceptions are the Grassy White Box woodlands in southern Australia, temperate native grasslands in Victoria, Western Australia's Yanchep Cave aquatic rootmat invertebrate communities and Sydney's Cumberland Plain woodlands. Recovery actions for threatened ecosystems have been suggested for each subregion and are a key information layer for regional natural resource management planning.

Overall, successful recovery outcomes for threatened species and ecosystems and identified community capacity to be involved in recovery planning is identified in only 20% of subregions. Comparatively modest conservation initiatives and investment levels will lead to significant biodiversity conservation gains in much of northern Australia such as the Northern Kimberley and Cape York Peninsula, and across central Australia (29% of all subregions). Investment in protective management in these bioregions is cost effective and a priority.

Major constraints on achieving recovery of threatened ecosystems due to the high level of habitat loss and poor landscape condition are identified for 43 or 11% of subregions. Significant effort is required in a further 34% of subregions but in these, limited community capacity and resource constraints exist.

Investment required in many subregions is substantial and it is likely that only selected activities will be able to be implemented. For example, the cost to achieve the revegetation of the 57 subregions that now have less than 30% remnant vegetation to a 30% target, is estimated to be well in excess of $4.5 billion. This makes it imperative to protect remnant natural habitat in these subregions and strategically target any investment in repair. Key biodiversity elements such as riparian zones and threatened ecosystems, are special priorities for rehabilitation in these landscapes.

INTRODUCTION

The protection of biodiversity across Australia requires the adoption of integrated natural resource management practices that specifically incorporate defined conservation objectives. One essential component is the need for targeted programs to recover threatened species and threatened ecosystems.

Reserves play a critical role in protecting a Comprehensive and Representative sample of biodiversity but the maintenance of regional biodiversity and the protection of ecological processes across the wider landscape requires complementary natural resource management activities. The identification of biodiversity conservation needs in the development of natural resource management strategies is the first step in this process.

The very large number of threatened species and threatened ecosystems identified in the Biodiversity Assessment implies that highly strategic approaches are required to achieve extensive recovery. Generally though, resources available to implement recovery plans are limited. Considerable effort has focused on providing legislative protection and on developing individual species recovery plans. As of August 2002 there were 145 recovery plans in place under the *Environment Protection and Biodiversity Conservation Act 1999*. The Commonwealth government is committed to the adoption of a recovery plan for every endangered and critically endangered species listed under the Act by 2005. State and Territory governments also prepare recovery plans under their legislation.

One of the strategic responses required is to implement a regional and all-encompassing approach to threatened species and ecosystems as part of regional natural resource management activities. For example, the Western Australian Department of Conservation and Land Management lists threatened species and ecological communities and broad recovery actions in each of their administrative regions to promote recovery planning initiatives. This initiative could be extended to the development of bioregional overviews, strategies and works for the protection of rare and threatened species and ecosystems.

Such an approach would provide better linkages with on-ground ecological conditions and constraints and other bioregional biodiversity conservation measures including the monitoring of the status of native ecosystems. The Biodiversity Assessment, through collating information on threatened species and ecosystems across all subregions and bioregions, has provided the first step in developing this approach on a comprehensive basis.

With the increasing emphasis being given to the regional delivery of integrated natural resource management that include biodiversity conservation programs, the Biodiversity Assessment has collated information on the effectiveness of existing natural resource management activities to deliver biodiversity outcomes and the various opportunities or constraints that might exist across subregions.

Ecological research and recovery of threatened species - fitting a radio tracker to a Bilby (P. Sattler).

THE ASSESSMENT

Threatened Species and Ecosystems

Important information needed at the regional level for biodiversity conservation is the occurrence of threatened species and ecosystems, their threatening processes, recommended recovery actions and the resources required to effect improvement. This information is vital for the development of catchment plans, local government plans and other instruments that seek to integrate biodiversity conservation with natural resource management activities.

The Biodiversity Assessment has investigated the conservation status of ecosystems as one means of highlighting the need to maintain viable ecosystems for the protection of biodiversity. An attempt was also made to identify groups of threatened species based on similar distribution, association with particular ecosystems, similar threats or taxonomic affinity where efficiency of scales might be achieved in planning recovery actions, for example, grouping of threatened coastal heath species or threatened upland rainforest frog species. The difficulties experienced by States and Territories in compiling this information indicate that further work is needed if integrated management activities are to be a key part of the response.

To contribute to regional recovery planning, the Biodiversity Assessment has identified the threatened species and ecosystems in each subregion based on species records held by States and the Territories. Where known, the range of recovery actions required for these species has been listed.

1. Habitat retention through reserves
2. Habitat protection on private lands
3. Habitat protection on other public lands
4. Regrowth retention
5. Fencing
6. Weed control
7. Feral animal control
8. Revegetation
9. Fire management
10. Translocation
11. Reinstatement of hydrology
12. Research
13. Capacity building required with community, landholders, industry and institutions
14. Other

Figure 9.1 Range of recovery actions assessed for threatened species and ecosystems.

To assist in the collation of results, a standardised list of recovery actions was provided to agencies (Figure 9.1).

The existence of current State, Territory and Commonwealth recovery plans are also recorded.

The recovery of threatened species and ecosystems through inclusion in regional planning processes and activities is dependent upon community capacity and opportunity. It is also important to consider where comparatively modest investments in conservation measures might result in significant biodiversity gains. Subregions were ranked in terms of threatened species and ecosystems recovery opportunity within a series of classes shown in Figure 9.2.

1. Major constraints to achieve conservation outcomes e.g., due to level of habitat loss or landscape condition
2. Significant off-reserve effort needed, resource constraints, limited community capacity
3. Relatively limited off-reserve effort will result in significant biodiversity gains
4. Range of off-reserve measures required, capacity exists and some achieved biodiversity outcomes
5. Off-reserve measures significantly in place

Figure 9.2 Criteria used to rank opportunity for the recovery of threatened species and ecosystems across subregions.

Integrated Natural Resource Management

A wide range of mechanisms are identified to promote biodiversity conservation across private lands (e.g. Young *et al.* 1996). The most appropriate mechanisms vary according to regional circumstances and the nature of the issues to be addressed, and continue to evolve. For example, a market-based incentive mechanism based on a tender system for landholders to carry out environmental services is being trialed in Victoria through the BushTender initiative. Elsewhere, debate is occurring as to whether a basic duty of care for natural resource management should be legislated for and accompanied by a stewardship payment for public conservation services over and above private management obligations (e.g. Bates 2001). This mechanism has been proposed to achieve rapid reform in vegetation management in Queensland (Fensham & Sattler unpublished).

To assist in identifying suitable mechanisms for regional planning, the Biodiversity Assessment has recorded the existing natural resource management actions that contribute significantly to biodiversity conservation. These were collated across subregions using a standardised list of natural resource management categories to aid compilation. The potential to implement such actions was also assessed, using the same categories, to assist in determining what might be priority activities for investment across subregions.

1. Incentives
2. Legislation including duty of care for leasehold and other lands
3. Institutional reform e.g. rural reconstruction, industry reconstruction, new tenure and management arrangements
4. Valuing ecosystem services, tradeable rights
5. Threat abatement planning as part of natural resource management e.g. vegetation management plans, pest management
6. Industry codes of practice
7. Environmental management systems, ecological sustainable product marketing
8. Capacity building required with community, landholders, industry and institutions
9. Other planning opportunities including local government planning
10. Integration with property management planning, catchment planning and Landcare
11. Other

Figure 9.3 List of categories used to identify existing and potential natural resource management actions that could contribute significantly to biodiversity conservation.

To complete the analysis, an Australia wide appraisal was carried out of the overall opportunities for integrated natural resource management to deliver effective biodiversity conservation outcomes. This included a ranking of subregions in terms of their constraints, capacity of regional communities, and the degree to which defined biodiversity outcomes are currently being achieved through integrated natural resource management across Australia (Figure 9.4).

1. Major constraints to implement effective natural resource management actions to achieve biodiversity outcomes e.g. structural reform needed owing to extent of past degradation, land capability, property size, social and economic disruption
2. Significant constraints to integrate conservation as part of production / development systems
3. Identified capacity for conservation to be integrated into natural resource management to achieve significant biodiversity outcomes
4. Natural resource management instruments in place with some achieved biodiversity outcomes
5. Conservation outcomes well integrated into production / development systems

Figure 9.4 Criteria used to rank natural resource management opportunities for biodiversity conservation across subregions.

FINDINGS

Threatened Species

The type and frequency of recovery actions for threatened species across subregions was collated as part of the Biodiversity Assessment. Examples of the required recovery actions for threatened species across subregions are shown for two bioregions - Cobar Peneplain and South East Coastal Plain (Figure 9.5) - as examples of the information presented on the Atlas.

Reserve consolidation and habitat protection on private lands and on other State lands were both consistently recorded as recovery actions required for threatened species on the Cobar Peneplain in western New South Wales. On the South East Coastal Plain of Victoria habitat protection on private lands, capacity building, fencing, fire management and feral animal control are some of the frequently recorded measures required to protect threatened species. In both bioregions the need for research into the ecological requirements for threatened species recovery was identified across all subregions.

The Richmond birdwing butterfly (*Ornithoptera richmondia*) is threatened. Community participation in the recovery plan through re-establishment of the host plant is greatly assisting in its survival (CSIRO).

Table 9.1 gives an example of some of the supporting information on recommended recovery actions for threatened species within the Cobar Peneplain that is available on the Atlas.

SPECIES NAME	EPBC LISTING	STATE LISTING	RECOVERY PLAN	RECOMMENDED RECOVERY ACTIONS
Antechinomys laniger (Kultarr)	-	E	No	Research - Determine distribution and habitat requirements as a primary action
Nyctophilus timoriensis (Greater Long-eared Bat)	V	V	No	Research to determine more about the basic ecology of the species
Ardeotis australis (Australian Bustard)	-	E	No No	Feral animal control - Control of foxes in known breeding sites; Habitat retention through reserves
Chalinolobus picatus (Little Pied Bat)	-	V	No	
Swainsona murrayana (Slender Darling-pea)	V	V	No	Capacity building with stakeholders - Management of populations with landholders as well as along travelling stock routes
Petrogale penicillata (Brush-tailed Rock-wallaby)	V	V	No	
Acacia curranii (Curly-bark Wattle)	V	V	No	

Table 9.1 Threatened species or species group in each subregion: their status, the existence of recovery plans and recommended recovery actions – Cobar Peneplain Atlas extract. (Endangered is denoted by E and Vulnerable is denoted by V).

Chapter 9

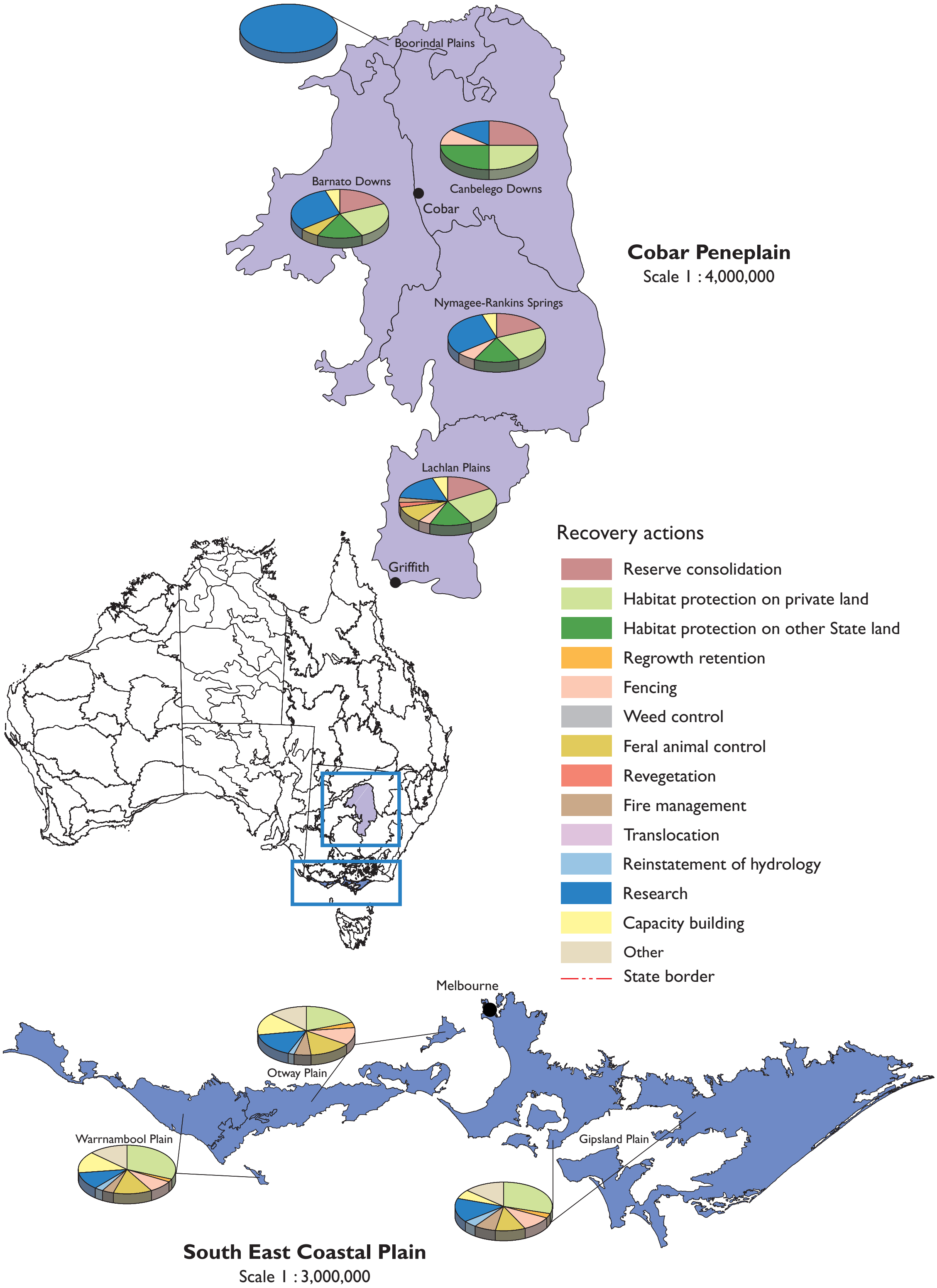


Figure 9.5 The type and frequency of recovery actions required for threatened species in subregions of the Cobar Peneplain and South East Coastal Plain bioregions. Pie charts do not convey relative importance of recovery needs but are an indication of frequency only.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

In total, 338 recovery plans exist across Australia, though often, implementation of the plans has been limited due to lack of resources. This confirms the need for a more strategic approach to the recovery of threatened species.

Threatened Ecosystems

Bioregional recovery planning for threatened ecosystems is an important and strategic action that can be undertaken as part of regional natural resource management. Action has been taken in some States and the Australian Capital Territory to provide legislative protection and regional planning frameworks for threatened ecosystems. The *Commonwealth Environment Protection and Biodiversity Conservation Act, 1999* has listed 27 'endangered ecological communities'. Further activities are warranted. The recovery of threatened ecosystems has not yet been comprehensively addressed. For example, in some jurisdictions there is no legislative protection to the clearing of the regrowth of endangered ecosystems.

The type and frequency of actions required for threatened ecosystem recovery across subregions was collated as part of the Biodiversity Assessment. Figure 9.6 identifies such measures for the Victoria Bonaparte and the Tasmanian Northern Slopes bioregions as examples of the information available for all bioregions on the Atlas.

In the Victoria Bonaparte bioregion in northern Australia, fire management, weed control and feral animal controls are the recovery actions consistently identified for threatened ecosystems across each subregion. In contrast, on the Tasmanian Northern Slopes reserve consolidation, habitat protection on private lands and a range of management activities including fencing are identified to protect and recover threatened ecosystems.

Table 9.2 identifies the recommended recovery actions for some threatened ecosystems within the Tasmanian Northern Slopes bioregion and is an extract from the Atlas.

There is a growing trend for aspirational targets for the revegetation of native ecosystems back to 30% of their pre-clearing extent proposed in some recent catchment plans. For example, restoration targets of 30% vegetation community extent is proposed for the Murray and Murrumbidgee Rivers in draft catchment blueprints to recover regional biodiversity and to protect hydrological regimes.

This target, if implemented Australia-wide, identifies two key issues for management and investment. Firstly, if a similar rehabilitation target is extrapolated across the 57 subregions that have less than 30% remnant vegetation (NLWRA 2001c), a total of nine million hectares will need to be revegetated. Greening Australia estimate that the cheapest revegetation cost, through direct seeding, is at least $500/ha. This means that the total repair bill to achieve this target would be at least $4.5 billion across Australia.

Rehabilitation costs may approach $10,000 /ha in

ECOSYSTEM NAME	RECOMMENDED STATUS	RECOMMENDED RECOVERY ACTIONS
Black peppermint forests on gravels (AI)	Vulnerable	Habitat protection on private lands
Black peppermint forests on sandstone (AS)	Vulnerable	Habitat protection on private lands
Brookers gum wet forests (BA)	Vulnerable	Habitat protection on private lands
Black peppermint woodland on gravels (Eai)	Vulnerable	Habitat retention through reserves; Habitat protection on private lands
Black peppermint woodland on sandstone (Eas)	Vulnerable	Habitat retention through reserves; Habitat protection on private lands
Black gum heathy woodland (Eh)	Endangered	Habitat retention through reserves; Habitat protection on private lands; Fencing; Weed control

Table 9.2 List of threatened ecosystems in each bioregion and subregion, their recommended status and recommended recovery actions – Tasmanian Northern Slopes Atlas extract.

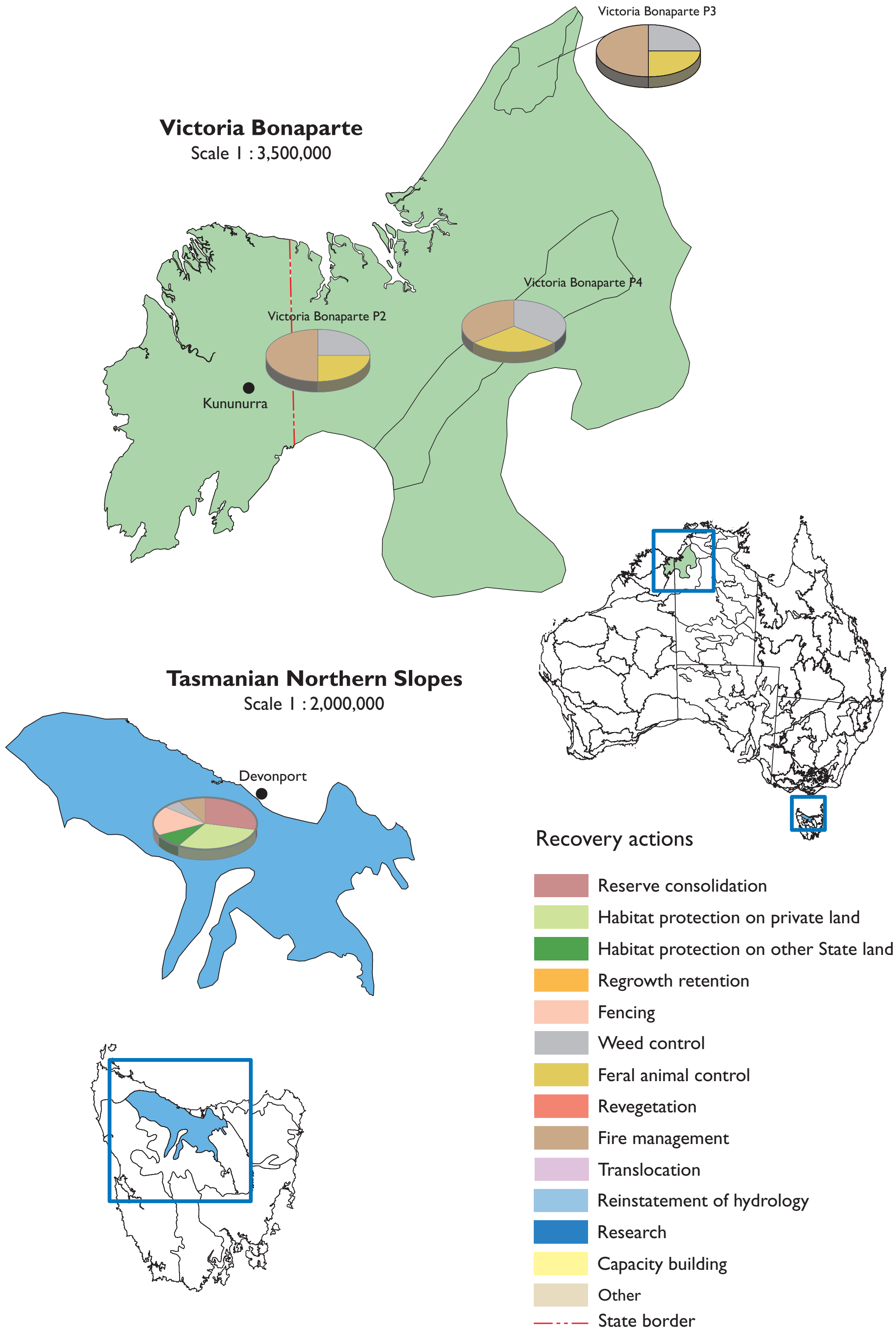


Figure 9.6 The type and frequency of recovery actions required for threatened ecosystems in subregions of the Victoria Bonaparte and Tasmanian Northern Slopes bioregions. Pie charts do not convey relative importance of recovery needs but are an indication of frequency only.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

those situations where direct seeding is not suitable and effective. Thus the $4.5 billion figure represents a very conservative estimate for vegetation repair. This huge cost clearly demonstrates that protection and management of existing habitat must be the priority action rather than environmental remediation of past mistakes.

Secondly, restoration in modified landscapes must be targeted to achieve the greatest biodiversity return as well as the protection and rehabilitation of ecosystem services. Issues such as the recovery of riparian zones, threatened ecosystems and other special values as identified in this Biodiversity Assessment, would be part of this regional analysis. The analysis should also recognise that if revegetation is not carefully targeted, such activity could significantly draw upon scarce resources at the expense of other conservation strategies. Preferably, revegetation should be implemented only as part of a mix of strategies that ensure existing remnants are secure and management is funded.

The complexity of rebuilding a functioning native ecosystem and additional logistical issues such as the availability of labour, expertise and local provenance seed in the quantities demanded by large scale revegetation works require careful consideration. Further research is needed into how large scale rehabilitation might be approached across bioregions.

The northern gastric brooding frog, *Rheobatrachus vitellinus,* is endemic to the Central Mackay Coast bioregion. It has not been sighted for a number of years. It is one of only two gastric brooding frogs in the world and is of medical interest due to its peculiar gastric physiology (QEPA).

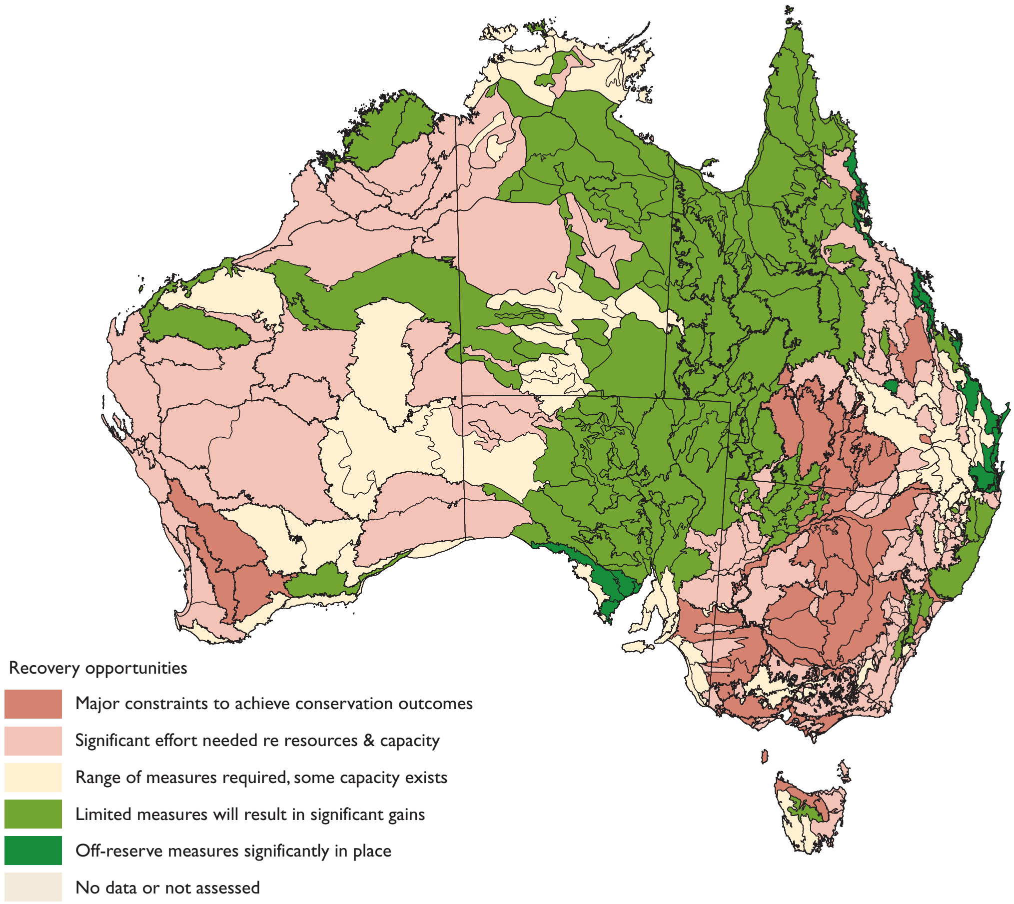
Threatened Species and Ecosystem Recovery Opportunities

The opportunities for threatened species ecosystem recovery across Australia in terms of constraints, regional capacity and where limited measures will result in significant biodiversity gains is shown in Figure 9.7.

Key findings from this analysis include:

- **Subregions with major biophysical constraints** - Throughout most of the Murray-Darling Basin including the Mulga Lands of Queensland, parts of Brigalow Belt North, the Victorian Volcanic Plain and South Coastal Plain, the Tasmanian Northern Slopes and Tasmanian Northern Midlands, the Avon Wheatbelt and parts of the Mallee bioregions in Western Australia, there are major constraints to achieve effective threatened species and ecosystems recovery (11% of subregions).
- **Subregions with significant resource constraints and limited regional capacity** - Across large parts of all States and Territories there is significant resource constraints and limited regional community capacity (34% of subregions).
- **Subregions where high levels of return are possible for limited investment** - Throughout central and northern Australia, including Cape York Peninsula and the Northern Kimberley, limited conservation effort would result in significant biodiversity gains (29% of all subregions). This is a particularly significant finding in terms of achieving greater efficiency for investment in biodiversity conservation.
- **Subregions where capacity exists and some recovery measures in place** - In 20% of subregions, a range of recovery measures are required though capacity exists and some biodiversity outcomes have been achieved.
- **Recovery measures significantly in place** - In parts of the Wet Tropics, Central Mackay Coast, South East Queensland and the Eyre Yorke Block bioregions, recovery measures are significantly in place (5% of subregions).

Figure 9.7 Threatened species and ecosystems recovery opportunities



Integrated natural resource management

Increasingly, a whole of landscape approach to natural resource management that includes biodiversity conservation is being advocated within regional, State and Commonwealth programs. This requires a broad range of management strategies to fit different environmental, land use and community circumstances.

Figure 9.8 shows the range of conservation measures currently being incorporated into two sample bioregions, the Gascoyne and Riverina bioregions. In the marginal rangelands across the Gascoyne, structural adjustment of the pastoral industry is working towards biodiversity measures, such as reserve consolidation and adoption of sustainable grazing regimes. Threat abatement planning that includes the adoption of codes of practice for sustainable pastoral management ensures a whole of landscape approach is implemented.

In the Riverina, vegetation management legislation, property management planning, incentives and a variety of planning instruments are some of the natural resource management actions contributing to biodiversity conservation.

Table 9.3 gives examples of existing natural resource management measures for biodiversity conservation and Table 9.4 gives examples of feasible opportunities for integrated natural resource management measures to contribute to biodiversity in each subregion.

With increasing investment in natural resource management initiatives as a strategic vehicle for biodiversity conservation, it is important to assess where current measures are contributing effectively to biodiversity conservation and where there are constraints and issues of regional capacity.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

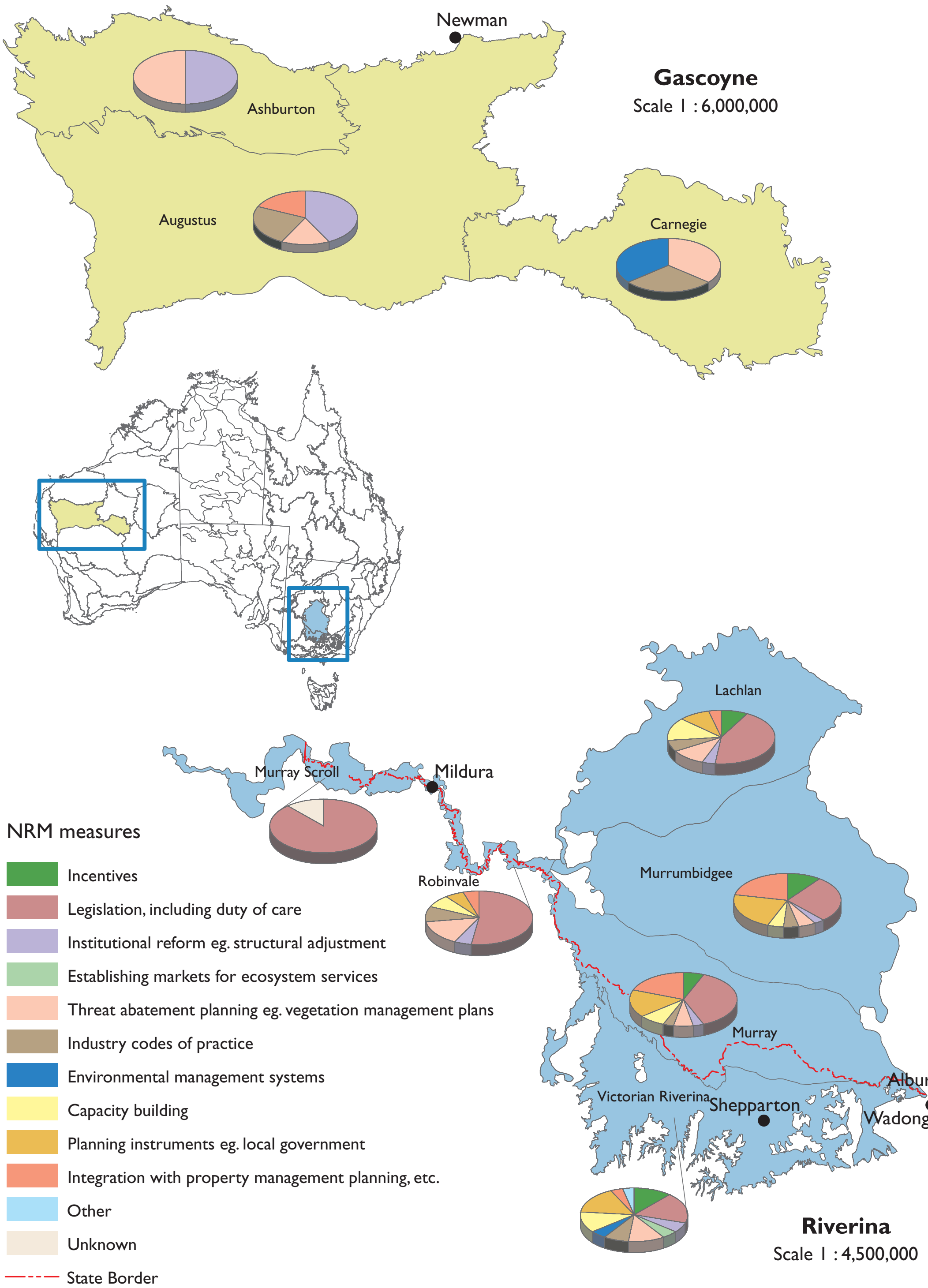


Figure 9.8 Frequency of existing projects contributing to biodiversity conservation as part of integrated natural resource management in the Gascoyne and Riverina bioregions. Pie charts do not convey relative importance of recovery needs but are an indication of frequency only.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

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SUBREGION	EXISTING ACTIVITIES	EXISTING ACTIVITIES NOTES	ASSESSED EFFECTIVENESS	ASSESSED EFFECTIVENESS NOTES
Mitchell (NK1)	Threat abatement planning	Threat abatement planning as part of NRM. Concerted and co-ordinated effort by the Department of Agriculture in the control of donkeys.	Major constraints to implement effective NRM	With off park priority for some focussed areas (eg. Mitchell Plateau), limited off park measures will result in significant conservation gains.
	Capacity building with stakeholders	Land Conservation District Committees established and provide a venue for discussion on conservation matters.	Major constraints to implement effective NRM	With off park priority for some focussed areas (eg. Mitchell Plateau), limited off park measures will result in significant conservation gains.
Berkeley (NK2)	Legislation including duty of care for leasehold etc	Pastoral lease inspections are undertaken by the Department of Agriculture and leaseholders notified of any problems via the Pastoral Lands Board.	Major constraints to implement effective NRM	A limited financial resource is a major constraint. The number of people available to implement strategies is a constraint. There is a need to increase awareness of conservation values throughout the community.

Table 9.3 The contribution of existing projects to the protection of biodiversity as part of integrated natural resource management measures in each subregion and assessed effectiveness - Atlas extract for the Northern Kimberley bioregion.

Figure 9.9 identifies that across much of the rangelands of Western Australia, the Swan Coastal Plain, the Northern Kimberley, the wheat / sheep belt of New South Wales, parts of the Murray Darling Depression bioregion and the Mulga Lands, major constraints to the implementation of effective natural resource management exist (14% of subregions).

These constraints may include the extent of degradation, the need for structural reform, limited land capability, small property size and the social-economic disruption that would be associated with implementing ecologically sustainable land use practices. In addition, significant constraints to integrate conservation as part of production systems are identified for a further 33% of subregions.

Ooline, *Cadellia pentastylis,* and Brigalow, *Acacia harpophylla,* a threatened ecosystem – Tregole National Park: Brigalow Belt South (P. Sattler).

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Table 9.4 Feasible opportunities for natural resource management to contribute to the protection of biodiversity in each subregion (Atlas extract for Mitchell (NK1) subregion).

OPPORTUNITIES	COMMENTS
Legislation including duty of care for leasehold etc	Improved implementation of existing legislation.
Environmental management systems	Environmental planning across tenure (weeds, fire and feral animals) coordinated through LCDC.
	Research is needed on the mechanism and impacts of threatening processes. Outputs of this should assess potential cost/effective solutions.
Capacity building with stakeholders (specify)	Improved communication required between all stakeholders and an acknowledgment of differing land management objectives.
Other planning opportunities	Shire plan incorporating biodiversity objectives incorporating an acknowledgment of the worth of the natural environment eg tourism, and the cost of management.
Integration with Landcare, catchment & property planning	Development of catchment and regional plans involving all stakeholders.

This accords with the findings of *Australians and Natural Resource Management* (NLWRA 2002b):

- farmers are Australia's front-line natural resource managers for at least 60% of the Australian landscape; however
- about 1% of the land area contributes about 80% of the profit from agriculture at full equity; and
- 14 river basins out of a total 246 account for 50% of the total profits from agriculture.

This does not necessarily imply that other parts of the landscape under agriculture and grazing are not profitable. Rather, it provides an insight into profitability per hectare, demonstrating quite clearly that for much of the agricultural and grazing landscape, returns per hectare are low and that additional on farm management activities to deliver biodiversity conservation outcomes may not be feasible.

Capacity to integrate biodiversity conservation into natural resource management is identified for 29% of subregions and natural resource management instruments are achieving some biodiversity outcomes across 21% of subregions. Conservation however, is well integrated into production in only 1.5% of subregions.

These results indicate while high expectations exist that integrated natural resource management is and will deliver significant biodiversity outcomes, there are major constraints and limited regional capacity across a large part of Australia.

Figures 9.7 and 9.9 indicate that significant effort is needed across rangelands to integrate biodiversity conservation with natural resource management in addition to current programs in the agricultural catchments.

Distinctive riparian zone, Gregory River – vital for the maintenance of regional biodiversity: Mt Isa Inlier (P. Sattler).

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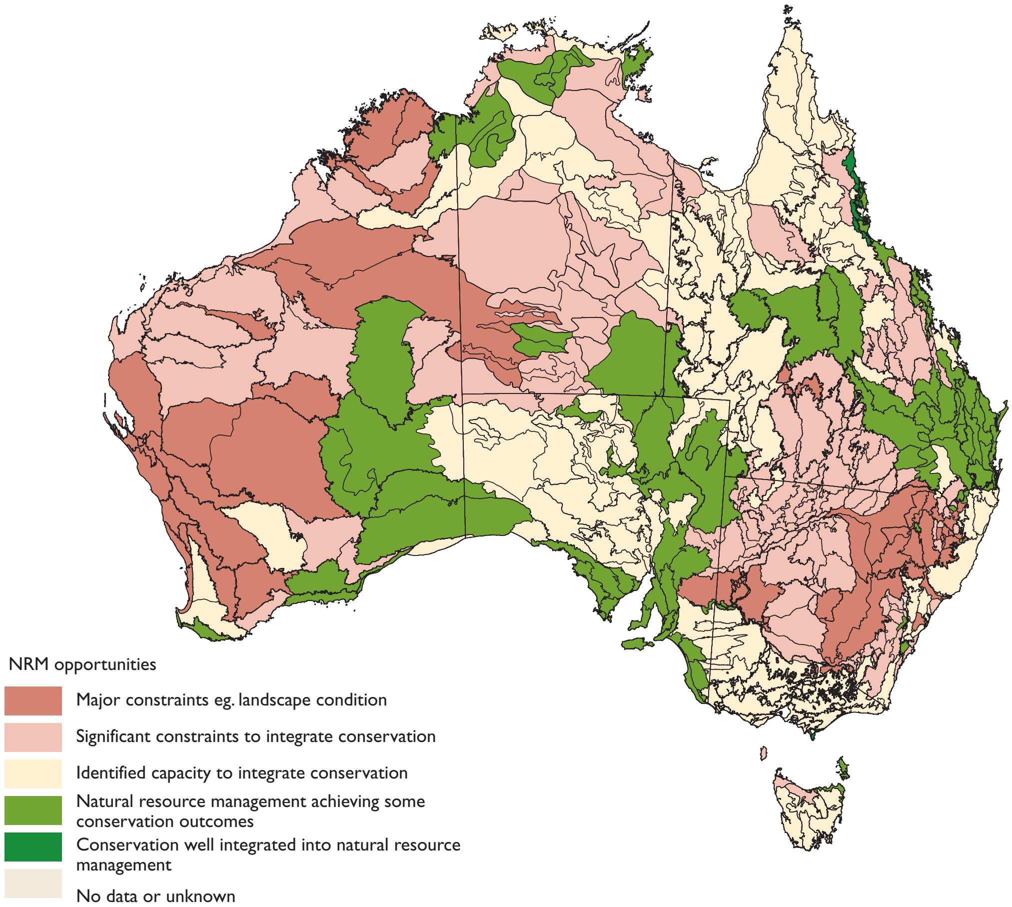
Figure 9.9 Integrated natural resource management opportunities for biodiversity conservation



Betsey Island Nature Reserve – planning for weed control: Tasmanian South East (R. Glazik).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

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CONCLUSIONS

A whole of landscape approach is essential if Australia is to address the decline in biodiversity and maintain ecological processes.

The size of the task of biodiversity conservation is large and growing, and requires a highly strategic approach as part of integrated natural resource management. In northern Australia and across the central Australia's rangelands, significant gains can be made for limited effort relative to the cost of repair in southern Australia. This includes the huge gains that can be made through promoting ecologically sustainable land use and preventing degradation compared with the cost of rehabilitation.

To achieve effective integrated natural resource management requires the clear identification of biodiversity conservation issues and targeted management responses.

In many parts of Australia, there are significant constraints and limited capacity to incorporate biodiversity conservation measures. This means that governments have a key responsibility to provide a range of programs ranging from effective incentives to structural adjustment and market mechanisms to ensure that land can be sustainably and viably managed whilst protecting biodiversity.

The delivery of regionally focussed programs will need much support and includes:

- providing information upon which to plan, such as the Terrestrial Biodiversity Assessment, the more detailed information on the Atlas and the other Audit assessments;
- coordinating monitoring and reporting on the changes to the condition of the landscape so that programs can be evaluated, investment fine tuned and additional programs developed;
- promoting the need to identify specific biodiversity conservation objectives as part of integrated natural resource management;
- assisting regional groups develop cost effective and outcome orientated investment strategies that maximize return on the limited resources available;
- facilitating management orientated research to enable cost effective recovery of threatened species and ecosystems; and
- underpinning and enabling regional management through a range of policy and funding initiatives to ensure natural habitats are protectively managed and to encourage rehabilitation and repair.

Natural resource management (QEPA).

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

10. Regional biodiversity management

Summary

Regional biodiversity management (QEPA)

SUMMARY

Fourteen case study regions, stratified across the six landscape stress classes and Australia's major agro-ecological regions, provide the basis of an analysis of the breadth and depth of biodiversity conservation issues and management responses required across Australia. The case studies comprehensively and systematically identify biodiversity issues and priority actions for conservation. These studies provide direction for determining cost-effective conservation priorities and the development of landscape management strategies.

In all case studies, a mix of reserve consolidation, threatened species and ecosystem recovery and integrated natural resource management measures are identified as essential to achieve effective biodiversity conservation. In many case studies, the wide range of planning activities leads to conflicting messages to the community. Integrated bioregional and multi-institutional planning as part of a whole-of-Government approach is imperative.

All 14 case studies identified that a significant increase of funding was necessary to achieve effective biodiversity conservation outcomes. Of the 14, seven estimated the level of expenditure required to achieve a significant practical effect for biodiversity conservation. The range of increase was between 1.5 to 23.6 times current expenditure. This varies with needs of bioregions. For example, for Tiwi Coburg bioregion, current expenditure is $225,000 and an estimated increase of $52,500 would deliver substantial biodiversity benefits. In comparison, for Northern Kimberley 1 subregion, current expenditure is $250,000 and the required increase is $5,650,000 to achieve significant conservation outcomes. A similiar proportional increase is also indicated for the Isaac-Comet subregion where a different suite of threatening processes exist. Acquisition of reserves is identified as a priority in a number of case studies where significant threats to the remaining key natural areas exist.

The case studies show that the investment required to deliver biodiversity conservation in predominantly natural bioregions is minimal compared to that required in the highly modified bioregions. Most of Australia's natural bioregions are in the rangelands and tropical woodlands. Therefore, a coordinated Australia-wide approach to biodiversity conservation for these bioregions is an investment priority.

In the more disturbed case study areas, there are many planning activities, which are often focused on a single issue. Yet in many of these regions the overall condition of biodiversity continues to decline. Either there are limited resources and commitment to go beyond the planning phase to implementation or we lack the knowledge to solve the problem (eg. salinity) in an affordable way. In these regions, strategic selection and funding of management activities may deliver higher returns than further planning activities. Planning under the Natural Heritage Trust extension and the National Action Plan for Salinity and Water Quality will need to be carefully coordinated so as to build on existing work and to focus on achieving well-defined outcomes.

The case studies demonstrate that increased attention by government to provide a policy environment and market drivers for biodiversity conservation on private lands is likely to yield substantial benefits for biodiversity conservation. Associated with an increased emphasis and encouragement of off-reserve conservation, the need for brokers is identified in some case studies to promote and coordinate activities on private lands to meet joint government and community targets for increased biodiversity conservation. Elsewhere it is indicated that little capacity exists to promote conservation without significant incentives.

The relationship between the case study subregions and other subregions was tested to demonstrate where similar biodiversity conservation measures may be required and where subregions are irreplaceable in terms of their species and the need to implement biodiversity conservation actions. The full text for each case study is available on the Atlas. The case studies should be referred to in regional planning where similar land use or landscape health scenarios exist. They provide a rich array of the detailed approaches taken to biodiversity conservation planning for different parts of Australia.

THE CASE STUDIES

To ensure that the Biodiversity Assessment was grounded in regional needs and identified the breadth of biodiversity issues and conservation responses, 14 case studies were undertaken. The case study subregions, and in some cases, entire bioregions, were stratified across the six landscape stress classes identified in the Landscape Health Assessment (NLWRA 2001a) and Australia's broad agro-ecological regions (Figure 10.1 and Table 10.1). Stratifying the case studies across Australia's agro-ecological regions enables each to be related to different regional land use patterns.

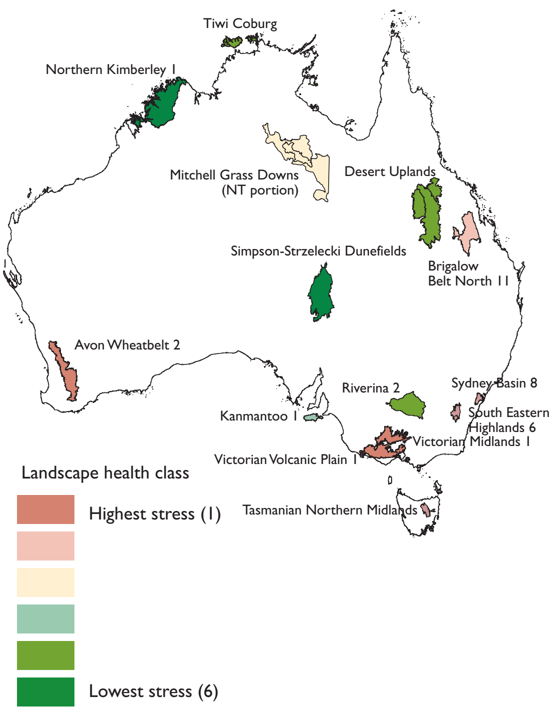


Figure 10.1 Location of the 14 case study regions and their landscape stress class.

These detailed case studies assist in quantifying the strategies and the resources required to achieve significant biodiversity outcomes from systematically assessing the needs of each subregion or bioregion. This approach accords with the bioregional planning activities of the States and Territories and the *Environment Protection and Biodiversity Conservation Act, 1999,* that has provisions to encourage bioregional planning.

All States and Territories requested that these case studies be an integral component of the Biodiversity Assessment to demonstrate the need for systematic analysis and the requirements to effectively implement bioregional conservation strategies.

The case studies illustrate the benefits of integrated bioregional planning compared with the difficulties of dealing with a myriad of thematic or species-based strategies that may be planned in isolation to overall bioregional priorities. They demonstrate the importance of assessing the mix of conservation actions required at the bioregion or subregion level and the need for such assessment to inform regional planning and natural resource management programs.

Information Collected on Case Study Regions

To ensure a focus on outcomes rather than process and inputs, only a broad guiding structure for case study planning was outlined:

Description - major characteristics of region (to help correlate to like subregions across Australia) and special values.

Condition/status and trend - of landscapes, ecosystems and species including threatened species and ecosystems, and other taxa of special biodiversity value.

Threatening processes - extent, rate, and land use changes.

Methods - a description of methods to demonstrate the diversity of approaches across different environments.

Management responses - detailing existing effort and the proposed effort required that would be practical and produce a significant conservation outcome. This analysis included pie diagrams based on:

- management priority amongst the three principal conservation strategies of reserve consolidation, species and ecosystem recovery and integrated natural resource management
- timeframe, up to 5 years
- existing conservation effort
- effort required to produce a significant conservation result.

Limiting factors - constraints and opportunities.

Future scenarios - for example, if action is not taken, what are the implications such as regional extinctions, increased extent of clearing, or increase in salinity affected landscapes.

Table 10.1 Case study areas, their agro-ecological region, landscape stress class and State or Territory

SUBREGION OR BIOREGION NAME	SUB-REGION CODE	AGRO-ECOLOGICAL REGION	LANDSCAPE STRESS CLASS	STATE OR TERRITORY
Mitchell (Northern Kimberley 1)	NK1	North-west wet/dry tropics	6 (lowest stress)	WA
Dieri (Simpson Strezelecki Dunefields 3)	SSD3	Arid interior	6 (lowest stress)	SA
Desert Uplands	DEU 1, 2 & 3	Semi-arid tropical/ subtropical plains	5 (second lowest stress)	QLD
Murrumbidgee (Riverina 2)	RIV2	Temperate slopes and plains	5 (second lowest stress)	NSW
Tiwi-Coburg	TIW 1 & 2	Northern wet/dry tropics	5 (second lowest stress)	NT
Kangaroo Island (Kanmantoo 1)	KAN1	Wet temperate coasts	4 (third lowest stress)	SA
Mitchell Grass Downs (partial), Barkly Tableland (partial) and Georgina Limestone (Mitchell Grass Downs 1, 2 & 3)	MGD 1, 2 & 3	Semi-arid tropical/ subtropical plains	3 (third highest stress)	NT
Isaac – Comet Downs (Brigalow Belt North 11)	BBN11	Subtropical slopes and plains	2 (second highest stress)	QLD
Avon Wheatbelt 2	AW2	Temperate slopes and plains	1 (highest stress)	WA
Cumberland Plain (Sydney Basin 8)	SB8	Wet temperate coasts	1 (highest stress)	NSW
Victorian Volcanic Plain 1	VVP1	Wet temperate coasts	1 (highest stress)	VIC
Murrumbateman (South Eastern Highlands 6)	SEH6	Temperate highlands	1 (highest stress)	NSW & ACT
Tasmanian Northern Midlands	TNM	Temperate highlands	1 (highest stress)	TAS
Goldfields (Victorian Midlands 1)	VM1	Temperate highlands and Temperate slopes and plains	1 (highest stress)	VIC

Major Issues Arising From the Case Studies

In all case studies, a mix of reservation, species and ecosystem recovery actions and integrated natural resource management measures were identified to achieve effective biodiversity conservation outcomes. Priority outcomes were determined from an analysis of biodiversity values, major threatening processes, management options available and major constraints. The difficulties in highlighting and addressing sometimes competing priorities reinforces the need for integrated bioregional planning that enables an examination of the impacts of threatening processes in like environments and to include the full range of conservation strategies.

All 14 case studies identified that a significant increase funding was necessary to achieve effective biodiversity conservation outcomes. Of the 14, seven estimated the level of expenditure required to achieve a significant practical effect for biodiversity conservation. The range of increase was between 1.5 to 23.6 times current expenditure. This varies with needs of bioregions. For example, for Tiwi Coburg bioregion, current expenditure is $225,000 and an estimated increase of $52,500 would deliver substantial biodiversity benefits.

In comparison, within the Tropical Savannas, for Northern Kimberley 1 subregion, the current expenditure is $250,000 and the required increase is $5,650,000. Similiarly, 21 times current expenditure is required within the Isaac-Comet subregion in the Brigalow Belt North bioregion to acquire key reserves, secure remaining vegetation on private lands and recover threatened species and ecosystems.

Acquisition of reserves is identified as a priority in a number of case studies where significant threats to the remaining key natural areas exist. However, for the extensively developed parts of Australia reserve consolidation options are rapidly disappearing or may no longer exist.

The case studies show that the investment required to deliver biodiversity conservation in predominantly natural bioregions is minimal compared to that required in the disturbed bioregions where recovery is unlikely owing to the extent of degradation or modification (eg salinity, urbanization) or may require planning horizons of at least 50 years. Most of Australia's natural bioregions are in the rangelands and tropical woodlands. Therefore, a coordinated Australia-wide approach to biodiversity conservation for these bioregions is imperative.

Major differences in terms of conservation options emerged owing to the extent of landscape modification. In particular, the huge difference in the cost of biodiversity recovery and landscape repair versus preventative action. In one instance, Tasmanian Northern Midlands, it was assessed that restoration of 30% vegetation cover could cost $98 million whilst elsewhere within the Isaac-Comet Downs, extensive clearing is still occurring in a region with less than 30% remnant vegetation. In such circumstances, the cost of financial incentives to end clearing would be relatively minor in comparison with future restoration costs.

Analysing Case Study Results

Associating Subregions by Biodiversity Values and Land Use Conditions

Case study subregions were compared with all other subregions using nine condition and trend variables. Whilst this approach has not been taken further to examine the relativity of each case study and to identify common issues across similar subregions, it demonstrates the potential usefulness of such analyses in planning national biodiversity conservation priorities.

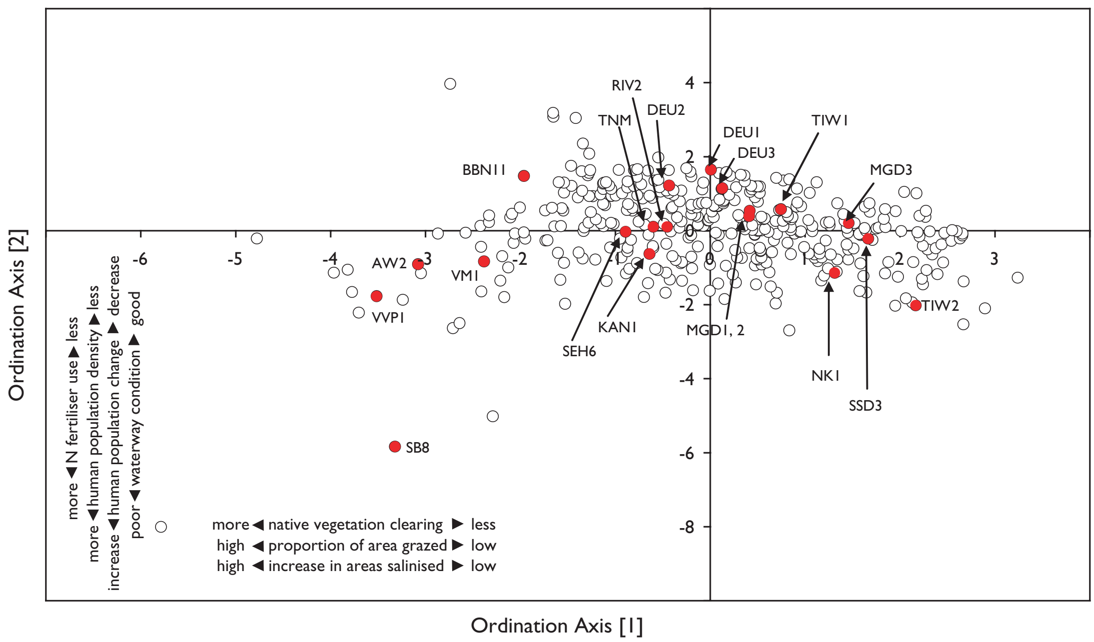


Figure 10.2 The fourteen case study regions (filled circles) relative to all other subregions (open circles) in ordination space. Abreviations for case study regions are shown in Table 10.1.

Nine condition and trend variables were selected to demonstrate the approach. These variables were used to define axes in ordination space describing the range of states of all subregions with respect to these variables (Figure 10.2).

The variables used to characterise land use condition for subregions were:

- river condition (NLWRA 2002b);
- human population density in 1997 (Australian Bureau of Statistics 2000);
- land cover change from 1990-1995 (Barson *et al.* 2000);
- intensity of pastoral use given by the proportion of a subregion more than 6 km from an artificial stock watering point;
- percent area of a subregion in a formal conservation reserve (this project);
- percent increase in the area of land to become salinised by 2050 (NLWRA 2001e);
- percent of area cleared of native vegetation (NLWRA 2001c);
- projected percent change in human population to 2020 (Australian Bureau of Statistics 2000); and
- rate of addition of fertilizer to subregions (NLWRA 2001b).

In the ordination depicted in Figure 10.2, Axis 1 describes the proportion of land cleared of native vegetation, the proportion that is within reach of domestic stock in the arid and semi-arid areas, and the likely increase in the proportion of area to become salinised. Large negative values on Axis 1 describes subregions that are either highly cleared and vulnerable to salinisation in the future (agricultural areas), or are highly developed for pastoralism (rangeland areas). Conversely large positive values of Axis 1 indicate regions that are relatively uncleared and lightly stocked. Axis 2 is a gradient of fertilizer inputs, river condition, and changing human population density (large negative values representing trends of greater biodiversity impact potential). Axis 1 correlates well with landscape stress class values (correlation coefficient R = 0.82) and with the proportion of the subregion cleared of native vegetation.

The case study regions are highlighted in the ordination space to indicate which non-case-study subregions are similar to the case study regions in terms of the landscape threat and change variables used in the ordination analysis. Subregions that were within a

The case studies demonstrate the cost-effectiveness of various management practices including improved fire regimes for relatively natural landscapes across northern Australia.

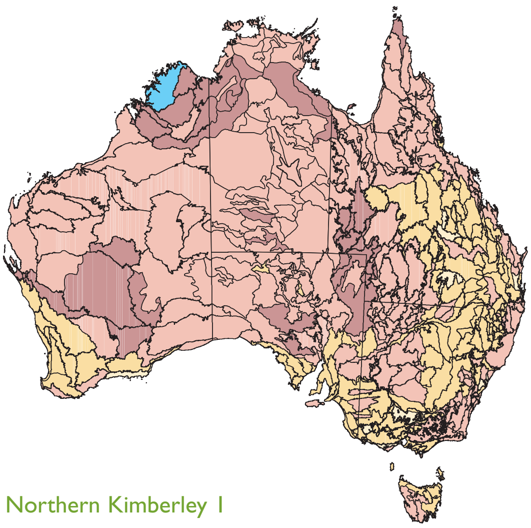
nominal distance of 0.8 units in the ordination space from the case study regions were considered to share a number of similar issues. Three examples of these associations are shown in Figure 10.3.

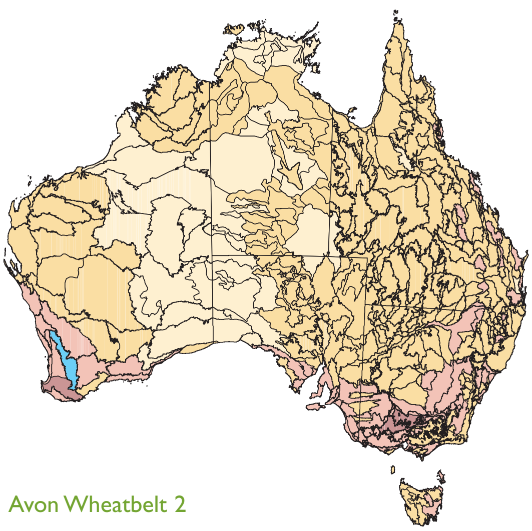
Hence, the solutions identified in the case study reports are also likely to be relevant to similar subregions.

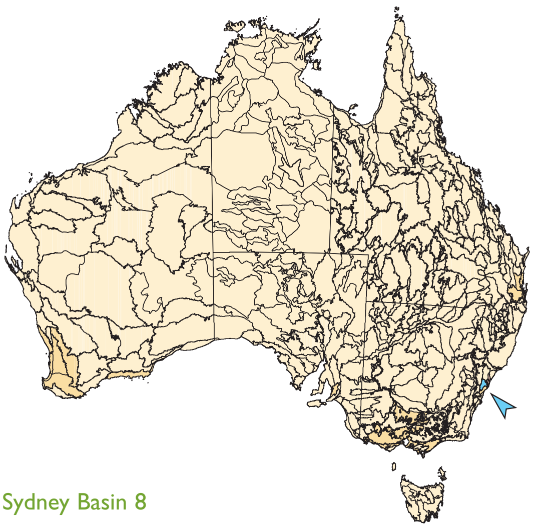
Figure 10.3 shows that a number of subregions have similar landscape threat and change scores to the North Kimberley 1 case study. These include other parts of the Tropical Savannas, the arid parts of Western Australia and the Channel Country. In these regions, similar land uses, such as grazing, are affecting biodiversity. Other factors such as feral animals and changed fire regimes, not included in these analyses because of the lack of data, are also having a significant impact on irreplaceable elements of biodiversity including critical weight range mammals (see Chapter 6).

A number of subregions are similar in land use condition to the Avon Wheatbelt 2 case study:

Southern Jarrah Forest, Goldfields and the Victorian Riverina in the south-eastern Murray-Darling Basin. This analysis reinforces the finding that for the intensively used agricultural parts of Australia, extensive effort in terms of landscape repair and restoration of ecological processes is required.







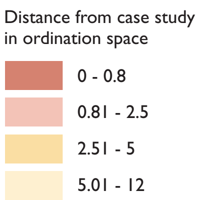


Figure 10.3 Subregions most similar to case study regions Northern Kimberley 1, Avon Wheatbelt 2 and Sydney Basin 8 in terms of landscape threat and change variables used in the ordination analysis. These are 'big-picture' relative risk maps and should not replace knowledge at scales appropriate to on-ground action.

No other subregions are similar to the Sydney Basin 8 case study, where extensive urban and periurban development presents a unique set of biodiversity conservation challenges.

Using Irreplacability to Define Biodiversity Risk

As indicated elsewhere in this report, subregions defined often in terms of their endemic or relictual biodiversity values are of special concern for planning biodiversity conservation. Using the data sets made available through this study, an initial analysis of the relative importance and risk for subregions was undertaken. A biodiversity value index based in Irreplacability was graphed against Axis 1 of the land use condition ordination (Figure 10.4). The analysis ranks subregions on the basis of their significance for the complement of species they harbour.

Four risk categories are defined in Figure 10.4. Risk category 1 has subregions that:

- contain the sets of species that are least substitutable (i.e., if they are lost from these regions then they are likely to be permanently extinct);
- contain large numbers of species and therefore potentially large habitat diversity; and
- are the areas in which natural ecosystems and species are most threatened by anthropogenic sources of landscape change.

Subregions with risk code 1 typically occur in highly modified agricultural areas.

Map Data Source: Natural Land and Water Resources Audit, Assessment of Terrestrial Biodiversity 2002 Database.
Data used are assumed to be correct from the data suppliers. © Commonwealth of Australia 2002.

Risk category 2 is assigned to subregions that also have highest irreplacability scores but score on the positive end of Axis 1 of the land use condition ordination. Subregions with risk category 2 are typical of arid, semi-arid and tropical savanna rangelands that are used for pastoralism. While it is tempting to think that these subregions are in "good" condition and should not be of concern, there are many threatening processes occurring in these subregions that were not included in the ordination variables because of a lack of data (e.g., predation by introduced predators, invasion by exotic plants and animals, altered fire regimes). The irreplacability of the species in these subregions warrants substantial attention and efforts to reverse declining trends for species where they are apparent.

Risk categories 3 and 4 are applied to subregions that score lower for irreplacability. While these subregions may still contain endemic species whose entire population occurs within the subregion, they tend to harbour a larger proportion of species which also occur in other subregions. Hence, the population is spread over a larger area and the probability of extinction could be reduced because of this range. Subregions with lower irreplacability indices should not be thought of as having no special biological values - it is likely that all subregions of Australia harbour some endemic species which could be lost if threatening processes are ignored and these relative rankings only relate to broad brush overviews. Subregions with risk category 3 are those of the slopes and plains west of the Great Dividing Range. Subregions with risk category 4 are those of inland Australia and tropical savannas.

These analyses show the similarity of case study subregions to other subregions and show the relative biodiversity value and risk to biodiversity for subregions. They facilitate the extrapolation of detailed information about each case study presented in the following section, to a broader range of subregions. They also inform us about which subregions have similar types of land use problems, and hence may share similar types of solutions and resourcing requirements.

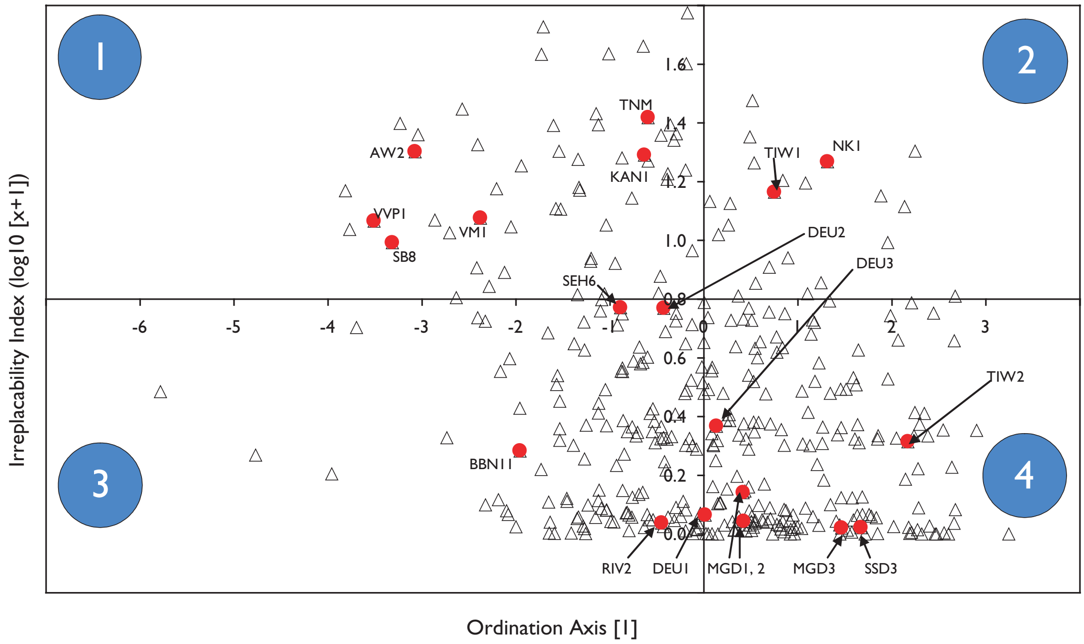


Figure 10.4 Irreplacability Index versus Axis 1 of the land use condition ordination and partitioned into risk categories 1 to 4. Subregions are shown as triangles and case study regions as filled circles. Abbreviations for case study regions are shown in Table 10.1.

Mitchell (Northern Kimberley 1) Lowest stress class

The Mitchell subregion is the dissected plateau of the Kimberley Basin. Vegetation includes savannah woodland over high sorghum grasses, and hummock grasses on shallow sandy soils on sandstone outcrops. Riparian closed forests of *Melaleuca* and *Pandanus* occur along drainage lines. Land uses include grazing on native pastures, Aboriginal use, mining, reserves and conservation.

There are a variety of rare features in the subregion, including:

- a sunken coastline with extensive coastal archipelagos that form a microcosm;
- mound springs and swamp rainforests;
- tropical laterite flora that includes a palm-dominated landscape unique in Western Australia;
- and Airfield Swamp on the Mitchell Plateau, a large perched wetland supporting paperbark forest.

There are animals of special interest such as *Isoodon auratus* (Golden Bandicoot), *Wyulda squamicaudata* (Scaly-tailed Possum), *Petrogale burbidgei* (Monjon), *Peradorcas concinna* (Nabarlek), *Mesembriomys macrurus* (Golden-backed Tree-rat), *Zyzomys woodwardi* (Kimberley Rock-rat), *Morelia carinata* (Rough-scaled Python), *Amytornis housei* (Black Grasswren). The subregion is fox- and rabbit-free and virtually uninhabited by humans. There are endemic species of possums, birds, reptiles and frogs. There are 12 endemic plants. Rainforest patches are particularly rich in endemic invertebrates, especially *Camaenid* land snails and earthworms.

Condition and trend

Wetlands and riparian zones within the subregion are in either good or near pristine condition. However, their trend is either unknown or declining. There are three threatened ecological communities and a further 14 ecosystems are considered to be at risk. Most are static or declining, although trends in some are unknown. Very little is known about trends and threatening processes affecting species at risk. Of the six that can be assessed, only the estuarine crocodile is improving; all others are declining. The north-western part of the sub-region is thought to have an intact mammal fauna, including its original component of critical weight range species.

Open savanna woodland on rugged sandstone and vine thickets on scree slopes under escarpments in the Prince Frederick Harbour (N. L. McKenzie).

Threatening processes

Parts of the subregion have been subject to a variety of threatening processes. The increasing incidence of late dry season fires is a matter of concern at the landscape scale. Impacts include changes to the savannah's perennial plant/annual grass dynamic, micro-hydrology, erosion processes and river dynamics. Rainforest patches are under threat from fire and stock. Ecosystems are simplifying as grasslands become dominated by annual species. These problems are exacerbated by damage to soils and native grasses caused by stock and feral animals. Overall there is a reduction in productivity and changes to the carrying capacity of the environment for critical weight range mammals and savannah birds. The subregion has a small but growing problem with weeds, and further introductions of exotic plant species are likely. Feral cats are common and other exotic predators pose potential threats, including *Bufo marinatus* and *Rattus exulans.*

The arrival of the cane toad is inevitable. Rapid increases in tourist visitation are also affecting parts of the subregion.

Management responses

Management responses have involved planning and recovery actions for both ecosystems and species. Flora has generally been more of a problem than vertebrate fauna in the recovery planning process, because it requires far more extensive surveys to clarify status and to identify habitat associations and potential threatening processes. No recovery plans exist yet for the ecosystems at risk, although research into the status and recovery for some ecosystems is being carried out. Fire, grazing pressure and other threatening processes are being addressed in a limited way, but need significant support and encouragement to maintain and accelerate cultural change. Processes to encourage a perpetual commitment to biodiversity conservation must also be developed.

There are opportunities for joint management arrangements between the State conservation agency and Aboriginal groups. Developing an involvement by the traditional owners in the management of this subregion is seen as a constructive step towards improving biodiversity conservation. In recent years, several pastoral leases have been purchased for tourism (eg Drysdale River) and protection of Bradshaw art sites (eg. Theda, Doongan).

Limiting factors

Twenty vegetation units and 10 ecosystems at risk are not captured by the bioregion's reserve system; more than 66% of the region's vegetation units are not reserved. The three main constraints on reserve acquisition are:

1. Competing land uses, mainly for pastoral production.
2. High land prices for pastoral leases.
3. Insufficient resolution of biodiversity patterns to accurately define all acquisition priorities on the ground.

Management capacity is constrained by resources available and a very low resident human population able to get involved in management activities and, associated with this, the lack of adequately trained personnel. There is also a need to increase awareness of conservation values throughout the community, and encourage a change in attitudes towards the value of conservation.

Future scenarios

Biodiversity conservation needs to be integrated with all land use activities rather than being seen as an imposition.

A quantitative survey and monitoring program for biodiversity, including pastoral lands, is needed to assess condition and provide a benchmark for determining trends. Challenges include the vast and remote nature of the areas involved, building capacity and adequate training, resources to tackle sustainability problems, and that the monitoring must be adopted by all stakeholders rather than being seen as a theoretical exercise undertaken by government. The program would yield a better understanding of sustainability of the various land-use activities at different levels of intensity. There is no code of practice for pastoralism. There has been an unwillingness to apply existing legislation aimed at protecting land condition. Some relevant legislation needs to be revised, and corresponding institutional reforms adopted, including the need for an array of government departments, stakeholders and community groups to co-operate in planning and in initiating specific investigations into the types, mechanism, impacts and amelioration of threatening processes.

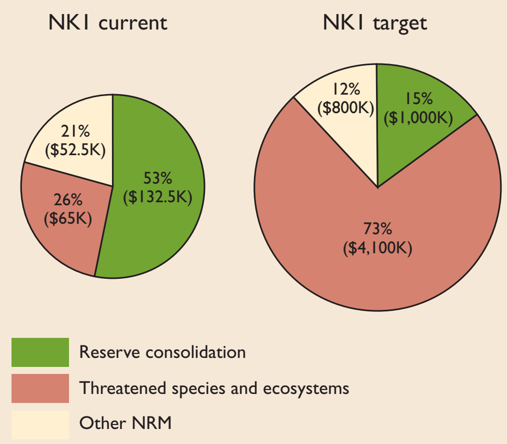


Figure 10.5 The differences in resources required and resources currently available to ensure adequate biodiversity conservation.

Dieri (Simpson-Strezelecki Dunefields 3) Lowest stress class

The Dieri subregion is dominated by a large expanse of red sand dunes of the southern Simpson and Tirari Deserts, two large ephemeral salt lakes (Lake Eyre North and Lake Eyre South), local concentrations of pans with cracking clay soils in the southern Simpson Desert, and the lower reaches of two of Australia's major inland river systems – Warburton and Cooper Creeks.

Lake Eyre is the terminus for one of the world's largest endoreic drainage basins that occupies approximately 16% of Australia and 35% of South Australia. It is the largest lake in Australia and the fifth largest terminal lake in the world. Although the Dieri subregion is in the driest part of the continent, with an annual rainfall of 100 to 150mm, the lake receives water from the Northern Territory and Queensland where heavy and regular monsoon rains fall.

Condition and trend

The Dieri subregion contains four ecosystems that have been identified as being at risk at the State level. The ecosystems are associated with major arid drainage lines and are:

- *Chenopodium auricomum* shrubland on cracking clay depressions subject to periodic waterlogging;
- *Eucalyptus coolabah ssp. arida* woodland on levees and channel banks of regularly inundated floodplains;
- *Acacia salicina, Eucalyptus coolabah ssp. arida,* +/- *Lysiphyllum gilvum* woodland of drainage lines and floodplains; and
- *Atriplex nummularia ssp. nummularia* open shrubland with occasional emergent *Eucalyptus camaldulensis var. obtusa* or *E. coolabah ssp. arida* on low sandy rises of floodplains.

Of the six nationally threatened species either occurring, or likely to occur, in the Dieri subregion three -*Dasycercus hillieri* (Ampurta), *Pseudomys australis* (Plains Rat) and *Frankenia plicata* (sea-heath) have been recorded within reserves. Insufficient information exists to provide an accurate assessment of the trend and condition of any of these species in this subregion.

Sandhill canegrass, *Zygochloa paradoxa*, on a dune crest in the Simpson Desert (P. Canty).

Threatening processes

The three nationally threatened mammals of the dune country (*Dasycercus hillieri, Pseudomys australis* and *Notomys fuscus*) face common threatening processes such as:

- habitat destruction by introduced herbivores such as camels, horses, donkeys and cattle;
- competition for resources with mainly rabbits and house mice; and
- predation by foxes and cats.

The main threats facing the three State-listed birds of the dune country (*Neophema chrysostoma* (Blue-winged Parrot), *Phaps histrionica* (Flock Bronzewing) and *Ardeotis australis* (Australian Bustard) are predation by foxes and cats and the loss of vegetation associated with rabbit and stock grazing. With large areas of habitat excluded from stock, and rabbit numbers at their lowest in years, the current conditions in the Dieri provide these species with a good opportunity to consolidate existing populations.

The main threatening processes for ecosystems at risk are:

- cattle and feral animal grazing (which has the potential to limit regeneration and establishment of seedlings of both overstorey and the main shrub layer);
- rabbit grazing (by suppressing regeneration of perennials); and

- tourism (camping and vehicle use can contribute to vegetation loss through off-road driving, trampling, firewood collection, soil compaction and accelerated erosion).

Special case

The Banded Stilt (*Cladorhynchus leucocephalus*) is an endemic Australian wader that inhabits saline wetlands in coastal regions of southern Australia, but will opportunistically fly long distances inland to breed on large ephemeral salt lakes such as Lake Eyre. Such breeding events occur irregularly and only five times in the past 70 years and follow heavy rains that flood these inland lakes.

During the most recent flood event in Lake Eyre in early 2000, water persisted for several months enabling four breeding episodes of Banded Stilts. However, Silver Gulls (*Larus novaehollandiae*) were responsible for heavy predation on eggs and young, and by early April, no nests remained. In response, the National Parks and Wildlife Service conducted an extensive Gull control program in July. This was spectacularly successful and by late August the total Banded Stilt population on Lake Eyre North was estimated at 100,000 birds. This action has led to the development of a breeding management action plan for Banded Stilt populations in South Australia.

Methods

The approach taken to develop biodiversity strategies in the Dieri subregion involved consideration of the following:

- A comprehensive, adequate and representative reserve assessment. This process identified four ecosystems as being priorities for inclusion in future reserves. It requires:
  - the inclusion within the reserve system of the full range of environmental associations described for the subregion;
  - inclusion within the reserve system of at least 10% of the whole subregion and of each environmental association it contains; and
  - the areas included from each environmental association reasonably reflect the biodiversity of the ecosystems present.
- Identification of candidate areas of these priority ecosystems for possible addition to the existing formal reserve system.
- Identification of species and/or ecosystems suitable for multi-species recovery programs. Two clear groupings were defined – 'species associated with longitudinal dunes and swales' and 'species and ecosystems associated with major arid drainage lines'.
- Development of recovery actions for the most threatened of the above two groups.
- Identification of existing and possible integrated natural resource management actions that maximise conservation of the most threatened species and ecosystems.

Management Responses

Some of the key management responses include:

- maintenance of Bushcare Grants Scheme as an incentive to pastoralists, in particular, a devolved grants scheme for on-ground works to be administered by the South Australian Rangelands Soil Board Executive Committee;
- continued provision of practical information and knowledge to pastoralists;
- ecologically sustainable use of major drainage channels and floodplains;
- provision of a policy framework to underpin pastoral lease development, particularly with respect to the establishment of new water points;
- efficient discharge and distribution of artesian water; and
- monitoring and control of feral animal and pest plant populations.

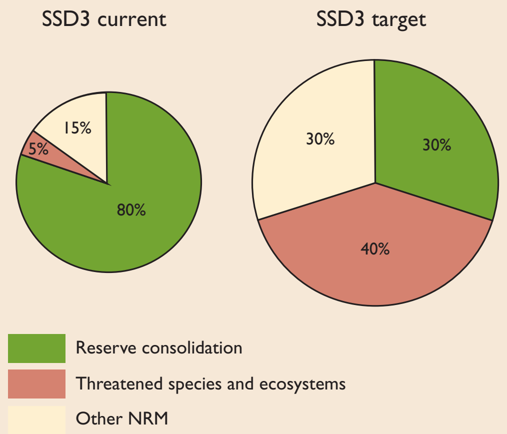


Figure 10. 6 The proportional difference among strategies of resources required and resources currently available to ensure adequate biodiversity conservation.

Desert Uplands (1, 2 & 3) Second lowest stress class

The Desert Uplands bioregion is dominated by woodlands of *Eucalyptus whitei, E. similis* and *Corymbia trachyphloia*. The semi-arid climate varies between the northern and southern parts of the bioregion, reflecting its extensive latitudinal extent with corresponding changes in vegetation. The bioregion has 73 ecosystems with influences from the Brigalow Belt, Mulga Lands, Mitchell Grass Downs, Einasleigh Uplands and Gulf-Carpentaria Plains.

The Desert Uplands is an area of very low soil fertility; phosphorous is particularly lacking in most soil types except in the alluvial systems. Large scale cattle grazing enterprises are the dominant industry, principally on the alluvial systems.

The dominant feature of the bioregion is the internal drainage patterns resulting in Lakes Buchannan and Galilee. A number of Artesian and Mound spring systems occur, and endemic species including fish and flora and snails have been recorded in these systems.

Condition and trend

While large areas of the Desert Uplands still have tree canopies in place, the overall condition is fair and declining. The naturally restricted ecosystems are often grouped around lake margins and are usually in poorer condition.

The Desert Uplands has nineteen threatened species including the Red Goshawk, Julia Creek Dunnart, *Eriocaulon carsonii* and *Edgbaston goby*. Most of these species are declining in population numbers and range.

Data collated for 1999 indicate that 87% of the bioregion remains uncleared, with 1% (102,250 ha) cleared in two years since 1997.

Of 73 ecosystems, 44 are under threat. Nine of these are static, while 29 are declining and 6 are rapidly declining. Fifteen of the ecosystems are regarded as likely to completely lose biodiversity values within the next 10-20 years while a further 29 are likely to lose biodiversity values unless management responses occur.

Yellow jacket, *Corymbia leichhardtii,* woodland with *Acacia complanata* on sandy earths associated with sandstone ranges (P. Sattler).

Threatening processes

Broad scale tree clearing, overgrazing and fragmentation of alluvial systems are the main threatening processes for both ecosystems and species. The threat of feral animals and changed hydrological regimes are also key threatening processes for fauna. Tree clearing is mainly occurring in the higher fertility areas in the south and along the floodplains of the alluvial systems. In particular the clay soils associated with Lake Galilee have been affected.

Overgrazing occurs in many of the ecosystems. Alluvial systems, lake margins and river banks are particularly susceptible. Although a large percentage of the ecosystems remain uncleared, the vulnerable ecosystems are of particular biodiversity conservation interest due to their declining status.

case study

Management responses

Due to the rapid decline in condition of this substantially intact bioregion, a range of conservation measures is urgently required. These measures encompass all three principal biodiversity conservation strategies including the consolidation of the national park estate, recovery of threatened species and ecosystems, and integrated natural resource management measures linked with structural adjustment of the pastoral industry.

Long-standing national park proposals exist for Lake Buchanan, the threatened Aramac and Doongmabulla artesian spring complexes and associated poorly conserved woodland and shrubland ecosystems. The Cape-Campaspe Plains subregion is unreserved.

Specific recovery actions are required for some critically endangered species such as the fish species of the Aramac Springs. This extensively vegetated part of the Great Dividing Range is also an essential link for migratory bird species.

The plight of the pastoral industry across this largely infertile region prompted a rural adjustment package to be put in place in recent years. This package has locally addressed a number of management issues.

At the broader scale of natural resource management, there is an opportunity for the community at large to consider the relative value and costs of pastoral production versus the extensive range of ecosystem services that this largely intact region provides. These values relate to biodiversity, maintenance of the Great Artesian Basin, control of greenhouse gas emissions and prevention of salinity and other forms of landscape degradation.

Structural adjustment that achieved the retirement of the most threatened and lowest capability lands to be managed for these multiple values would provide considerable benefits to society in the longer term. Australia-wide policy initiatives upon which to base such a long-term program are required. The resources required to achieve extensive structural adjustment are not reflected in Figure 10.7.

Limiting factors

Immediate opportunities include increased conservation covenants with property owners through the Desert Uplands Build Up Committee and negotiated protected area agreements.

Though a number of conservation agreements have been reached with devolved grant projects continuing incentives are required. Negotiation of key areas to consolidate the national park estate is constrained by the lack of resources for both acquisition and management.

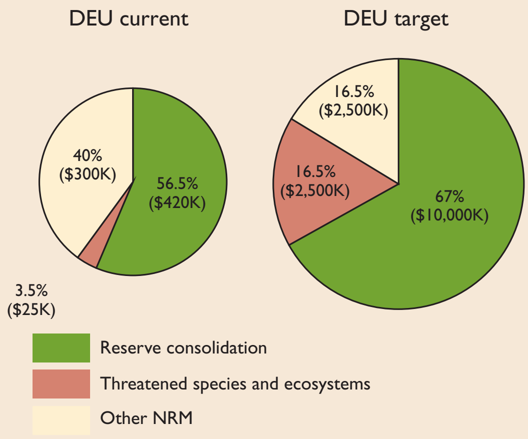


Figure 10.7 The differences in resources required and resources currently available to ensure adequate biodiversity conservation.

Murrumbidgee (Riverina 2) Second lowest stress class

The Murrumbidgee subregion is within the Western Riverina region in the south-west of NSW. The Murrumbidgee River dissects this subregion from Narrandera in the east to Balranald in the west, near the confluence of the Murray and Murrumbidgee Rivers.

A wide range of vegetation communities occurs in the subregion, some of which are unique to the Riverine Plain of NSW. The vegetation supports a diversity of species, including several endangered species. The Murrumbidgee subregion also contains extensive wetland areas including the Lowbidgee Floodplain wetland, the most extensive wetland in the Murrumbidgee catchment.

Land tenure is mainly a mix of freehold and leasehold. State Forest comprises less than 1% of land and is principally along the Murrumbidgee River. The subregion is a highly productive agricultural area, particularly the irrigation areas adjacent to the Murrumbidgee River. Sheep grazing on native pastures is the dominant land use (84% of the subregion). Approximately 6.8% is used for irrigated cultivation.

Murrumbidgee River (NSW NPWS).

Condition and trend

About 25% of the land has been cleared of native vegetation, mostly on floodplains where the landscape is flat, soils are fertile and there is easy access to water. Compared to the whole bioregion, the Murrumbidgee subregion still retains areas of continuous native vegetation cover, as rainfall is lower and access to water more restricted. Condition is better to the west of the subregion, with native vegetation in the eastern portion more fragmented. Recent vegetation clearing information indicates that clearing rates are increasing to the west.

Threatening processes

Key threatening processes include:

- clearing and overgrazing;
- intensive agricultural production on lands adjacent to the Murrumbidgee River, leading to altered hydrological regimes, water logging, salinity, land degradation, vegetation decline and fragmentation;
- feral animals - one of the great historical impacts on the region's biodiversity was the massive proliferation of rabbits from the 1870's. This, combined with the droughts of 1883-85 and 1890-95, severely reduced the extent and condition of grass and herb species as well as those fauna species dependent on saltbush and grassland;
- fragmentation and degradation of woodland habitat, which threatens a number of species and ecosystems. Connectivity of woodland habitat is important for species that have a limited range and do not tolerate disturbance around their nest sites; and
- illegal egg collection and trapping for the bird trade, especially parrot species.

case study

Management responses

The vegetation types that are reserved are not representative of the diversity of vegetation types or ecosystems that exist within the subregion, and are biased towards a few vegetation types. Two major planning process have the potential to assist reserve system design: Riverina Bioregional Conservation Planning; and Regional Vegetation Planning.

Species recovery plans are being developed for three bird species (Plains-wanderer, Superb Parrot, Regent Parrot) and one orchid (*Caladenia arenaria*).

Options to increase nature conservation on private land will be investigated within the Riverina Bioregion Conservation Planning project. These include:

- Voluntary Conservation Agreements (*National Parks and Wildlife Service Act*). These agreements are permanently binding on the land title and offer funding assistance and possible tax deductions as well as advice and support from NPWS staff.
- Wildlife Refuges (*National Parks and Wildlife Service Act*). A temporary voluntary mechanism. This also has some general legal requirements governing the management of the land while the refuge remains in place. It again offers the opportunity for advice and support from agency staff.
- Property Agreements (*Native Vegetation Conservation Act*). These agreements may be permanently or temporarily binding. Technical and management advice is provided and funding assistance may be provided depending on the length of the agreement.

The Conservation Trust Revolving Fund program will provide incentives for landholders to protect areas of high conservation value on private property compensates for the loss of productive land.

Limiting factors

The historically poor reservation status of both the Murrumbidgee and the Riverina is a consequence of several factors, namely the:

- historical lack of systematic State and region-wide conservation reserve planning;
- limited availability of Crown land for incorporation into the reserve system; and
- limited opportunity to purchase land due to high acquisition costs.

Key impediments to progress include:

- the overall lack of strategic coordination between government agencies, and between agencies and the private land owner communities. A good example is the Plantations Code of Practice and the Interim Regional Vegetation Schedule for the Riverina Highlands area that will allow for a further clearing of 40% of Yellow Box Woodland and 40% of White Box Woodland, without consent, as part of the government's drive to encourage farmers to establish plantations at minimum cost;
- available programs are not adequately resourced; and
- the plethora of target setting processes being undertaken by various agencies and groups for NSW landscapes. These diverse, and at times competitive, target exercises do not necessarily relate easily to the overall achievement of landscape conservation outcomes.

Future scenarios

Some significant gains in biodiversity conservation are expected to result from the Riverina Bioregional Conservation Planning Project. The current levels of degradation and loss of biodiversity will continue without considerable improvement in delivery of biodiversity conservation programs.

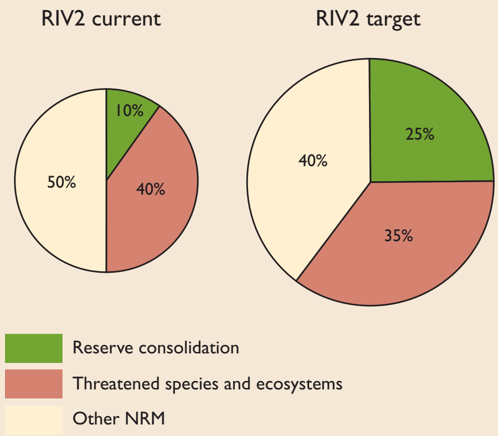


Figure 10.8 The proportional difference among strategies of resources required and resources currently available to ensure adequate biodiversity conservation.

Tiwi-Cobourg (1 & 2) Second lowest stress class

Tiwi-Cobourg is a small coastal bioregion at the extreme north of the Northern Territory. It comprises one mainland section (Cobourg Peninsula), the two large Tiwi Islands (Bathurst and Melville), Croker Island, and smaller satellite islands around these. All lands in the bioregion fall under three parcels that are inalienable Aboriginal owned lands. The population is about 2750. There is little commercial land use in the bioregion, although this may change with projected major development of a forestry industry based on plantations of exotic timbers. The ecological fabric of the bioregion is influenced by the extremely seasonal climate, the highest rainfall in the Northern Territory, and frequent destructive cyclones.

The principal vegetation type is extensive open forest dominated by *Eucalyptus miniata, E. tetrodonta* and *Corymbia nesophila*. The eucalypt forests in this bioregion are the best developed in the Northern Territory. There are also large areas of "treeless plains" (shrublands and grasslands dominated by *Acacia, Banksia* and *Lophostemon* species), a vegetation type unique to this bioregion. Monsoon rainforests are also unusually well developed in this region and their highly fragmented distribution poses particular management challenges. The bioregion also contains mangroves, coastal dunelands, and small floodplains. Biodiversity information includes good documentation of traditional Aboriginal knowledge.

The region has many conservation values, including:

- at least 9 endemic plant species, 4 endemic invertebrate species, 8 endemic bird subspecies and 2 endemic mammal subspecies;
- 34 taxa listed as threatened by the Northern Territory or the Commonwealth (including 14 taxa listed under the *Environment Protection and Biodiversity Conservation Act 1999*);
- many major nesting colonies of seabirds, and colonial breeding sites of marine turtles; and
- one listed Ramsar wetland.

The major conservation value of the bioregion is more pervasive - the maintenance of large continuous tracts of relatively unmodified environments.

Coburg Peninsula coastline (PWCNT).

The bioregion contains only one conservation reserve, the large (2207 km2) Garig Gunak Barlu (formerly Gurig) National Park, which occupies all of Cobourg Peninsula and its satellite islands. This park is Aboriginal owned and co-managed by Aboriginal owners and the Northern Territory conservation agency.

Condition and trend

The bioregion is in good condition, and without obvious acute loss or degradation. Notwithstanding its apparent untouched naturalness, at least one bird species (the threatened Gouldian Finch) appears to have been lost over the last 150 years. There have been no recent records from Cobourg Peninsula for a further four bird species and one mammal species, and the endemic subspecies of Hooded Robin on Tiwi Islands may have disappeared in the last two decades.

The apparent paradox of biodiversity loss within a superficially intact system is a recurring theme across much of remote Australia. The paradox is resolvable by recognition of the landscape-wide degradation of habitat quality due to impacts of feral animals, spread of weeds and altered fire regimes.

case study

Threatening processes

The underlying management problem in the Tiwi-Cobourg bioregion is lack of resources. The economic base of the bioregion is so meagre that there is little that the landowners can do to combat threats to biodiversity. Indeed, in many cases, landowners will embrace land uses or factors which are harmful to biodiversity but which may bring in resources (e.g. meat from, and trophy payments for, feral animals). Hence there is little incentive to control feral animals, and because their impacts may be subtle and remote, there is no marked trigger for a management response. The most damaging of the ferals are pigs on Bathurst Island, Croker Island and Cobourg Peninsula, buffalo on Melville Island, horses on Croker Island, and banteng on Cobourg Peninsula. Feral cats may also be a major problem on the Tiwi Islands and Croker, and their spread to Cobourg Peninsula is a potential problem. Weed impacts are relatively minor, but recently there has been a series of small infestations of several weeds with potential for major impacts. Traditional burning regimes have changed across almost all of the bioregion due to aggregation of Aboriginal people to a few settlements; less immediate dependence upon, and intimate care for, the land; and some loss of traditional management knowledge. There is now a higher incidence of extensive, hot, late dry season fires, with more marked environmental costs.

A major forestry industry on Melville Island has been approved. This will clear between 30,000 and 100,000 ha of high quality eucalypt forest and replace it with plantations of the exotic *Acacia mangium.*

Management responses

Although 22% of the bioregion is reserved, the reserves contain representation of only four of the 11 mapped vegetation types, and no representation of most of the endemic and threatened taxa. It is relatively easy to design additional reserve(s) on the Tiwi Islands to remedy most of this inadequacy, but this is a futile exercise unlikely to be implemented unless the Tiwi landowners can realise benefits from any new national parks. Benefits such as employment opportunities, training and income need to be clearly articulated. Given the sparsity of alternative economic options, a small investment in natural resource management and employment prospects is likely to be far more effective and accepted in this bioregion than in more developed bioregions of temperate Australia. Management costs were estimated to include:

- the establishment of a conservation reserve on the Tiwi Islands (with training and employment of some Tiwi landowners);
- support of community rangers on Croker Island;
- actions to reduce feral animals;
- removal of pioneer outbreaks of weeds and maintain surveillance for new weeds; and
- restoration of traditional burning practices.

Limiting factors

The main constraint is the lack of resources required to achieve these management objectives. National conservation management resources in Australia have often been directed at highly imperiled or degraded fragments in temperate Australia. As evidenced in this bioregion, the less obvious management needs in remote Australia can be remedied far more effectively, efficiently and cheaply.

Future scenarios

The problem with ongoing gradual degradation is that there is no trigger. Without the resource contribution described in this case study, the highly significant conservation values will continue to diminish and Aboriginal landowners will continue to look elsewhere for employment or income. Many of the proposed alternative land uses may come at considerable cost to the region's biodiversity.

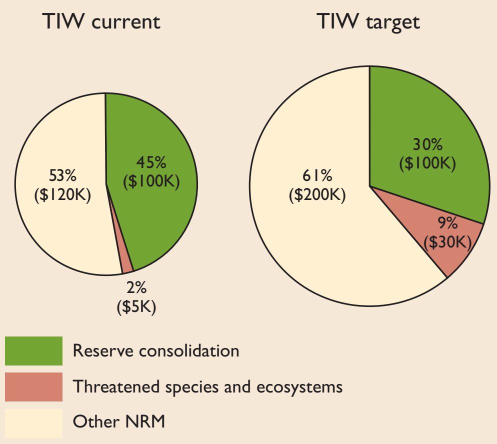


Figure 10.9 The differences in resources required and resources currently available to ensure adequate biodiversity conservation.

Kangaroo Island (Kanmantoo 1) Third lowest stress class

The Kangaroo Island subregion comprises Kangaroo Island itself and several smaller satellite islands. Kangaroo Island is the most important area for nature conservation in the higher rainfall areas of South Australia. It retains the highest proportion of uncleared natural vegetation of the agricultural districts, but more importantly, rabbits and foxes have not been introduced to the island.

Condition and trend

Eight of the region's ecosystems are either listed as vulnerable or endangered at the State level. All are declining in condition.

Four nationally threatened fauna species have been recorded on Kangaroo Island.

- The Glossy Black-cockatoo (*Calyptorhynchus lathami halmaturinus*) has a recovery plan in place and is gradually increasing.
- A recovery plan has been completed for the Kangaroo Island Dunnart (*Sminthopsis aitkeni*).
- Many of the known populations of both the Dunnart and the Southern Brown Bandicoot (*Isoodon obesulus obesulus*) are within reserves. While the trend for both is considered static, populations are low and recovery is likely to require significant management.
- The Heath Rat (*Pseudomys shortridgei)* is only known on Kangaroo Island from a single 1967 record and no information is available on its current status.

Fourteen nationally threatened plant species are known to occur on Kangaroo Island. While all have been recorded within at least one protected area, most are poorly conserved with the largest populations occurring on roadsides in the extensively cleared agricultural areas of the eastern end of the island. Most are declining in condition and in need of management to ensure recovery.

The north coast of Kangaroo Island looking east towards Cape Torrens (P. Sattler).

Threatening processes

The nationally threatened flora species and State-listed ecosystems face common threatening processes:

- road maintenance activities;
- fire frequency;
- weed invasion;
- limited remaining extent, making populations extremely vulnerable to catastrophe such as bushfire or disease;
- grazing and, in the case of some eucalypt communities, koala browsing;
- dryland salinity; and
- the root rot fungus *Phytophthora cinnamomi.*

Mammal species are threatened by:

- habitat fragmentation;
- predation by cats and dogs; and
- inappropriate fire regimes.

The Glossy Black-cockatoo is threatened by:

- nest hollow shortage and competition;
- low breeding success;
- nest predation;
- limited food supply (drooping sheoaks);
- fire, particularly where it reduces available nest hollows or drooping sheoaks; and
- suppression of drooping sheoak regeneration by stock grazing.

Special case

Koalas (*Phascolarctos cinereus*) were introduced to Flinders Chase National Park in the 1920's. An assessment of Koala numbers and tree condition in 1994 estimated the total population on the island to be between 3000 and 5000 individuals. More recent estimates are much higher. If Koala populations are not limited, over-population will not only continue to kill trees and degrade riparian habitats, but could also result in a food shortage for the Koalas, leading to starvation.

A management program was developed that focussed on sterilisation, translocation, habitat protection and restoration, and community education. Thus far the monitoring of tree health has indicated a general improvement in tree canopy condition in some areas where Koalas have been removed. Better integration of the annual monitoring, modelling and management programs is required if amelioration of the impacts of Koala browsing at an island-wide scale is to occur.

Methods

The approach taken to develop biodiversity strategies in the Kangaroo Island subregion involved consideration of the following:

- A comprehensive, adequate and representative reserve assessment. This process identified four environmental associations that are less than 7% conserved. Within those environmental associations with more than 10% of area conserved, a further four ecosystems and two threatened plant species were identified as inadequately represented within the reserve system.
- Identification of a possible candidate areas of these priorities for addition to the existing formal reserve system.
- Identification of species and/or ecosystems suitable for multi-species recovery programs, such as nationally threatened plants of the Amberley Environmental Association.
- Development of recovery actions.
- Identification of existing and possible integrated natural resource management actions that maximise conservation of the most threatened species and ecosystems.

Management responses

Key management responses include:

- maintenance of Bushcare Grants Scheme to provide incentives for landholders to conduct on-ground works;
- re-introduction of IBIS Award Scheme to encourage ecologically sustainable production;
- whole-of-catchment response to salinity management;
- maintenance of existing on-ground works aimed at arresting decline of native vegetation;
- encouraging further initiatives such as Heritage Agreements and fencing grants to protect remnant native vegetation;
- retention of viable threatened plant populations on roadsides;
- revegetation of corridors to link remnants of threatened ecosystems;
- coordinated weed control, particularly in areas of remnant native vegetation and coordinated feral animal control;
- maintenance of threat abatement program for *Phytophthora cinnamomi*;
- development of agricultural industry codes of practice that limit impact to flora and fauna; and
- recognising the Island's special values and support nomination as a biosphere reserve.

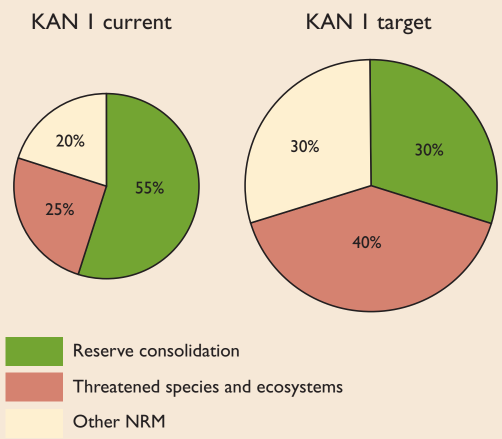


Figure 10.10 The proportional difference among strategies of resources required and resources currently available to ensure adequate biodiversity conservation.

Mitchell Grass Downs (Partial), Barkly Tableland (Partial) and Georgina Limestone (Mitchell Grass Downs 1, 2 & 3) Third highest stress class

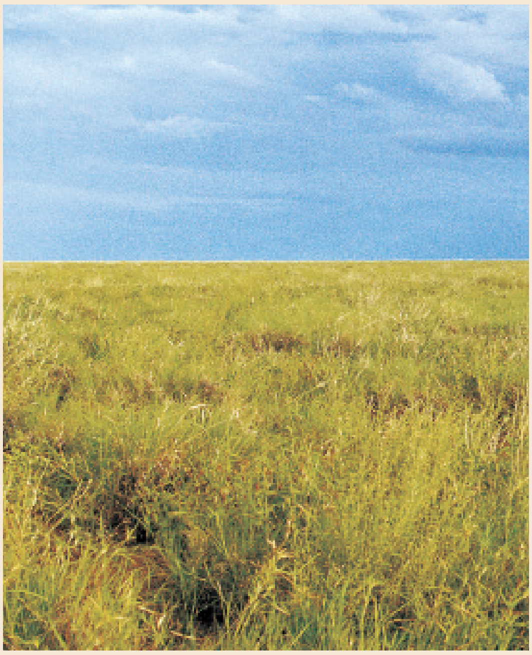
The bioregion occupies 92,680 km2 in the Northern Territory and Queensland. This case study focuses on the Northern Territory portions. This area is characterised by relatively homogeneous plains of cracking clay soils that support Mitchell (*Astrebla spp.*) grasslands, Coolibah (*Eucalyptus microtheca*) and Gidgee (*Acacia georginae*) woodlands and Bluebush (*Chenopodium auricomum*) swamps, as well as some large intermittent lakes. These communities have high pastoral value and virtually the entire bioregion (97.2%) is contained within pastoral leases and used for grazing cattle on native pastures. Five large pastoral companies hold more than 80% of the region.

There are three small protected areas within the bioregion with a total area of 556km2 (0.6% of the bioregion area) although only Connell's Lagoon Conservation Reserve is managed as an IUCN category I-IV reserve. The two other reserves are exposed to continual or intermittent grazing pressure. These reserves incorporate samples of 6 of the 26 described vegetation types within the bioregion, and do not represent some vegetation types that are largely restricted to the bioregion. The reserve system is also inadequate in the representation of threatened species and significant wetlands.

The conservation values include a series of large but mostly impermanent wetlands of national significance, with some meeting criteria for international significance. These are important for waterbird populations. The region also has five threatened plants and animals, four of which are associated with wetland riparian areas. The bioregion harbours distinctive biota, although there have been possible losses of some species associated with wetlands and tall grasslands, and declines for species, such as the Flock Bronzewing (*Phaps histrionica*), which has proven relatively intolerant to changes induced by grazing.

Condition and trend

Much of the region's biota has been retained despite extensive pastoral land use. The very sparse historical record suggests regional losses of at least three mammal species and substantial decline for the Flock Bronzewing pigeon. Recent studies of the response of invertebrates, vertebrates and plants to grazing gradients suggest that a suite of species is disadvantaged by grazing and has probably declined substantially. Nonetheless, grazing pressure in the Northern Territory portion of this bioregion is generally less intensive than that in the Queensland portion where paddock sizes are generally smaller, and where areas are subjected to grazing by sheep.



Mitchell Grass Downs of *Astrebla spp.* and the annual Flinders grass, *Iseilema spp.* (P. Sattler).

There is a trend for increased pressure on species disadvantaged by grazing, because of increased development in the Northern Territory portion through proliferation of artificial water points, and more subdivision of paddocks.

Threatening processes

Pastoralism is the most pervasive factor affecting the region's biodiversity, especially in chenopod shrublands (bluebush swamps) and mitchell grasslands. Partly accompanying pastoral management, the region's biota may also be affected by altered fire regimes. There is almost no information available on the response of the region's biota to fire, but the widespread aim of fire exclusion would be detrimental to some species.

Several weed species, most notably parkinsonia (*Parkinsonia aculeata*), rubber bush (*Calotropis procera*), mesquite (*Prosopis spp.*) and noogoora burr (*Xanthium occidentale*) are generally increasing and are of environmental significance. Prickly acacia (*Acacia nilotica*) is a major environmental and land use problem in the Queensland portion of the bioregion, and has the potential to become a major pest in the Northern Territory portion.

Feral cats occur at high densities, particularly around bores and other water sources. Other exotic animals recorded include: house sparrow, house mouse, red fox, rabbit and are generally more localised or present less serious problems.

Management responses

Many of the conservation values of the bioregion are likely to be retained under responsible pastoral management that aims to sustain high cover of native perennial grasses. Some of the region's principal pastoral enterprises already operate under environmental codes of conduct which include this goal, and it is widely recognised within the area as the desirable and best practice.

Increased reservation would provide a greater level of security to site-specific values, notably significant wetlands and habitat for threatened species and guarantee the maintenance of some diffuse values such as maintaining populations of grazing sensitive species. Although new reserves need not be large, this approach is likely to be problematical because of the high cost of acquiring pastoral land and opposition from landholders.

A complementary approach to achieving these goals is the development of management agreements with pastoral landholders. This would guarantee the maintenance of a network of ungrazed or lightly grazed areas across the bioregion as on-property conservation areas. A system of management agreements based on existing water-remote areas may be achieved at relatively low cost. Costs would increase substantially if an adequate geographic and environmental spread of on-property conservation areas is to be achieved, as well as the protection of some site-specific values. Incentives and a strategic approach to support management by landholders is an essential first step.

Enhanced conservation management will be best achieved in the context of a detailed land use and conservation plan. Studies over the last few years have provided a good foundation for such a regional plan and it is now timely to develop a planning process, involving community participation and the consideration of a range of land use options and incentive packages.

Limiting factors

The major limiting factor to biodiversity conservation in this region is that the environments are the highest quality lands for pastoralism in northern Australia. Removal of lands from pastoral use to conservation reserves will be costly and unlikely to gain local community support.

Conservation efforts may need to be channelled into improved management of pastoral properties and would be extremely cost effective. Here, the major limiting factor is the impact of such changed management upon pastoral profitability. There are few incentives currently available.

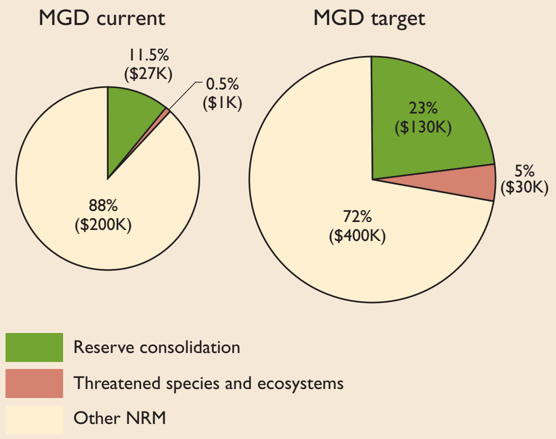


Figure 10.11 The differences in resources required and resources currently available to ensure adequate biodiversity conservation.

Isaac-Comet Downs (Brigalow Belt North 11) second highest stress class

The Isaac-Comet Downs subregion incorporates the Isaac, Comet, Upper MacKenzie Rivers as well as portions of the Fitzroy and Nogoa Rivers. Land uses include grazing native pastures, grazing improved pastures and some cultivation.

Predominant vegetation includes brigalow (*Acacia harpophylla*), Dawson gum (*Eucalyptus cambageana*) and residual vegetation including narrow-leaved ironbark (*E. crebra*), bendee (*A. catenulata*) or lancewood (*A. shirleyi*). Alluvium is dominated by brigalow or coolibah (*E. coolabah*).

The subregion contains important habitat for a diverse range of fauna (particularly birds) and habitat for rare and threatened species including star finches, platypus, turtles, the red goshawk and golden tailed geckos. Several properties have important stands of remnant brigalow, poplar box, ooline and bonewood, and possibly Bridled Nail-tail Wallaby populations. Important wetlands support high fish diversity, Freckled Duck populations and over 100 other waterbird species.

Condition and trend

Condition of riparian vegetation within the subregion is fair with a rapidly declining trend.

Of the 82 ecosystems, 29 are listed as endangered in Queensland and a further 19 considered as vulnerable but not protected on freehold land. The majority of threatened ecosystems are eucalypt woodlands with grassy understoreys and brigalow forest and woodlands. Most of the threatened ecosystems in the region are still declining although clearing of endangered ecosystems has been halted by recent legislative changes in Queensland.

There are 25 threatened species in the subregion. This includes five vulnerable and one extinct bird, one vulnerable insect, two endangered mammals, four vulnerable reptiles and nine vulnerable and three endangered plants. Threatened species are generally declining. For a large number of species, particularly plants, there is little information about their condition or trend.

Bottle tree, *Brachychiton rupestre* (P. Sattler).

Threatening processes

Broadscale vegetation clearing has resulted in less than 26% natural vegetation remaining and is a continuing, major threat to species. Grazing pressure, changed fire regimes and feral animals, in particular pigs, cats and foxes are additional threats to biodiversity. Extensive clearing has contributed to habitat fragmentation with many remnants below a size capable of retaining regional fauna diversity, has encouraged weeds, and changed hydrology. Those ecosystems occurring on alluvial soils and hills with shallow soils have the greatest number of threats.

Management responses

Isaac-Comet Downs' ecological health has been severely degraded and a coordinated strategy is imperative if some level of biodiversity conservation is to be achieved. The subregion, and indeed the whole bioregion, has the highest priority for reserve consolidation to secure the key remaining large areas of high conservation value. Lack of funding to quickly acquire and manage these remaining key areas is of serious concern.

case study

Major constraints exist to achieve off park conservation outcomes. The degree and rate of land clearing and fragmentation means that existing remnant vegetation within the subregion must be protected and managed for biodiversity conservation.

Restoration targets of 30% are now proposed in some catchment plans in parts of southern Australia to restore landscape function and biodiversity (refer chapter 9). The cessation of clearing in the Isaac-Comet subregion, where less than 30% vegetation remains, is therefore a priority to avoid costly restoration in the future. Appropriate mechanisms to end clearing and to reward property owners who retain vegetation above what might be a reasonable duty of care should be considered as part of structural adjustment.

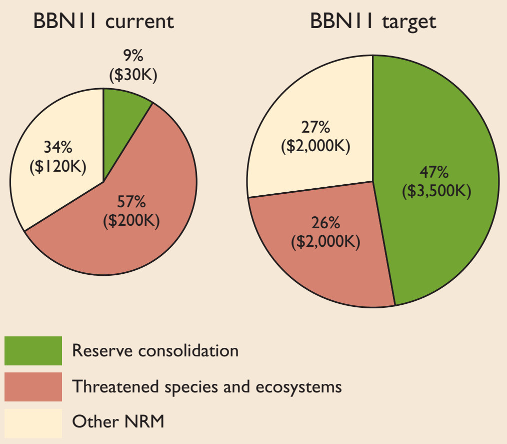


Figure 10.12 The differences in resources required and resources currently available to ensure adequate biodiversity conservation.

Incentives are needed to drive private land conservation. This includes encouraging the protection of regrowth to enhance key remnants, the management of habitat of threatened species and recovery of endangered ecosystems. Further protection of habitat with fencing to manage grazing pressure, and control of feral animals and weeds are other important management actions required.

A high number of species have no recovery plans or recovery actions identified and resources are needed for ecological research.

Avon Wheatbelt 2 Highest stress class

The Avon Wheatbelt 2 subregion is within the south-west corner of Western Australia. The dominant vegetation includes woodlands of Wandoo, York Gum and Salmon Gum with Jam and Casuarina and some areas of proteaceous scrub-heaths. The subregion is rich in endemics, on residual lateritic uplands and derived sandplains. Dominant land use is a mixture of dryland agriculture and grazing. Smaller areas used for conservation, crown reserves, forestry and rural residential. Special values include critical weight range fauna, ecosystems of high diversity, centres of endemism and refugia.

Condition and trend

There are two threatened ecological communities and five ecosystems at risk. All communities are either declining or rapidly declining, including wetlands of national importance and riparian zones. Species at risk are in fair or poor condition with a static or declining trend. The exceptions are two critical weight range mammals, Western Quoll (*Dasyrus geoffroii*) and the Black-footed Rock-wallaby (*Petrogale lateralis lateralis*), that show an increasing size of population and range as they respond to predator control and translocation strategies.

Threatening processes

Historic broad scale clearing has affected 93% of the native vegetation. Extensive clearing has contributed to a number of other threatening processes that are also affecting biodiversity, including:

- habitat fragmentation;
- grazing pressure from domestic stock, rabbits, and kangaroos;
- foxes and cats, which are the most important factors limiting populations of small mammals;
- exotic weeds, which cause modifications to habitat structure, smother native species, out-compete them for nutrients, water and light, prevent regeneration, and alter fuel loads;
- changed fire regimes;
- pathogens such as *Phytophthora* spp., *Armillaria* and fungal stem cankers;

Proteaceous scrub with 'Woody Pear' on deep yellow sand deposits associated with uplands of Tertiary plateau (N. L McKenzie).

- secondary salinisation of soil and water, waterlogging of some areas and death to most plant species; and
- poisons, especially agricultural pesticides and eutrophication of some wetlands.

Methods

Given the extent of vegetation clearing across the wheatbelt, consolidating the reserve system to meet comprehensive, adequate and representative thresholds may not be possible to achieve biodiversity conservation goals.

The Department of Conservation and Land Management is developing a conceptual framework for managing biodiversity in the wheatbelt using five key components:

1. A description of the key elements of the wheatbelt environment, including the cycles that drive component interactions
2. An aspirational goal and management goals that guide operational management
3. Description of the biological assets that must be conserved to achieve the aspirational goal and management goals
4. Description of threats to goal achievement, and their implications in ranking management

strategies, and identifying priority management units for action
5. Monitoring and evaluation methods that link goals, on-ground outputs and outcomes

Management responses

The situation for Avon Wheatbelt 2 biodiversity is very serious. The full effects of secondary salinisation of land and water, particularly in the eastern part of the subregion, will not be fully evident for another hundred years. There are a number of actions to prevent further loss of biodiversity, including:

- continued broad scale feral predator control such as already underway through the Department of Conservation and Land Management's Western Shield program to recover threatened species;
- commercial industries aimed at revegetation of deep-rooted vegetation based on regionally native perennial plant species;
- incentives, already involving revegetation and remnant vegetation fencing and may include earthworks or financial assistance for on-farm remnant vegetation management;
- legislation, with changes proposed to the *Wildlife Conservation Act 1950* and *Conservation and Land Management Act;*
- changing values and land use pattern with the purchase of bushland – this is already making a significant contribution to re-align land use;
- regional natural resource management groups, continuing restructure of some State agencies and establishment of Bush Brokers will add opportunities for improved conservation; and
- local government policies to apply State planning policy for the environment and natural resources to local decision-making.

There are many planning activities underway or proposed. These include:

- threat abatement planning and strategies implemented in the context of the State Salinity Strategy, Report of the Salinity Taskforce, Weed Management and Dieback Guidelines;
- industry Codes of Practice - such as Environmental Code of Practice – Extractive Industries, Environmental Management in the WA Mining Industry, Code of Practice for Timber Plantations in Western Australia and Roadside Conservation;
- Environmental Management Systems and ecological sustainable product marketing - the Wheatbelt Region of Department of Conservation and Land Management is preparing an Environmental Management System to identify values, threats, goals and prioritise management across the landscape;
- capacity building - with State agencies, regional natural resource management groups (eg. Avon Catchment Council), Greening Australia (WA) and World Wide Fund for Nature Australia (through Woodland Watch in particular); and
- property management planning, catchment planning and Landcare and now regional natural resource management strategies under local planning instruments.

A major difficulty is finding the resources to implement this suite of plans. On-ground actions by Department of Conservation and Land Management represent a significant contribution to biodiversity conservation in the sub-region at this time.

Limiting factors

A key constraint to biodiversity conservation is the lack of capacity including knowledge and available resources. The potential for incentives does exist, however for issues such as salinity, technical solutions that are economically viable to implement are a limiting factor. Legislation pertaining to the *Wildlife Conservation Act 1950* is limiting and the cost of policing legislation is prohibitive.

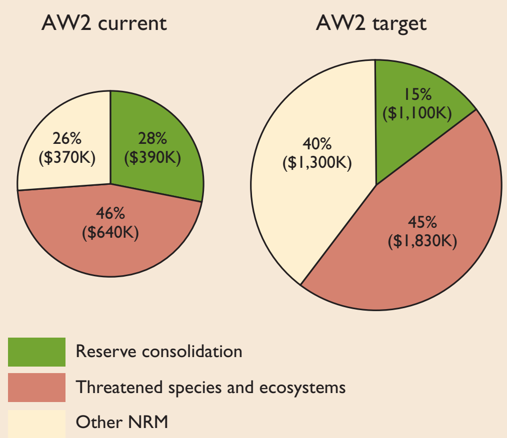


Figure 10.13 The differences in resources required and resources currently available to ensure adequate biodiversity conservation.

Chapter 10

Cumberland Plain (Sydney Basin 8) Highest stress class

The Cumberland Plain is the most highly developed portion of the Sydney Basin bioregion forming the major western area of greater Sydney. It is an area of gently undulating countryside and fertile soils developed for agriculture, and more recently, developed for residential and industrial uses as part of the expansion of Sydney.

Condition and trend

The Cumberland Plain is amongst the most threatened regions in NSW, with only 13% of the native vegetation cover remaining. Another 12% contains scattered trees with some native understorey. Several ecological communities are listed as endangered by the NSW Scientific Committee under the *Threatened Species Conservation Act 1995*. Two of these ecological communities have also been listed under the *Environment Protection and Biodiversity Conservation Act 1999*. Much of the remaining vegetation is still under threat from rural, urban and industrial expansion.

The region has five nationally important wetlands; Bicentennial Park, Longneck Lagoon, Newington Wetlands, Pitt Town Lagoon and Thirlmere Lakes. Wetlands of subregional importance include Baker's Lagoon and Bushells Lagoon.

Approximately 10% of the estimated extent of riparian vegetation remains. This remaining vegetation is important as habitat for species that only occur on riverbanks with deep alluvial soils close to the water table, and plays a significant role in maintaining aquatic ecosystems and riverbank stability. The riparian vegetation of the Cumberland Plain is highly significant as a wildlife corridor and includes threatened species, such as Camden White gum (*Eucalyptus benthamii*).

The NSW National Parks and Wildlife Service has identified and gazetted 10 endangered ecological communities. It is thought that all endangered ecological communities that occur on shale and alluvium derived soils are endemic to the area. There are 85 species listed under the *Threatened Species Conservation Act 1995* as endangered or vulnerable. The Commonwealth lists 35 species as endangered or vulnerable.

Leppington locality (NSW NPWS).

Threatening Processes

The largest threat to the ecosystems of the Cumberland Plain is urbanisation. Threats associated with the encroaching rural, residential, and industrial development are:

- clearing of remnant vegetation;
- further fragmentation of larger areas; and
- and exotic species, both plant and animal.

There is also considerable and growing pressure for access to bushland patches for formal and informal recreational purposes even where tree canopy is retained. Much of the perceived value of urban bush remnants is for sport – as green usable spaces, as opposed to conservation of biodiversity and ecosystem services *per se*.

Management responses

The National Parks and Wildlife Service is compiling a recovery plan for endangered ecological communities inside and outside of reserves. Planning NSW has an overall planning strategy for the region that covers the environment as well as planning areas of work, housing and access. The plan focuses on improved air and water quality, protection and management of waterways and riverine corridors, development of open space resources to allow recreation and protect biodiversity, protect biodiversity outside reserves and protect significant landscapes, European and Aboriginal heritage. At a local government level, the Biodiversity Planning Guide for NSW Local Government has been developed through funding from the NSW state Biodiversity Strategy. The guide helps councils to use existing planning mechanisms, such as local environmental plans, to achieve biodiversity outcomes. It shows councils how to:

- identify and assess biodiversity values;
- use biodiversity information to map development constraints and find opportunities for conservation;
- work out when planning and other tools are useful, and appropriate, to conserve biodiversity;
- use development/conservation incentives;
- choose from a range of options for on-the-ground management, such as fencing, fire controls, restrictions on access; and
- use planning tools and other mechanisms to conserve Aboriginal heritage, acknowledging the direct concern Aboriginal people have for biodiversity conservation and the overlap between Aboriginal cultural heritage and biodiversity.

A pilot program to trial the development of the plans is currently being undertaken with a small number of local councils.

In addition to two national parks, there are 9 nature reserves and 1 state recreation area, giving a total of 1.5% reserved area. Other areas of reservation include regional parks and public lands managed by local councils and the Commonwealth Government, including defence lands and local parks. The ecosystems of the Cumberland Plain are endemic, implying no possibilities for reservation outside the subregion. The potential to increase reservation is minimal because of the lack of remaining suitable land. Land that is suitable for formal reservation is often valued for other purposes and highly cost-prohibitive. The threatened communities are inadequately reserved and it is unlikely, recognising the pressures and alternate values, that recovery of biodiversity values will occur.

Future scenarios

Involvement of the local councils and communities through implementation of Local Government Biodiversity Action Plans and local community green corridors and open spaces provide opportunities to enhance biodiversity outcomes.

Recognising the high value of the land to competing uses a wide range of opportunities are being canvassed. These include:

- public or grant-aided purchase of priority areas;
- incentives to ensure protection;
- Environmental Funding Programs;
- agricultural land set aside schemes;
- wetland reserves;
- conservation easements;
- cost-sharing/management agreements;
- species enhancement schemes;
- incentive payments for organic farming;
- taxation measures;
- international biodiversity transfers; and
- regular auditing and re-assessment of conservation priorities.

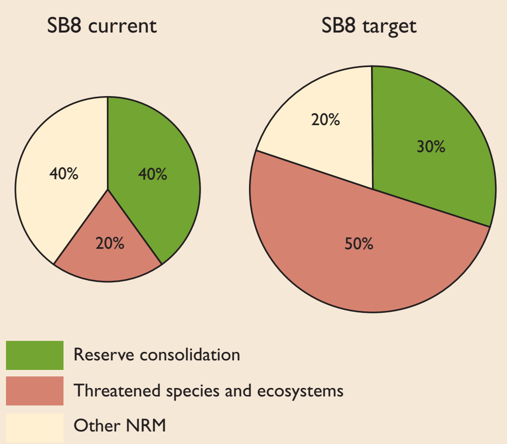


Figure 10.14 The proportional difference among strategies of resources required and resources currently available to ensure adequate biodiversity conservation.

Victorian Volcanic Plain | Highest stress class

The Victorian Volcanic Plain is an area of flat to undulating plains stretching from north of Melbourne to Portland in Western Victoria. The region is characterised by fertile volcanic derived soils that was covered with open grasslands and grassy woodlands, interspersed with stony rises and numerous volcanic eruption points, large shallow lakes and wetlands. Few major rivers cross the plain.

The Victorian Volcanic Plain was one of the first areas settled for agriculture in Victoria. Originally the Volcanic Plain was developed as pasture. Cropping and plantation forestry are now major land uses. There is very little public land.

A high quality remnant of Basalt Plains Grassland. This threatened ecosystem once covered over 75% of the subregion – approximately 1% remains and much of this is degraded (V. Craigie).

Condition and trend

Greater than 95% of all native vegetation has been cleared. Seventy-eight Ecological Vegetation Classes and floristic communities were mapped in the bioregion. Fifteen percent of these are probably extinct and 78% threatened. Plains Grassland and Grassy Woodlands once covered three quarters of the subregion. Today only approximately 1% remains, and much of this is degraded.

Sixty-five taxa are listed as nationally threatened and 173 as threatened in Victoria (15 mammals, 61 birds, 4 reptiles, 1 frog, 8 fish, 2 invertebrates and 93 plants). Twelve are listed as extinct. Twenty taxa were assessed as having declining populations, 18 as static and 6 as increasing.

Nine lakes are included in the Ramsar convention of wetlands of international importance. An additional twenty-six wetlands are listed in the Directory of Important Wetlands in Australia. Over 75% of shallow freshwater wetlands have been modified or destroyed and while most of the deeper permanent freshwater wetlands remain, their margins are often highly degraded. Waterways throughout the region are in poor health, with the majority of stream lengths being rated as in poor or very poor condition.

Threatening processes

The extreme depletion and relict nature of native vegetation and habitats including wetlands and the small size of the majority of remnants is the major threat to conservation of biodiversity. The impacts of severe fragmentation and lack of remaining habitat on vegetation communities and plant and animal populations are yet to be fully realised.

Major threatening processes include:

- dryland salinity;
- altered hydrological regimes,
- erosion and sedimentation;
- the modification or exclusion of fire regimes;
- predation by foxes and cats;
- environmental weed invasion; and
- prolonged intensive grazing by domestic stock, kangaroos, or rabbits.

Management responses

Nature conservation reserves occupy approximately 1.3% of the Victorian Volcanic Plain. Approximately 40% of ecological vegetation classes are represented in parks and reserves. Land acquisition through the National Reserve System Program has increased the reservation level of Grassland and Plains Grassy Woodland. A comprehensive investigation of all known unreserved high priority vegetation remnants has been carried out and identifies priorities for further protection and reserve acquisition.

Biodiversity conservation will rely heavily on management on private land and the network of road and rail reserves and other public land. Threatened species recovery actions have been systematically documented at a landscape scale for species identified as high priority in the Victorian Volcanic Plain as part of the bioregional Action Plan. An action statement under the *Flora and Fauna Guarantee Act 1988* has been prepared for the Western (Basalt) Plains Grassland Community, which was dominant across much of the subregion and is now extremely depleted. A process for prioritisation of protection, enhancement and restoration of native vegetation will be implemented through the Regional Native Vegetation Management Plans when these are finalised. Recovery actions are an immediate priority given the widespread extent of threatening processes, the extreme depletion of native vegetation and the vulnerability due to small size and isolation or habitat remnants and the populations they contain.

Integrated natural resource management activities are of great importance in the subregion to maintain basic ecosystem function and services and the biodiversity that is essential for and dependant on these processes. These activities are primarily coordinated through the strategies and associated plans of Regional Catchment Management Authorities (Glenelg-Hopkins and Corangamite) or the Port Phillip Catchment and Land Protection Board.

Relatively large areas of forest occur in the south-west of the region and these are widely used for resources, conservation and recreation. The management of these areas is under a Regional Forest Agreement that includes an assessment of forestry management and its impact on threatened species and communities.

Innovative projects with a biodiversity focus in the Victorian Volcanic Plains include a project to assess the potential impacts of raised bed cropping on biodiversity. This project will facilitate identification of areas where land use change may be detrimental to biodiversity. A second project is developing a biodiversity module for environmental management systems that integrate biodiversity management objectives into farm grazing practices.

The voluntary “Land for Wildlife” and conservation covenant programs have resulted in significant conservation gains. Fencing incentive schemes are targeted for biodiversity protection outcomes.

Other opportunities for improved natural resource management include incorporation of biodiversity conservation objectives into Local Planning Schemes, wider use of overlays and local policies to highlight and protect significant biodiversity values, and full implementation of local government roadside conservation plans.

Limiting factors

Opportunities for improving the occurrence of many vegetation types within the conservation reserve system are constrained by the limited areas of these communities remaining and hence the options available for either reservation of public land or purchase of private land. The generally high land prices across the Victorian Volcanic Plain, due to its suitability for agriculture or urban development, further limit opportunities for consolidating the reserve system.

Community capacity to undertake recovery actions is variable across the bioregion. It may be particularly limited where declining commodity values have reduced the profitability of dominant farming practices and alternatives have yet to be found. Improved stewardship schemes and further public investment would provide opportunities to increase the actions undertaken and strengthen the viability of some farming businesses. Increased access to information, technical training and key resources would greatly add value to these efforts.

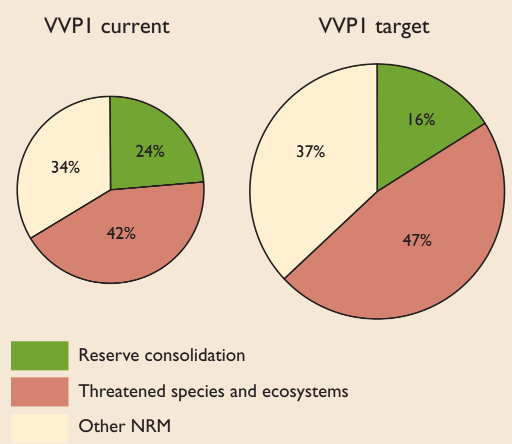


Figure 10.15 The proportional difference among strategies of resources required and resources currently available to ensure adequate biodiversity conservation.

Murrumbateman (South Eastern Highlands 6) Highest stress class

The Murrumbateman subregion is part of the South Eastern Highlands bioregion and traverses the Australian Capital Territory and New South Wales border. Land tenure is mainly private freehold land in New South Wales and leasehold in the Australian Capital Territory. The bioregion comprises grasslands and grassy woodlands, including some wetland and riparian communities. Much of the previous woodland area has been cleared and sown to improved pastures for grazing.

Land use is dominated by grazing, horticulture (grapes and olives), plantation forestry, and urban development. Only a relatively small area is formally reserved. Management for biodiversity conservation is largely in the hands of rural landowners and leaseholders.

Condition and trend

The natural temperate grasslands that are one of the dominant ecosystems in the Murrumbateman subregion is the most threatened ecosystem in Australia, having declined by 99.5% since European settlement. Similarly, the woodlands of the South Eastern Highlands bioregion are under threat from the combined factors of grazing, clearing, urban expansion and introduced plants.

The once widespread Yellow Box/Red Gum (*Eucalyptus melliodora / E. blakelyi*) grassy woodland community has been reduced in total area from 295,000 ha to 25,200 ha. A similar reduction has occurred with the native grassland (*Themeda sp / Danthonia sp*). The now highly fragmented distribution of these two communities mirrors the condition of all other native plant associations and communities. Fragmentation of the dominant vegetation communities has also resulted in the loss of connectivity of the communities across the landscape. Corridors between the larger areas of remnant native forest and woodlands, and west to east links are almost absent in the sheep-wheat area within New South Wales.

Associated with the decline of the formerly dominant grasslands and grassy woodlands is the reduction in abundance and distribution of many of the characteristic native plant and animal species.

Tinderry Nature Reserve from the Monaro Highway (NSW NPWS).

The latest figures for approvals for clearing native vegetation in NSW indicate that clearing continues in the subregion within New South Wales.

Threatening processes

The identified threats to biodiversity conservation have arisen primarily from rural land clearing and more recent rural residential development and urbanisation. Resulting impacts include:

- changed hydrology from farm dams and irrigation reducing water flow;
- predation by domestic cats on native fauna;
- grazing;
- salinity, particularly in the Yass River catchment;
- soil acidity in areas subject to pasture improvement and heavy application of artificial fertilisers; and
- reduction in groundwater and surface water quality following increased salinity and reduced surface run-off.

Management responses

Clearing of native vegetation should be immediately curtailed generally and specifically prohibited in those areas most greatly affected by past clearing, (eg the area of the sub-region in the sheep-wheat belt in New South Wales). There are few opportunities for acquisition of lands for the formal reserve system, and achievement of a comprehensive, adequate and representative reserve system is not likely to be achievable in the South Eastern Highlands bioregion. The emphasis for biodiversity conservation will be on off-reserve initiatives including establishing conservation management networks and conservation partnerships with landholders.

Action plans for the two major endangered ecological communities in the Murrumbateman subregion have been prepared for the ACT portion only. Recovery plans are in preparation for Box woodlands in NSW. The combined recovery programs will aim to assign conservation status at local and regional levels, and to identify opportunities for establishing conservation management networks.

There is considerable scope and capacity for landholder involvement and there is significant interest in doing so.

Several off-reserve initiatives in the ACT contribute to biodiversity conservation, including:

- urban open space (a statutory public land use zone under the ACT's territory plan);
- Memorandums of Understanding with Commonwealth Government agencies occupying land with threatened species or threatened ecological communities; and
- land management agreements covering leasehold rural land.

Limiting factors

A key requirement for achieving better biodiversity outcomes in the subregion is strategic coordination between government agencies, and between agencies and the private land owner communities. Provision of adequate resources is essential to support emerging cross-border cooperative programs for biodiversity conservation in the region.

Targeted rehabilitation and management programs are essential to support retention of existing areas with significant biodiversity values. The costs of revegetation can be prohibitively high. Using Yellow Box woodland as an example, it is estimated that some 7 to 8 million trees would have to be planted to raise the status of the Yellow Box woodland by about 1% from its current status of 4.5% extant occurrence. At about $2 per seedling planted, the costs would be a minimum of $14 to 16 million.

Future scenarios

Overall, the prognosis is for current levels of degradation and loss of biodiversity to continue unless there is considerable improvement in delivery of biodiversity conservation programs.

A coordinated program could be established within the context of conservation within the area of the region within the sheep-wheat belt. Such a program could include:

- activities to fully inform various decision making processes of the status and condition of biodiversity to NRM committees, Landcare, Local Government and other management groups and at the property level;
- curtail of broad scale clearing generally, and prohibit any further clearing in those areas most greatly affected by past clearing;
- increased investment in conservation initiatives for both reserve and off-reserve lands including tax and other financial incentives, covenants and other conservation agreements;
- support for programs that integrate conservation into land management plans and activities and provide management information across the landscape; and
- building upon existing cross-border cooperation for biodiversity conservation planning by ensuring appointment of a lead independent agency to broker and coordinate activities across all parties.

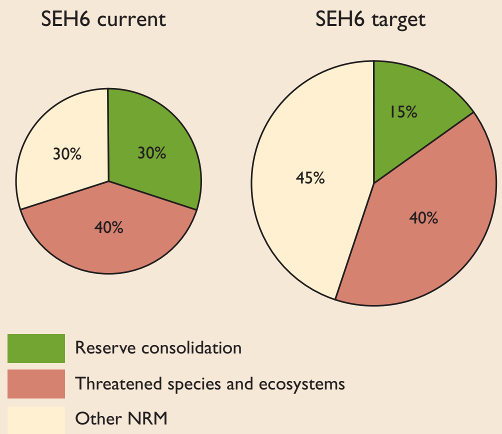


Figure 10.16 The proportional difference among strategies of resources required and resources currently available to ensure adequate biodiversity conservation.

Tasmanian Northern Midlands Highest stress class

Soils of the Northern Midlands are diverse and predominantly sandy, supporting extensive agriculture and forestry. More than 95% of the bioregion is in private ownership. Less than 30% of the area remains as native vegetation.

The bioregion has significant biodiversity conservation values, including:

- 10 plant species endemic to the bioregion (including 7 endemic orchids);
- two endemic freshwater mussels, and endemic freshwater snails and caddisflies;
- 32 nationally threatened taxa;
- more than 180 plant and animal species listed by the *Tasmanian Threatened Species Protection Act 1995;*
- 24 nationally threatened plant species which have a restricted distribution in Tasmania, most of their range within the bioregion with very high regional conservation significance; and
- 12 wetlands listed on the Directory of Important Wetlands in Australia, and 10 wetlands of regional significance.

The comprehensiveness, adequacy and representativeness of the reserve system are extremely low with most of the threatened ecosystems not protected in reserves. Less than 2% of the bioregion is protected (0.7% in reserves and 1% in nature refuges).

Condition and trend

The Northern Midlands was the second area in Australia to be settled and there has been a history of vegetation clearance and degradation. Less than 30% of the original vegetation remains - much of it in scattered small remnants in poor condition. There has been significant loss or degradation of wetlands and riparian vegetation is degraded and in decline.

Threatening processes

The past two decades have seen major changes in this landscape with serious and continuing problems of vegetation loss and degradation, soil erosion, degraded river systems, dryland salinity, rural tree decline, denuded north-facing slopes and weed invasion. There is widespread concern over the threat posed by weeds such as gorse (*Ulex europaeus*) and willows (*Salix spp.*).

The threatened lowland Poa Tussock grassland ecosystem (L. Gilfedder).

Threatening processes for riparian zones are broad scale vegetation clearing, increasing fragmentation and loss of remnants, firewood collection, grazing, feral animals, weeds, salinity, changed hydrology (in-stream and off-stream dams), pollution, increased sediment loads and bank erosion, and simplification of riparian vegetation.

Land clearance is often associated with the conversion of native grasslands to crops such as opium poppies and potatoes. The region's upper catchments are subject to timber harvest operations, and commercial firewood harvesting is widespread. Some lowland forest ecosystems that have been identified as threatened continue to be cleared. The bioregion has some of the most severe dryland salinity in Tasmania, with over 60% of potentially affected land systems in Tasmania occurring in this bioregion, and in excess of 30,000 ha potentially at risk. One of these potentially affected land systems at Tunbridge in the south of the region contains 6 key wetlands and an important nature reserve.

A recent spate of credible fox sightings in the region signals a new and potentially devastating threat to biodiversity. The persistence of some threatened vertebrates in Tasmania has been attributed to the absence of foxes. Were this pest to become established in the Northern Midlands it might precipitate the extinction of species that are already in decline such as the Eastern Barred Bandicoot, Southern Brown Bandicoot, Tasmanian Bettong and Southern Bell Frog.

Management responses

Tasmania Together is a long term strategic plan that has been developed by the community through wide-ranging consultation. Tasmania Together has established indicators and targets in a number of areas relating to biodiversity and natural resource management. Reservation benchmarks for forest and non-forest vegetation are being established and targets to 2010-2020 for the percentage of land to be protected either by legislation, covenant or management agreements. In addition, the Tasmanian Government has developed a Tasmanian Natural Resource Management Strategy to guide the future management of natural resources across the State.

With less than 2% of the bioregion reserved in the protected area network and little public land in the area, the focus of conservation planning is off-reserve conservation initiatives. A total of 67,093 ha (56786 ha forest and 10307 ha non-forest) has been identified as rare, vulnerable or endangered ecosystems or as ecosystems with a high conservation priority.

The need for action to reverse the decline in the extent and condition of native vegetation in the region is urgent and is reflected in the formation of 54 community-based groups who are trying to reverse the trend. Over $2m has been spent in the past year alone on natural resource management issues.

A number of projects funded by the Natural Heritage Trust have achieved significant conservation outcomes and improved awareness of conservation issues:

- Midlands Bushweb - a devolved regional project, is implementing a Rate Rebate Scheme across 3 councils and an Environmental Levy scheme is being investigated as a possible means of funding rate rebates beyond the life of the Natural Heritage Trust.
- The Protected Areas on Private Land Program has covenanted a total of 181 ha on three properties, and the Private Forest Reserves Program has 1106 ha on nine properties and one management agreement covering 113 ha. Three purchases have also been made for a total of 775 ha.
- Land and Water Australia and Australian Wool Innovations are jointly funding a project to develop and promote the adoption of viable sheep grazing systems to provide for ecologically sustainable agriculture and protect biodiversity in the Northern Midlands bioregion of Tasmania. A key issue is the integration of biodiversity conservation into sustainable grazing systems.

Limiting factors

The lack of public land in the bioregion means there is little opportunity to add to the protected area system without a significant acquisition program. It could cost over $46m to establish a protected area system using a mix of acquisition, covenants and management agreements. Strategic revegetation to achieve 30% native vegetation cover on the lower slopes of the bioregion could cost over $98m and take 50 years or more to achieve. Complementary initiatives will require voluntary participation from landowners with incentives or stewardship schemes to facilitate voluntary participation.

Future scenarios

Severe degradation and loss of biodiversity will continue unless considerable resources are made available for recovery actions and reserve consolidation. Recent changes to legislation have led to vegetation clearance controls for forest vegetation. These need to be extended to non-forest ecosystems. Local government authorities will need to incorporate vegetation retention targets into their planning processes. Retiring land from production may be an option for some producers, and agricultural accreditation, particularly in the wool industry, may be a real incentive for biodiversity protection and improved environmental management.

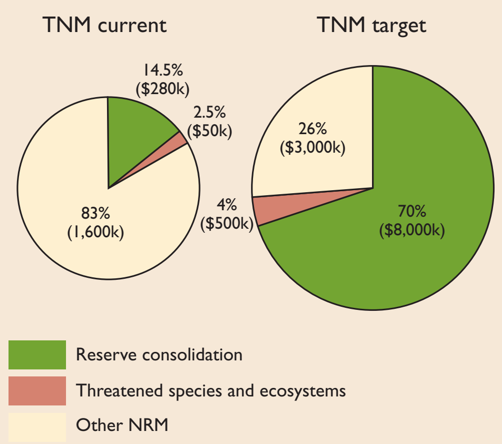


Figure 10.18 The differences in resources required and resources currently available to ensure adequate biodiversity conservation.

Chapter 10

Goldfields (Victorian Midlands 1) Highest stress class

Grassy Woodlands naturally dominated the Victorian Goldfields with Box Ironbark Forest, Heathy Dry Forest and Grassy Dry Forest ecosystems dominating the lower slopes or poorer soils. The Goldfields has a unique and relatively early history of European settlement due to the gold rushes. The landscape has been radically changed within the last 150 years. Most of the region is private freehold used for agriculture. There are also large blocks of public land.

Condition and trend

Native vegetation now covers around 28% of the Goldfields bioregion. Modelling of pre-1750 native vegetation indicates 41 different ecological vegetation classes would have been present. Thirty-four of these have been identified in existing native vegetation, one is listed as probably extinct and six represent minor occurrences of an ecological vegetation class more typically found in adjacent bioregions. About 11% of the existing area of native vegetation is endangered, 6% vulnerable and 68% depleted. The condition of the threatened ecological vegetation classes is generally declining, and the condition of the majority of the box-ironbark vegetation is highly modified.

Forty-three taxa listed as nationally threatened and 146 listed as threatened in Victoria have been recorded in the subregion (6 mammals, 42 birds, 4 reptiles, 1 frog, 6 fish, 4 invertebrates and 87 plants). Of the taxa in the subregion 15 were assessed as having declining populations, 13 as static and 8 as increasing.

Threatening processes

The selective loss of the more fertile vegetation types, fragmentation of remnant native vegetation and the degraded nature of much of that which remains are the overarching issues which compound the impacts of the many other threatening processes in the Goldfields. Past clearing has resulted in the loss of most of the habitats on more fertile land and fragmented and isolated populations of taxa that survive in the box-ironbark remnants. The size and condition of the remnant patches of native vegetation may be insufficient to support viable populations of many native plants and animals. Woodland birds are declining across the bioregion. Clearing continues to have a minor impact, particularly associated with subdivision for rural living around regional centres.

Box Ironbark Forest: one of the dominant and characteristic Ecological Vegetation Classes in the Goldfields (P. Kinchington).

Key threats include:

- grazing, both along watercourses, where it is often associated with weed invasion, and of those vegetation types where only relicts survive, often largely on private land and linear reserves such as road and stock reserves;
- over-browsing by kangaroos and vegetation destruction and erosion caused by rabbits;
- predation by foxes and cats;.
- timber and firewood harvesting changes the structure of the vegetation and can decrease habitat values by removing large old trees and dead timber;
- changed fire regimes;
- changed hydrological cycles, reduced stream flows, nutrient input and increased sedimentation and algal blooms; and
- mining and fossicking.

A number of other threatening processes have been identified in the subregion.

- Recreational uses may conflict with conservation values on public land, through physical disturbance or damage to flora populations.
- Illegal removal of orchids is a significant impact for some taxa.
- *Eucalyptus* oil production impacts upon relatively restricted mallee eucalypt species (e.g. Blue Mallee) which may be dominated locally by this high-disturbance, single-use activity.
- Cinnamon Fungus, a water-borne root pathogen, has been detected in Rushworth State Forest within the bioregion.
- The Goldfields bioregion contains numerous eucalypt species which, when in flower, are highly sought-after by apiarists. An ongoing issue is the potential competition for nectar resources between managed hive-bees and native nectar-feeders, but opinion is divided as to the level of ecological threat to the natural biota posed by managed honey bees.

Management responses

Approximately 3.5% of the Victorian Goldfields is within conservation reserves. About 60% of Ecological Vegetation Classes are represented in reserves. Reserve consolidation is a priority over the next 1 to 5 years. Candidate areas to improve the comprehensiveness, adequacy and representativeness of the reserve system have been identified and will be implemented through the Victorian Government's response to the Environment Conservation Council's final report on the Box-Ironbark Forests and Woodlands. This will double the area of reservation.

Threatened species recovery actions have been systematically documented at a landscape scale for species identified as high priority in the Goldfields as part of the Bioregional Action Plan.

Ecosystem recovery planning is at an earlier stage. A process for prioritisation of protection, enhancement and restoration of native vegetation will be implemented through the Regional Native Vegetation Management Plans. Recovery Actions are a priority over the next 5 years given the rapid progress and widespread extent of threatening processes and the fragmentation and coverage of remnant native vegetation.

Four Catchment Management Strategies provide the framework for planning and action. Landholders are generally receptive to conservation issues, time and money being the principal obstacles to their fuller adoption. "Good Neighbour" programs for pest plant and animal control and cooperative management agreements address management issues across both public and private land. The development of a biodiversity component for farm Environmental Management Systems is being trialed in the subregion. Incentive schemes, both the voluntary "Land for Wildlife" and conservation covenant programs have resulted in significant biodiversity gains. BushTender, where landholders tender to provide defined biodiversity benefits through management of significant remnants, has been successfully trialed. Increasing the capacity of local government has also been identified as an important step in enhanced biodiversity outcomes. The great majority of NRM actions are an immediate priority because of the high rate of landscape degradation, vegetation loss, and the widespread nature of many threatening processes.

Limiting factors

Constraints to recovery actions on private land include the levels of funding available from various grant and incentive schemes, often with strong competition, which may lead to discouragement of unsuccessful applicants. This is compounded by the small number of extension officers with suitable knowledge of the diversity of funding sources to guide the planning and implementation of on-ground works. Increased coordination possibly through some form of brokering arrangements is essential.

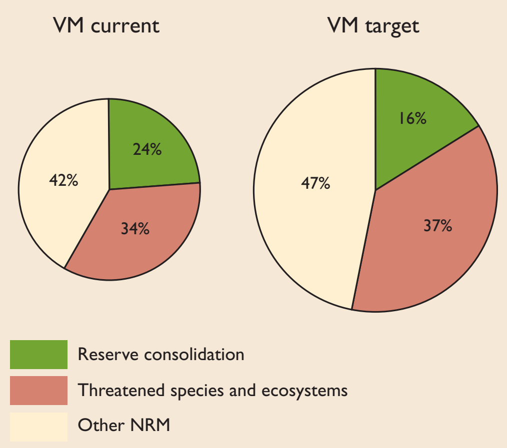
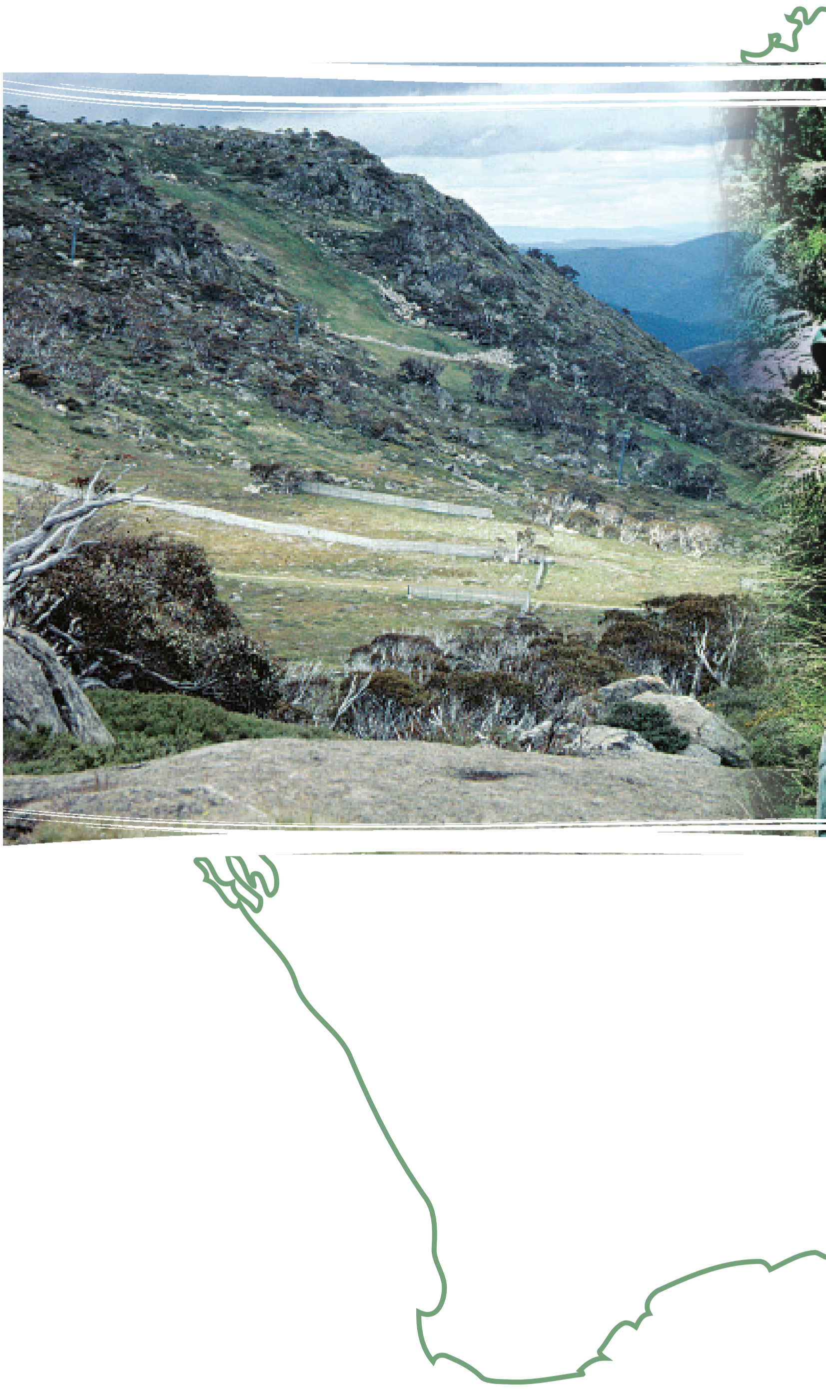


Figure 10.17 The proportional difference among strategies of resources required and resources currently available to ensure adequate biodiversity conservation.



11. Ways forward - providing the information to underpin effective biodiversity conservation

Summary

Ghost Gum, *Eucalyptus papuana*: Mt Isa Inlier (P. Sattler)

SUMMARY

Each of the chapters in this report summarises some of the key management activities required for the conservation of Australia's biodiversity. Synthesising priorities in the context of policy and investment strategies is beyond the scope of this assessment and is a necessary follow-on activity by Australia's nature conservation agencies. This chapter concentrates on opportunities for collecting and enhancing information to monitor biodiversity and inform management priorities.

To meet the increasing demand on the use, productivity and health of our natural resources, Australia should implement an integrated and coordinated monitoring and assessment program, building on State and Territory activities. For Australia's terrestrial biodiversity, this would cover its condition and status, trend and management needs using an hierarchical and landscape based bioregional monitoring and assessment program that tracks change in species, populations and ecosystems, determines the impact of threatening processes, details management activities and assesses opportunities for improved management.

The bioregional, subregional and ecosystem hierarchy that underpins the Terrestrial Biodiversity Assessment provides a sound scientific basis for monitoring condition and trend. Considerable support from partner agencies exists for the Biodiversity Assessment data to be further enhanced as a fully distributed and linked information system across jurisdictions.

Distributed and linked information systems refer to a similar database operating in each jurisdiction with a standard set of fields but with the flexibility to add unique fields relevant to their particular needs. This type of information system allows for cost-effective, timely and relevant updates by State and Territory lead agencies. A strategic and systematic approach to monitoring and reporting on Australia's terrestrial biodiversity requires a strategic analysis of the existing database in order to define and clarify information needs and link to other data sets.

Coordination is best undertaken through the continued National Land and Water Resources Audit with clearly identified partnership arrangements with Commonwealth, State and Territory agencies. The Audit would provide technical support through ensuring the database is part of and linked to other datasets within the Australian Natural Resources Data Library and corresponding State and Territory data library systems under the Australian Spatial Data Infrastructure. Information collated from the databases and linked to other natural resource information should be provided through the Australian Natural Resources Atlas and corresponding State and Territory information systems.

This assessment identified some necessary improvements to the existing biodiversity database:

- an update where new data are known to be available but not yet included in the current national database
- a review of cross border data and standardisation of qualitative components of the assessment
- better definition of the key attributes for threatening processes and for species and ecosystem management
- refinement of the information on wetlands, threatened ecosystems and threatened species

Assessing and reporting on the condition of Australia's terrestrial biodiversity needs to be an ongoing process. Five-yearly intervals are likely to be most cost-effective for Australia-wide assessment and reporting, working closely to the time scale of major management programs and maximising opportunities to inform these programs. Ongoing assessment at five-yearly intervals would also link to and inform the Australian State of the Environment reporting process

Building Australia-wide Biodiversity Information

The Terrestrial Biodiversity Assessment was limited in scope and resources. It was undertaken in one year with $1M. Within these limitations it has clearly shown the commitment of all States and Territories to working collectively and with an Australia-wide focus to provide information. Most importantly, it has demonstrated the role of information in setting priorities for investment in biodiversity conservation at both national and regional scales.

The Audit's Final Report (NLWRA 2002c) details nine recommendations as to the way forward to assess and manage Australia's natural resources based on information that set priorities and foster increased understanding of the key issues. In summary, these recommendations cover:

- information, the currency for implementing sustainable development;
- translating information into priorities and actions;
- tracking changes in natural resource condition and use;
- integrating social, economic and biophysical components of natural resource management;
- assessments, the key to improving programs and policies;
- meeting changing client demands and providing information on emerging issues;
- maximising returns on investment in data collection;
- coordinating data collection and the provision of information; and
- establishing an Australia-wide natural resources information agency with a formal process of review and provision of strategic advice on natural resource priorities and investment.

All of these components of a strategic approach to information delivery apply to terrestrial biodiversity information activities.

Specifically, tracking changes in terrestrial biodiversity is included in recommendation 3 of the Final Report as follows:

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

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

Implementation of this recommendation could be part of the functions of the continuation of the Audit as part of natural resource monitoring and should complement the range of existing processes relevant to biodiversity information and reporting. These include the National Framework for Natural Resource Management Standards and Targets, the National Natural Resource Management Monitoring and Evaluation Framework and the National Action Plan and Natural Heritage Trust regional delivery model. The following sections detail the key activities required to meet this recommendation and deliver information that will support investment in biodiversity management.

Warrumbungle National Park (NSW NPWS).

A Bioregional Framework

There has been a growing trend towards the more widespread use of bioregional planning by the States, Territories and Commonwealth since the inception of the Interim Biogeographic Regionalisation for Australia (IBRA) in 1995. The Biodiversity Assessment and several other assessments undertaken by the Audit have utilised the IBRA framework and the IBRA subregions as units for analysis. With each Audit assessment the States and Territories have increasingly committed to this bioregional approach for data collection and analysis because of its functionality and veracity for biodiversity conservation planning. Two things have emerged from this process. Firstly, the clear benefits of the States and Territories being directly responsible for data collection and interpretation. Secondly, the importance of the agreed IBRA framework as a mechanism for unifying both data collection and interpretation to enable continental overviews to be built up from local spatially referenced datasets.

There is an array of regional frameworks for program delivery and other administrative purposes. To avoid unnecessary duplication and confusion, biodiversity monitoring should reflect an established ecological framework rather than contemporary administrative arrangements. Administrative arrangement can change dramatically over time and thus provide limited benefits for the monitoring of Australia's biodiversity. The bioregional, subregional and ecosystem hierarchy that underpins the Audit approach reflects patterns within the natural environment and provides a sound scientific basis for monitoring trend and condition of terrestrial biodiversity.

Distributed and Linked Information Systems

Distributed information systems allow for cost-effective, timely and relevant updates by State and Territory lead agencies. Revision of the data collated for this assessment and Australia-wide adoption of an ongoing system for tracking the condition of terrestrial biodiversity requires the following steps:

1. Strategic analysis of the existing database to:
   - reassess and define information needs and therefore determine key data fields
   - specify and facilitate data queries and reporting that meets the client needs for information
   - identify information gaps
   - define links to other information within the Australian Natural Resources Data Library such as the National Vegetation Information System
   - define links to the National Frameworks for Monitoring and Evaluation and Standards and Targets
   - define process that allows State and Territory agencies to add additional fields to suit individual needs
2. Design a revised database that:
   - meets the requirements specified in the strategic analysis
   - specifies agreed standards for data fields
   - is linked and distributed across jurisdictions with overall version control maintained by a lead agency
3. Implementing an Australian terrestrial biodiversity information system which will involve:
   - building the database structure
   - refining standards for data collection and collation in all States and Territories
   - fostering commitment within key agencies as well as links to other data collection activities within States and Territories such as those for native vegetation, river condition and estuary condition
   - gaining resources to fill key gaps
   - undertaking assessment and reporting, demonstrating the role and management relevance of the system
   - determining processes for collation, assessment, distribution, client access and reporting

Roles and Responsibilities

Coordination of this set of tasks should be reviewed in terms of the proposed future direction of the National Land and Water Resources Audit. Technical support will also need to be reviewed and at least, the database should be linked to other datasets within the Australian Natural Resources Data Library and corresponding State and Territory information systems under the Australian Spatial Data Infrastructure.

Provision of information collated from the databases and linked to other natural resource information is probably best provided through the Australian Natural Resources Atlas and corresponding State and Territory information systems. Assessment and reporting would meet various client needs and might be done Australia-wide as part of the next Australian State of the Environment Report in 2006-2007.

Key Information Gaps and Improvements to the Data Collated

During this assessment, corrections were made directly to the maps and output tables. The original database needs to be updated to include these corrections and additional data that have since become available. Cost-effective version control of the database is required to ensure current and correct information is available to all clients.

Differences in the scale of data available across State and Territory borders make Australia-wide assessments difficult. As part of the process to update data sets and information for biodiversity-related decision-making, the report supports the progressive use of more quantitative data together with a collective review amongst all partners of the standards and methods. This approach is currently being used to develop measurement methods for performance indicators related to the National Monitoring and Evaluation Framework.

Refining standards for updating biodiversity data is essential.

For example, the qualitative rankings of condition and trend, and the interpretation of threats and management constraints present opportunities for inconsistency of interpretation to occur. The progressive use of more quantitative tools together with a collective review amongst all partners of standards and methods is part of the process to upgrade data sets and information upon which management decisions can be made. Similarly, more comprehensive and compatible spatial data sets are required to inform assessments.

It is difficult to link changes in species distribution and population abundance with threatening processes. This knowledge is essential to plan species or ecosystem protection or recovery. Research activities ranging from comprehensive vegetation mapping and monitoring of spatial change in vegetation, through to understanding life history and ecological requirements of particular species are required. In addition, systematic fauna survey and collection of floristic data are needed to assess the impacts of landscape change. Findings of these research initiatives would inform the next assessment and specify further the key attributes to be monitored.

Regionally significant wetlands were identified Australia-wide in most jurisdictions for the first time as part of this assessment. Completion of the identification of these wetlands and further data on their biodiversity values, condition, trend and management needs would be valuable for regional conservation and management initiatives, as would a more complete delineation of their spatial extent and occurance.

Nocoleche Nature Reserve (J.Winters/NPWS).

The provisional list of threatened ecosystems across Australia is one of the significant outputs of this assessment. The scale of delineation of threatened ecosystems varies. In some States and Territories it has not been possible to determine the proportion of threatened ecosystems across bioregions because of differing scales of ecosystem data available within the bioregion. More comparable delineation of ecosystems across bioregions and assessment of their condition require further investigation. In addition, the linking of these threatened ecosystems with the National Vegetation Information System's Major Vegetation Subgroups provides the first broad grouping of threatened ecosystems to compare where strategic conservation effort is required. The grouping of threatened ecosystems into finer categories is desirable, as well as for on-ground interpretation of protection and recovery strategies, and this represents a key aspect for the future development of the National Vegetation Information System. This would contribute to the development of whole of landscape biodiversity conservation planning.

The database could be refined by further cross-referencing of threatened species with subregional trend and threatening processes and to identify groups of threatened species for multi-species recovery planning. This would assist in developing a more strategic approach to recovery planning.

The eucalypts and acacias component of the assessment demonstrate the need to consider biodiversity values that are not specifically associated with threatened species issues, especially endemism, richness and irreplacability. Extension of this work to other taxa would be a useful addition to the Biodiversity Assessment and provide further information of relevance to management.

A strategic review of priorities for further data collection would recognise the role of modeling to complement mapping and monitoring activities. The strategic review would also need to address the issues of distributed database systems and how any new Australia-wide system interfaced with or enhanced existing systems, such as the database developed to support the *Environment Protection and Biodiversity Conservation Act 1999.*

Integrated Natural Resource Information and Management

While the Terrestrial Biodiversity Assessment may have been limited in scope and resources, it has demonstrated the importance of information in setting priorities for investment in biodiversity conservation at both the national and regional levels. The information provided through the assessment provides context for regions across Australia in the development of their plans in response to the requirements of both the National Action Plan for Water Quality and Salinity and the extension of the Natural Heritage Trust.

The challenge before each of these regional groups is how best to utilize these various information sets to create a regional investment strategy, trading-off various values and determining the most cost-effective and achievable activities to improve the productive and environmental quality of their landscape, refer Box 11.1.

The Australian Natural Resources Atlas will soon have the capability to subset relevant regional information from the Australia-wide information. The next step, requiring consideration as part of the Audit Phase 2, is the development of decision support tools and knowledge brokering activities that assist the regional groups translate these information sets into strategies and activities for their region and allow the evaluation of various investment options.

Much remains to be done at the regional scale. The information provided through the Biodiversity Assessment provides the context for developing key biodiversity management strategies. In addition, it identifies where some major constraints to achieving effective biodiversity outcomes as part of integrated natural resource management may occur. It should be noted that the information reflects our current state of knowledge and data collection and significant gaps remain. These constraints and any identified opportunities should be further investigated so as to inform the development of regional investment strategies.

Box 11.1 Working towards integrated natural resource management

Integrating total catchment management with bioregional planning for biodiversity can provide an effective framework for improved natural resource management and the achievement of biodiversity outcomes.

A mix of tools is required to address natural resource management and biodiversity issues at a range of scales. These tools include:

- **preventative measures** such as land use planning that recognises the constraints and capabilities of the land and alternative market and non-market values;
- **protective measures** that protect key natural areas managed principally for nature conservation and the maintenance of landscape function;
- **rehabilitation measures** that target key degraded resources and threatened biodiversity values;
- **extension measures** that build an understanding of how natural systems operate and of appropriate practices to maintain ecosystem function, biodiversity and sustainable production;
- **decision support systems** that integrate biophysical, social and economic needs;
- **best practice management** that seeks continuous improvement in natural resource management so that biodiversity outcomes are effectively integrated and external costs are minimised;
- **demonstration sites** to provide examples of improvement as catalysts for change;
- **policy initiatives** that translate natural resource management aspirations into outcomes;
- **incentives** to off-set the costs that individuals often bear when implementing practices to manage and protect common property resources;
- **legislation and regulatory approaches** to underpin natural resource outcomes; and
- **monitoring and evaluation** to assess progress of resource condition and program outcomes.

Coordination, Continuation and Sponsorship

The Biodiversity Assessment is the first step in providing Australia-wide information on terrestrial biodiversity. As well as additional information on the attributes collated and the inclusion of other aspects of biodiversity, biodiversity information needs to be related with other natural resource information that describes the Australian landscape. Most importantly, collection and collation of biodiversity data and its interpretation need to be linked with other monitoring activities that are designated as part of Audit Phase 2 responsibilities. These include Australia-wide monitoring of rangelands, soil condition, water quality, water use, river and estuary condition, native vegetation, resource accounting and dryland salinity.

The coordination role of Audit Phase 2 should be to continue the Australia-wide partnerships and to ensure inter-relationships with other datasets so that Australia-wide information is provided to meet client needs. Sponsorship within the States and Territories, championing and leading the collection and collation of biodiversity information for a particular jurisdiction is probably best undertaken through their lead nature conservation agency and will need to be formalised as part of Audit Phase 2.

Assessment and reporting of the condition of Australia's terrestrial biodiversity needs to be an ongoing process. Five-yearly intervals are likely to be most cost effective for Australia-wide assessment and reporting, working closely to the time scale of major management programs and maximising opportunities to inform these programs. Ongoing assessment at five-yearly intervals would also link into and inform the Australian State of the Environment reporting process.

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Chapter 5 - Birds

Primary authors:

- Stephen T. Garnett, Queensland Environment Protection Agency;
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Chapter 6 - Mammals

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Chapter 7 - Acacias and eucalypts

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ABOUT THE NATIONAL LAND AND WATER RESOURCES AUDIT

Who is the Audit responsible to?

The Minister for Agriculture, Fisheries and Forestry has overall responsibility for the Audit as a program of the Natural Heritage Trust. The Audit reports through the Minister for Agriculture, Fisheries and Forestry to the Natural Heritage Board also comprising the Minister for the Environment and Heritage.

How is the Audit managed?

An Advisory Council manages the implementation of the Audit. Dr Roy Green, with a background in research, science policy and management chairs the Advisory Council. Members and observers on the Advisory Council and the organisations they represent are: Drew Clarke (ANZLIC), Warwick Watkins (LWRRDC), Bernard Wonder (AFFA), Stephen Hunter (EA), John Radcliffe (CSIRO), Peter Sutherland (SCARM), Jon Womersley (SCC), Roger Wickes (SCARM) and Colin Creighton (Audit).

What is the role of the Audit Management Unit?

The Audit Management Unit's role has evolved over its five-year life. Phases of activity include:

Phase 1: Strategic planning and work plan formulation—specifying (in partnership with Commonwealth, States and Territories, industry and community) the activities and outputs of the Audit—completed in 1998–99.

Phase 2: Project management—letting contracts, negotiating partnerships and then managing all the component projects and consultancies that will deliver Audit outputs—a major component of Unit activities from 1998–99 onwards.

Phase 3: Reporting—combining outputs from projects in each theme to detail Audit findings and formulate recommendations—an increasingly important task in 2000–2001 and the early part of 2001–02.

Phase 4: Integration and implementation—combining theme outputs in a final report, working towards the implementation of recommendations across government, industry and community and the application of information products as tools to improve natural resources management— the major focus for 2001–2002.

Phase 5: Developing long term arrangements for continuing Audit-type activities—developing and advocating a strategic approach for the continuation of Audit-type activities—complete in 2001–2002.

The Audit Management Unit has been maintained over the Audit's period of operations as an eight-person multi-disciplinary team. This team as at December 2001 comprises Colin Creighton, Warwick McDonald, Stewart Noble, Maria Cofinas, Jim Tait, Rochelle Lawson, Sylvia Graham and Drusilla Patkin.

How are Audit activities undertaken?

As work plans were agreed by clients and approved by the Advisory Council, component projects in these work plans are contracted out. Contracting involves negotiation by the Audit to develop partnerships with key clients or a competitive tender process.

Facts and figures

Total Audit worth, including all partnerships – in excess of	$52 m
Audit allocation from Natural Heritage Trust	$34.19 m
Percentage of funds allocated to contracts	~ 92%
Total number of contracts	130

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