


Bioregional Summary  
of the  
2002 Biodiversity Audit  
for Western Australia



*A contribution to the development of Western Australia's  
biodiversity conservation strategy*





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Edited by N.L. McKenzie, J.E. May and S. McKenna



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## Acknowledgments

This project was jointly funded by the National Land and Water Resources Audit and the Western Australian Department of Conservation and Land Management.

Paul Sattler and the staff of the National Land and Water Resources Audit defined and funded the project.

The regional accounts contained in this document have drawn on the subregional synopsis reports (cross referenced to the synopsis document) and information contributed by:

Western Australian Museum, Perth Herbarium, Western Australian Threatened Species and Communities Unit (WATSCU), Sally Black, David Blood, Jenna Brooker, Andy Chapman, Mike Clarke, Gary Connell, John Dell, Alex George, Stuart Halse, Sheila Hamilton-Brown, Natalie Jolakoski, Bronwen Keighery, Greg Keighery, Kevin Kenneally, Michi Maier, Libby Mattiske, Jelena May, Sue McKenna, Norm McKenzie, Keiran McNamara, Nathan McQuoid, Shaun Molloy, Alan Payne, David Pearson, Jeff Richardson, Tony Robinson, Geoff Stoneman, John Stretch, Roy Teale, Klaus Tiedemann, John Woinarski, Gordon Wyre and many others.

Front cover photo: Spinifex pigeons by Peter Kendrick.

Back cover photo: A weed infested lily pond in the Pilbara, by Jiri Lochman.

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## Foreword

Western Australia is recognised internationally for the incredible diversity of its native plants, animals and ecosystems. The south-west of the State, for example, is one of the world's 25 biodiversity 'hotspots'. This is because of the large number of species, the fact that a high proportion of them are endemic, and that they face significant threats to their continued survival. But threats to biodiversity are not confined to the south-west – they exist across all the bioregions of the State.

In recognition of this, the State Government is preparing new legislation that will provide a framework for biodiversity conservation and protection for the 21st Century. This is part of an integrated approach that also will involve the development of a Biodiversity Conservation Strategy for Western Australia.

In 2001–02, the Department of Conservation and Land Management undertook an extensive audit of the State's terrestrial biodiversity as part of the National Land and Water Resources Audit Biodiversity Assessment. This was undertaken to provide a basis from which to determine the priorities for conservation action and has been published by the National Land and Water Resources Audit in summary form.

This document – Bioregional Summary of the 2002 Biodiversity Audit for Western Australia – provides a summary of the findings for each of the biogeographic regions. The companion volume – A Biodiversity Audit of WA's 53 Biogeographical Subregions 2002 – provides the far more detailed information gathered for each of these subregions during preparation of the national audit. Both volumes are an important contribution to the development of the State's proposed Biodiversity Conservation Strategy and will be significant references for Government agencies, other research institutions, landowners, natural resource management groups, community organisations and people generally interested in conserving the State's natural biodiversity.

Although the 2002 Biodiversity Audit is a 'snapshot in time', over the next few years, gaps in the information will be addressed and the audit will be updated. It is therefore a dynamic process that will continue to add to our knowledge and, combined with sound science, will assist in conserving the State's biodiversity for its intrinsic value and for the benefit of present and future generations.

The State Government acknowledges the contribution of staff of the Department of Conservation and Land Management and the WA Museum to this audit. It also acknowledges the Commonwealth Government for its assistance with funding for the audit through the National Land and Water Resources Audit of the Natural Heritage Trust.



*Judy Edwards*

Dr Judy Edwards MLA  
Minister for the Environment



*Keiran McNamara*

Keiran McNamara  
Executive Director  
Department of Conservation  
and Land Management

September 2003

# Introduction

This report summarises the nature conservation issues that Western Australia's biogeographical regions faced in 2002.

The data and interpretations presented are based on first-hand experience. They were compiled from 53 subregional 'synopsis reports' prepared by the Department of Conservation and Land Management's regional nature conservation staff. These synopses were compiled between July 2001 and January 2002, and are being published as a separate, more detailed report.

By providing an overview of the status of the species and ecosystems in each region's lands and waterways in terms of a consistent set of criteria, this report provides a broad, systematic basis for assessing conservation priorities among different parts of Western Australia. It also indicates the likely consequences for biodiversity if no action is taken.

Its parent document, the 'subregional synopses' publication, provides a more detailed comparison and contributes to an audit of nature conservation issues Australia-wide.

We expect that there will be a range of gaps and omissions in this initial edition, and that the next version (in about two years) will address these. No summary is included for bioregions that are predominantly in the Northern Territory or South Australia – these are the Central Ranges, Ord Victoria, Tanami Desert and Victoria Bonaparte bioregions. The information will become more extensive as data continues to be gathered and nature conservation work in Western Australia progresses.

In many instances, the reader will become aware that a bioregion, subregion or area is under ecological threat from forces ranging from grazing, to salinity, to weed control. Some of these problems are challenging, and in some places they are not being well managed. Where feasible, potential solutions have been indicated.

These solutions need to become part of the day-to-day management of our lands and waters, with the hope that they will result in an improvement to the status of the environment.

Western Australia signed contracts to complete this State-wide biodiversity audit after a meeting of representatives from the various State, Territory and Commonwealth environmental agencies held in April 2001. A broader Australia-wide project was carried out and published under the auspices of the Natural Heritage Trust's National Land and Water Resources Audit (Australian Terrestrial Biodiversity Audit 2002).

The contributing authors are Gordon Graham (Kimberley), Peter Kendrick and Fran Stanley (Pilbara), Anthony Desmond and Alanna Chant (Mid-West), Mark Cowan and Brad Barton (Goldfields), Brett Beecham (Wheatbelt), Kim Williams and Roger Hearn (Jarrah Forest), Roger Hearn (Warren), David Mitchell (Swan) and Sarah Comer, Sandra Barrett, Lawrie Anderson and Klaus Tiedemann (South Coast).

The photographs used in this report have been chosen to represent the character of each bioregion.

Norm McKenzie and Jelena May  
Science Division  
Department of Conservation and Land Management  
Western Australia

# Avon Wheatbelt



Acacia community on vegetation remnant in the foreground, wheat fields with saline flats in the background, Avon Wheatbelt Bioregion, W.A.  
Photo: B. Beecham



## Description

### Bioregional description and biodiversity values

This region is a dissected plateau of Tertiary laterite in the Yilgarn Craton. Its climate is semi-arid (dry) warm Mediterranean. There are two subregions – the eastern and western parts.

The eastern subregion is an ancient, gently undulating plain of low relief and ancient drainage that has dissected the plateau. There is no connected drainage; salt lake chains occur as remnants of the ancient drainage systems and now only function in very wet years. Residual lateritic uplands are dominated by derived yellow sandplain covered in proteaceous scrub-heaths, which have a high number of endemic plant species. Mixed eucalypt, sheoak and jam woodlands dominate on Quaternary alluvials and eluvials.

The western subregion comprises gently undulating rises to low hills with abrupt breakaways. Its drainage is rejuvenated and comprises continuous stream channels that flow in most years. Alluvial and eluvial processes are active. Residual lateritic uplands and derived sandplains are covered by areas of proteaceous scrub-heaths (which are rich in endemics). Quaternary surfaces of erosional slopes and valley floors support woodlands of wandoo, York gum, jam and casuarina.

Land uses are primarily dryland agriculture and grazing. Smaller areas include Crown reserves (mainly conservation estate), mining operations and rural residential communities.

The region has been extensively cleared for agriculture and grazed by stock, and consequently has numerous environmental problems, threatened ecological communities and species at risk. It is an interface between the south-western forests and the Transitional Rainfall Zone, and its rich flora includes many endemics, particularly in *Grevillea*, *Hakea*, *Verticordia*, *Eucalyptus*, *Acacia*, *Dryandra*, *Ihotskya*, *Eriostemon*, *Wohlia*, *Baeckea*, *Melaleuca*, *Chamelaucium*, *Micromyrtus*, *Thryptomene* and the Asteraceae family. Approximately 25 per cent of the declared rare flora in WA occurs in eucalypt woodlands in this region. Rare features include extant populations of critical weight range mammals, plant communities of granite outcrops, gypsum dunes, the Wongan Hills greenstone belt and associated laterite-capped mesas and Toolibin Lake.

### Overall condition and trend

Remnant vegetation, wetlands, riparian systems, populations of species and ecosystems at risk are in poor condition, with the trend expected to decline. Extensive clearing of native vegetation has led to salinity problems (expected to affect up to 30 per cent of the region's area). Both subregions have a continental stress class of one (awful).

### Conservation priorities

Threatened ecosystems and populations of threatened species need to be preserved. There needs to be a focus on protecting remaining populations of threatened species, both on and off reserves. Reserves and other ecosystem remnants low in the landscape need to be protected from salinity and excessive inundation. Weeds, fire, pathogens, feral herbivores and predators on reserves and other vegetation remnants should be controlled. Clearing should be halted. An integrated whole-of-landscape approach to landscape management is required.

### Nationally important wetlands

The five wetlands of national importance are lakes and rock pools (Yorkrakine Rock Pools, Coyrecup Lake, Dumblebung Lake, Toolibin Lake and Yealering Lakes System).

Their condition is fair but all are declining. Recovery will require significant management intervention. The causes of the decline are water diversion, excessive damage (by off-road vehicles to vegetation mats, water skiers and vandalism), water pollution (fouling by stock and rabbits), exotic plants (bridal creeper *Asparagus asparagoides*), salination (surface inflow, rising water table) and excessive inundation.

Siltation and eutrophication (agricultural fertilizers) are killing the remaining live trees, leading to algal blooms and the disappearance of surrounding vegetation.

### Wetlands of regional significance

Four wetlands are considered to be vital to the preservation of biological processes at a regional level. These are:

- the Mollerin Lake System,
- the Buntine to Marchagee Braided Saline Drainage Line,
- Cowcowing Lake and
- the Mortlock River System.

Their condition is either good or fair but all are predicted to decline due to increases in water salinity and siltation.

## Riparian zone

The principal streams and catchments are the Avon, Blackwood and Moore-Hill River headwaters and the occluded salt catchment area of the Yarra Yarra River. All watercourses are reported as being degraded as a result of virtually all native vegetation having been cleared around them. The trend is for further rapid decline. Threatening processes include vegetation fragmentation, grazing pressure, exotic weeds, pathogens, increasing salinity and altered flow regimes.

## Ecosystems at risk

One Threatened Ecological Community (TEC) has been declared critically endangered, five are endangered and four are vulnerable under WA legislation. One is now presumed extinct (Morilla Swamp). The critically endangered community is the Perched Wetlands of the Wheatbelt region with extensive stands of living swamp sheoak (*Casuarina obesa*) and paperbark (*Melaleuca strobophylla*) across the lake floor, which occurs at Toolibin Lake, and on private property in the Shire of Dowerin. The trend for the critically endangered and endangered wetlands is rapidly declining; that of vulnerable TECs ranges between declining and rapidly declining. Key threatening processes are:

- vegetation clearing,
- exotic weed invasion,
- increased salinity,
- altered flow regimes and
- feral animals.

Other ecosystems at risk include:

- wetlands and riparian areas,
- thickets or forests with emergent *Eucalyptus* spp., plant assemblages of the Wongan Hills System,
- brown mallet communities low in the landscape,
- red morrell woodland communities of the western wheatbelt,
- wheatbelt mottlecrah (rose mallee) and
- microbial, invertebrate and plant assemblages of natural saline seeps.

All these other ecosystems at risk are in fair condition and are declining, with the exception *Banksia prionotes* and *Xylomelum angustifolium* on low level sandplains and Tamma-Dryandra-Eremaea shrublands on cream sands of the Ulva landform unit, which are both in near pristine condition and static in trend.

All non-TEC ecosystems at risk are threatened by:

- clearing,
- landscape fragmentation,
- salinity and changed hydrology,
- grazing,
- weed invasion and
- changed fire regimes.

In addition to ecosystems listed above, vegetation associations found on valley floors and lower slopes have been extensively cleared and are subject to secondary salinity.

## Species at risk

There are 45 plant species that have been declared as critically endangered, 39 as endangered, 26 as vulnerable and one is extinct under WA legislation. Critically endangered fauna include two invertebrates, both trapdoor spiders (Yorkrakine and Minnivale).

Endangered species include one mammal and one bird. Three mammals, two birds, one reptile and one invertebrate are vulnerable. More than 35 per cent of the Avon's original mammal fauna is now regionally extinct.

All plant species are threatened by:

- vegetation clearing,
- fragmentation,
- salinity and changed hydrology,
- grazing,
- weed invasion and
- changed fire regimes, and
- occasionally *Phytophthora* sp.

They are generally only in fair condition. Trends range from being static to declining rapidly.

Mammals are threatened by:

- feral predators,
- vegetation clearing and
- fragmentation.

Other animals are threatened by vegetation clearing and fragmentation, as well as salinity, changed hydrology, grazing, weeds and changed fire regimes. Large numbers of ground dwelling invertebrates are locally endemic and face extinction from salinity if their populations are confined to valley floor woodland. Fauna are declining or remaining static although the rock wallaby (*Petrogale lateralis lateralis*) is improving in condition under fox control.

# Management responses

## Reserve system

There are 468 nature reserves, and one conservation park in the bioregion. They range in size from less than a hectare to more than 10,000 hectares, with an average area of 452 hectares in the eastern part and 214 hectares in the western part. Most reserves are small and isolated by wheatfields. They are dominated by sandplain, pavement and breakaway surfaces high in the landscape, the uppermost reaches of valleys, and saline drainage floor surfaces.

Nineteen of 159 vegetation associations have high reservation priority because they are at risk and not yet reserved, or are reserved only as fragments. These include:

- sheoak,
- York gum,
- *Casuarina obesa* woodland,
- melaleuca woodland,
- medium woodlands and saltbush over samphire,
- mallet and blue mallet,
- salmon gum and gimlet,
- scrub-heath on sandplain,
- *Melaleuca* thicket on valley floors,
- *Allocasuarina campestris* scrub,
- *Dodonaea* scrub,
- jam, and
- mallee and broombush over samphire.

In addition, 18 at risk ecosystems are not reserved or are poorly reserved and are a high priority for reservation. These include:

- the riparian area of the Avon,
- wheatbelt mottlecah,
- Morilla Swamp,
- herbaceous plant assemblages on bentonite lakes,
- salt flats plant assemblages of the Mortlock River (east branch),
- *Banksia-Xylomelum* communities on low level sandplains,
- Tamma-Dryandra-Eremaea shrublands,
- perched clay wetlands of the wheatbelt,
- plant associations of the Billeranga, Inering, Wongan Hills, Koolanooka, and Moonagin Systems,
- assemblages of natural saline seeps and
- *Melaleuca* thickets with emergent Eucalypts.

Most ecosystems or vegetation associations with a high reserve priority are the woodlands and shrubland communities on the fertile quaternary soils of valley

slopes and valley floors. These valley floors have been extensively cleared to provide land for agriculture and grazing, and are salt affected.

Constraints on reserve acquisition:

- Some ecosystems have already been cleared below CAR thresholds (generally below 10 per cent).
- Most remaining areas of lowland ecosystems will be lost to salinity.
- There are insufficient resources to acquire and manage an increased conservation estate.
- There are more than 1000 reserves that have some conservation function, but most are tiny fragments.
- There is competition with other government agencies and local government for remaining fragments.

Both subregions are in the highest class of IBRA Reservation Priority (Class 1) because clearing has been extensive, and rising saline groundwater threatens up to 30 per cent of the landscape. The reserve management standard is poor: salinisation is not managed (except for the highly localised ground water pumping at Toolibin Lake). Fox baiting occurs on 9.7 per cent of the conservation reserve estate. Fires are infrequent. Weed control is minimal.

## Off-reserve conservation for species and ecosystem recovery

Priority species and ecosystems include:

- critical weight range mammals and threatened birds,
- biota of granite outcrops, and
- Declared Rare Flora especially on roadsides and of lowland communities.

Recovery actions for all species and ecosystems include:

- habitat retention through reserves, private lands and other state lands, as well as weed control,
- feral animal control,
- fencing,
- fire management,
- survey and mapping work,
- incentives for landholders to conserve communities,
- control of mining activities (particularly gravel),
- pumping to control water table (especially lowland areas),
- translocation,
- revegetation,
- germplasm storage and
- capacity building with local government authorities and landholders.

Constraints on some of these actions include:

- many species are locally extinct (particularly mammals),
- habitat patches large enough to sustain many vertebrate populations no longer exists,
- predators need to be controlled,
- there is no viable technology to control salinity,
- a lack of survey data and knowledge on habitat requirements, and
- a lack of staff resources.

Both the eastern and western parts have priority rank of 1 for off-reserve conservation.

### Integrated natural resource management (NRM)

NRM initiatives include incentives for revegetation, fencing remnant vegetation and abating threats such as dieback, feral animals, fire, salinity and weeds.

To this end, industry codes of practice and integrated regional management plans exist, and environmental management systems are being prepared. State agencies and non-government organisations are interacting to build capacity among landholders and to implement strategic plans, including new industries based on native biota, particularly deep rooted perennial plants.

The main constraints on success include:

- the lack of resources (human and infrastructure) for implementation,
- the lack of rigor in the NRM area,
- a poor understanding of the relevant socio-political processes,
- the lack of economically viable technical solutions,
- the need for more controls on land clearing and
- drainage.

While various Acts protect wildlife and soils, there is no duty of care legislation.

Both the eastern and western parts have an NRM rank of 1, which indicates major constraints to implement effective NRM actions to achieve biodiversity outcomes

### Major data gaps and research priorities

- A field survey of biodiversity in relation to physical landscape attributes is required in vegetation remnants. This commenced in 1999.
- Robust biodiversity surrogates need to be identified, as does population viability in the context of the region's fragmented landscape and fire.
- A standardised database and GIS application is also essential for data querying and management.

# Carnarvon



Low open woodlands of Mulga and Bowgada over herbfield on red sandy plains of central Carnarvon Bioregion, W.A.  
Photo: N. Gibson

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## Description

### Bioregional description and biodiversity values

This bioregion comprises Quarternary alluvial, aeolian and marine sediments overlying Cretaceous strata.

It is a mosaic of saline alluvial plains with samphire and saltbush low shrublands, Bowgada low woodland on sandy ridges and plains, snakewood scrubs on clay flats, and tree to shrub steppe over hummock grasslands on and between red sand dune fields. Limestone strata with *Acacia stuartii* and *A. bivenosa* shrublands outcrop in the north, where extensive tidal flats in sheltered embayments support extensive mangroves.

The climate is arid, semi-desert to sub-tropical with variable summer and winter rainfall. Cyclonic systems may affect the coast and hinterland annually. The bioregion contains two subregions, Cape Range and Wooramel.

Special values include the islands of Shark Bay, Exmouth Gulf, the Muiron group, the Lowendal group, the Barrow group and the Montebello group. All are important for sea turtle breeding and seabirds. These islands also support populations of endangered mammal species, some of which are no longer found on the mainland.

The karst system of Cape Range has a large troglobitic fauna of international significance, with Bundera Sinkhole having the only known example of Remipede (*Lasionectes exleyi*) community in southern hemisphere, and Camerons Cave supporting a unique assembly of terrestrial and aquatic troglofauna.

Extensive mangroves occur along the southern and eastern coast of Exmouth Gulf.

The extensive and diverse wetland system of Lake MacLeod is rich in aquatic invertebrates and waterbirds. The region is a centre of evolutionary radiation for the lizard genus *Lerista*, and has many locally endemic species.

### Overall condition and trend

Most pastoral landscapes in the region are poor or degraded with widespread loss of soil litter layers and mineral A-horizon. Even the main river channels are occluded with sand. The trend is to decline, as goats continue to replace sheep and cattle as the main source of income for the pastoral industry.

Nearly 50 per cent of the region's original non-volant mammal fauna is now extinct. The continental stress class of the bioregion is three (medium). It would be rated worse than this, except for three factors - the loss of native vegetation biomass and soil has not been measured, there are several large reserves in the region, and the extensive areas of sandplain and dunefield are mostly in good condition because they provide poor grazing for stock and feral herbivores.

### Conservation priorities

The coverage of the reserve system needs to be improved. The islands need to be protected from disturbances. Feral animal, fire and weed control is a priority across all lands. Management of pastoral lands needs to be re-emphasised towards protecting biodiversity values, including soil profile conservation.

### Nationally important wetlands

There are six nationally listed wetlands including subterranean karst systems, brackish to saline lagoons, intertidal flats, marshes and swamps, ephemeral freshwater lakes and swamps, salt pans and beaches.

Five are in good condition and static in their trend but one is in a fair condition and declining rapidly (McNeill Claypan).

Threatening processes are:

- pollution,
- grazing by feral animals (goats),
- increased salinity,
- weeds,
- mining fragmentation,
- inappropriate tourism and
- fishing.

### Wetlands of regional significance

There are nine wetlands of regional significance comprising major rivers. Conditions range from poor in the case of wetland sections of the Wooramel, Gascoyne and Minilya Rivers to good for the subterranean waterways of Barrow Island to good for Yardie Creek, Bay of Rest, Ningaloo Reef and intertidal communities of the Montebellos.

The only subregionally significant wetland in near pristine condition is Mangrove Bay.

Trends for most wetlands are to decline and others are likely to remain static. The rivers are particularly important. They control alluvial processes throughout the region, and their riverine ecosystems act as biological refuges. Threatening processes include:

- changed hydrology from massive sediment loads,
- weeds (buffel grass and Athel pine),
- grazing pressure from cattle and
- feral animals (foxes, cats, rabbits and goats).

## Riparian zone

The bioregion includes riparian zones associated with the western (lower) reaches of the Wooramel, Gascoyne, Minilya, and Lyndon Rivers. Their catchments have the same name, but are almost entirely in the Murchison and Gascoyne bioregions, to the east.

All riparian zones are degraded and infested with buffel grass. Permanent and semi-permanent pools are affected by cattle, sheep and goats and are declining in condition. Threatening processes are:

- grazing pressure,
- feral animals (cattle, sheep horse, goats and rabbits) and
- weeds.

## Ecosystems at risk

Two threatened ecological communities have been declared as Critically Endangered under WA State legislation (both are cave communities). However, at least 26 other ecosystems are known to be at risk.

These include:

- stygofauna,
- coastal marine,
- ephemeral creeklines,
- permanent soaks,
- plant, invertebrate and reptile assemblages,
- mangrove,
- floodplain and
- samphire.

Most of these degraded ecosystems are declining in condition. The main threatening processes are feral animals (fox, cat, goats and rabbits) and grazing pressure.

## Species at risk

Under State legislation, 20 invertebrates are listed as endangered, including arachnids, crustaceans and millipedes – all of which are cave dwellers or stygofauna.

Most populations are in good condition but the trend for all species is unknown. Seven mammals, two birds, five reptiles and two fish are listed as endangered. Further, one mammal, one bird and two reptiles are listed as vulnerable.

Those mammal species still persisting on the mainland, as well as the bird species, are at risk from feral predators, fragmentation of habitat and grazing pressure.

Most listed mammals are restricted to islands off the coast of the mainland. These island populations are not subject to current threatening processes but would be susceptible to the introduction of disease, feral predators or a loss of genetic diversity.

The main threatening process for invertebrate species is pollution. Only one species of Declared Rare Flora is recorded for the bioregion (*Thryptomene wittweri* which is vulnerable). Its population is only in fair condition (see Glossary) and declining. It is at risk from grazing by feral goats.

# Management responses

## Reserve system

Regional conservation lands include:

- three national parks (Cape Range, Francois Peron and Kennedy Ranges),
- one marine park (Ningaloo),
- two conservation parks (Bundegi and Jurabi),
- four large nature reserves (Toolonga, Bernier Island, Dorre Island and Barrow Island) and
- many smaller island nature reserves (Gulf islands, Muiron Island, and Lowendal, Barrow and Montebellos groups).

The 762,866 hectares of conservation estate occupies 8.3 per cent of the bioregion with 46 of the 100 vegetation associations reserved.

The management of reserves is ranked as fair because, although foxes are baited effectively on one national park, there is usually poor access for management vehicles.

Only a minimal goat control program exists, even though grazing by both goats and rabbits is widespread. Virtually no fire management occurs and there is considerable public use of islands and coastal reserves. Significant conservation work is being undertaken on some islands.

Fifty-eight vegetation units, including 18 ecosystems at risk, have a high priority for acquisition.

They include:

- mosaic grassland,
- sedgeland with low trees,
- hummock grasslands,
- hummock grasslands with shrubs and low trees,
- shrublands,
- mosaic shrublands,
- woodlands,
- succulent steppe,
- mangroves and
- bare areas (mud flats, claypans and salt lakes).

There are constraints in terms of the cost of land and in terms of implementing management. Competing land uses include prospective mining interests (limestone and oil) over karst, and pastoral production. Inappropriate recreation developments (marina resorts) are also proposed.

### Off-reserve conservation for species and ecosystem recovery

The main recovery actions for species include:

- monitoring populations,
- controlling feral animals (including goats),
- translocation efforts,
- habitat protection and retention, and
- protecting turtles from human activities.

The main recovery actions required for ecosystems at risk include habitat retention, weed control on islands, fencing of sensitive areas where there are heavy goat numbers, feral animal control and fire management. A significant off-reserve effort is needed for the bioregion. However there are resource constraints and limited community capacity.

### Integrated Natural Resource Management (NRM)

Institutional reform through the Gascoyne Murchison Strategy represents major initiatives to purchase pastoral leases for conservation estate.

Threat abatement planning as part of NRM includes:

- the limited management of feral animals on the pastoral estate,
- vegetation management plans and
- pest management.

The mining (and oil) industry has various codes of practice. Integration with property management planning, catchment planning and Landcare through Landcare District Committees are delivering conservation biodiversity benefits.

Further opportunities for NRM include:

- tighter legislative control over pastoral management to control feral animals;
- structural reform of the grazing industry on State lands so that a range of natural resource benefits are emphasised, including the protection of biodiversity, noting that some pastoral areas are already attempting to implement ecologically sustainable practices through processes developed by the Rangelands Environmental Management Program of the Gascoyne-Murchison Strategy;
- specific management of islands including the control of goat, fox and weeds; and
- the Code of Practice for the oil industry including specific measures to protect troglifauna and sea turtles (lighting).

Constraints include the Land Administration Act and operations of the Pastoral Land Board which both require Pastoral Leases to operate in ways that may be inconsistent with conservation. There is a need to increase awareness of conservation values through education of major industries (mining, agricultural) and the public in general.

### Major data gaps and research priorities

There is an urgent need for substrate mapping at better than 1:250,000 scale. Quadrat-based biodiversity survey data is sparse and confined to Wooramel and Cape Range. As a result, there is little data to provide a regional context on population trends for ecologically significant species.

These species include:

- mammals,
- spinifex reptile communities,
- ants and termites, and
- weeds such as buffel grass, kapok bush and ruby dock.

Detailed data is required on species' ecological requirements, life histories and effect of disturbing processes. This applies to virtually all invertebrate species (including troglotic species), plants, persisting critical weight range mammals, uncommon vertebrate and plant species, and even to ecologically dominant plant communities such as hummock grasslands.





The Montebellos.  
Photo: P. Kendrick

# Central Kimberley



Tropical savanna of eucalypts  
over annual grassland on  
undulating footslopes of rugged  
sandstone King Leopold Ranges,  
Central Kimberley Bioregion, W.A.  
Photo: N.L. McKenzie

## Description

### Bioregional description and biodiversity values

The bioregion is hilly to mountainous. Its parallel siliceous ranges of Proterozoic sedimentary rocks are partially mantled by skeletal sandy soils supporting *Triodia* spp. hummock grasses and scattered trees. Earths on Proterozoic volcanics in valleys support ribbon grass (*Chrysopogon* spp.) with scattered trees. Open forests of river red gum (*Eucalyptus camaldulensis*) and *Pandanus* spp. occur along drainage lines.

The climate is dry hot tropical, sub-humid to semi-arid, with summer rainfall.

There are three subregions:

The Pentecost subregion is the true central Kimberley. It is mostly underlain by middle Pentecost sandstone strata, with King Leopold and Warton sandstone ranges along its southern peripheries. Large areas are mantled by Cainozoic soils and there is moderate dissection by several rivers (Durack, Chamberlain and Fitzroy).

The Hart subregion is dominated by Hart dolerite exposed along the eastern edge of the Kimberley Craton where basement strata are folded. It is the driest subregion, has a rugged topography, and is the headwaters of the Ord, Dunham and Fitzroy Rivers.

The Mount Eliza subregion is on the south-western edge of the Kimberley Craton. It is very rugged with intense folding and exposure of basement strata such as King Leopold sandstone.

Two of the Kimberley's major rivers, the Fitzroy and the Ord, originate in this bioregion. It is fox and rabbit free and essentially uninhabited. The exposed folding of the rock strata in the King Leopold Ranges is of particular note. The Declared Rare Flora *Eucalyptus mooreana* is found in this bioregion.

### Overall condition and trend

The Mt Eliza subregion has a continental stress class of six (near pristine), while the other two are rated as five (see Glossary). However, the effects of late dry-season fires, feral animals and stock are equally evident in all three subregions, and substantial changes to vegetation structure are ubiquitous. The trend is for a continued decline.

### Conservation priorities

A change in current fire management and feral animal and stock control practices is required across the entire landscape, including conservation reserves. A formal region-wide assessment of species and ecosystem status and of the impact of fire, grazing and weeds is essential. Substantial reservation effort is required to fill gaps in the reserve system.

### Nationally important wetlands

One permanent freshwater lake (Gladstone Lake) is listed as nationally important for the maintenance of ecological processes, migratory species, and as a drought refuge, breeding and feeding ground for a diversity of taxa. Its condition is good but declining. The primary threatening process is grazing pressure from cattle.

### Wetlands of regional significance

The only wetland of subregional significance is Windjana Gorge which includes a river that runs seasonally and is significant for the maintenance of ecological processes. The condition is near pristine, the trend is static but the threatening process is grazing.

### Riparian zone

Vegetation along creeks and rivers is in good condition, but declining. Threatening processes, acting independently or jointly, include:

- changed fire regimes,
- grazing pressure from feral herbivores,
- weeds and
- changed hydrology in the catchments as a result decreasing perennial vegetation cover and loss of top soil in the savanna.

### Ecosystems at risk

No Threatened Ecological Communities have been declared in the region, although 10 ecosystems are considered to be at risk. They include:

- tropical and sub-tropical rainforest,
- tropical forests and woodlands,
- paperbark forests and woodlands,
- herbland, sedgeland and rushland and
- freshwater lakes.

The rainforests are in fair condition but declining rapidly; the other ecosystems are fair to good with undocumented trend. The main threatening processes are:

- grazing pressure,
- weeds and
- changed fire regimes.

More work is required in this bioregion to define ecosystems at risk and threatening processes.

## Species at risk

One bird is listed as endangered, and three are declared as vulnerable under State legislation. The threatening processes for individual vertebrates are poorly understood or unknown, although a changed fire regime is considered to be the main threatening process for the Gouldian finch.

There is one vulnerable species of Declared Rare Flora in the Central Kimberley (*Eucalyptus mooreana*). The trend in the condition of all species is mostly unknown, as are threatening processes for the plants.

## Management responses

### Reserve system

The only conservation reserve in the bioregion is part of the large King Leopold Range Conservation Park. This reserve comprises 4.4 per cent of the bioregion, and includes examples of only 12 of the region's vegetation associations.

Reserve management in the bioregion is ranked at poor to fair. Apart from a donkey control program and the presence of a full time ranger, there are no feral animal control programs, only limited prescribed aerial burning, and no formal understanding of threatening processes such as weeds.

Soil and vegetation changes are occurring in the park because of uncontrolled stock access. The presence of pigs is a serious concern.

Fifty-seven vegetation associations are not reserved anywhere in the bioregion and seven of its 'at-risk' ecosystems are poorly reserved or not reserved.

The vegetation associations include grassland, grassland with associated woodland, hummock grasslands, various mosaic communities, shrublands, woodlands, mangroves and bare areas (freshwater lakes and mudflats).

The 'at-risk' ecosystems are riparian zones, swamps, herbfields and savannah communities.

Constraints include:

- competing land uses such as pastoral production,
- land purchase costs and
- the poor resolution of available data on biodiversity patterns.

## Off-reserve conservation for species and ecosystem recovery

Recovery actions for mammal, bird and plant species at risk require data on status, population trends and mechanisms of threatening processes, as well as locations of remaining populations.

Ecosystems at risk need feral stock to be removed, closer management of stock on adjacent lands, the eradication of donkeys and pigs, and no frequent, broadscale, hot, late dry-season burning in savanna.

Savanna fire regimes and grazing are the main causes of decline in biodiversity values throughout the region, including its rainforests and riparian zones. To address this issue, coordination between Government agencies, the pastoral grazing industry, traditional owners and the broader community will need to be improved. A large off-reserve effort is needed and there are resource constraints and limited community capacity.

## Integrated natural resource management (NRM)

Existing natural resource management actions include legislation for pastoral lease condition inspections by the Department of Agriculture. Pastoralists are notified of any problems and, ultimately, the Commissioner for Soil Conservation can resume the lease. In practice, this process does not appear to be very effective.

Other actions include threat abatement planning by the Department of Agriculture to control donkeys, and Land Conservation District Committees that provide a venue for discussing conservation matters and integrating property and catchment planning.

There is a range of opportunities for natural resource management.

- The duty-of-care for biodiversity on pastoral lands needs to be tightened.
- Environmental management systems for controlling weeds, fire and feral animals should be coordinated across a variety of land tenures through Land Conservation District Committees, supported by research into the mechanism and impacts of these threatening processes and cost effective solutions.

- Shire planning should incorporate biodiversity objectives and acknowledge the worth of the natural environment to tourism and the cost of managing biodiversity and making national parks accessible.
- Catchment and regional plans should be developed collaboratively by all stakeholders. Constraints include financial resources, the small number of people available to implement strategies and that few people recognise biodiversity benefits.

### Major data gaps and research priorities

- There are no region-wide vegetation, soil and environmental geology maps at better than 1:250,000 scale for planning.
- There is no quadrat based fauna and flora survey of region for assessing species and ecosystem status, condition, trend and effects of threatening processes such as cats, cattle, donkeys, pigs, fire and weeds.

# Coolgardie



Mixed woodland of *Eucalyptus longicornis* and *E. corrugata* over *Eremophila*, *Scaevola* and *Dodonaea* shrub understorey in the Coolgardie Bioregion, W.A.  
Photo N. Gibson

## Description

### Bioregional description and biodiversity values

The bioregion is within the Yilgarn Craton. Its granite basement includes Archaean Greenstone intrusions in parallel belts. Drainage is occluded. The climate is arid to semi-arid warm Mediterranean with 250–300mm of mainly winter rainfall.

Diverse woodlands, rich in endemic eucalypts, occur on low greenstone hills, on alluvial soils on the valley floors, around the saline playas of the region's occluded drainage system, and on broad plains of calcareous earths.

The granite basement outcrops at mid-level in the landscape. It supports swards of 'granite grass', wattle shrublands and York Gum. The playa lakes support dwarf shrublands of samphire. Sand lunettes are associated with playas along the broad valley floors, and sand sheets surround the granite outcrops.

Upper levels in the landscape are the eroded remnants of a Tertiary lateritic duricrust, with yellow (in the Southern Cross subregion) or red (in the Eastern Goldfields subregion) sandplains, gravel plains and laterite breakaways. These support scrubs and mallees. In the west, these scrubs are rich in endemic Proteaceae; in the east they are rich in endemic acacias.

Three subregions are defined:

The Mardabilla subregion is an Eocene marine limestone plain with, in its western parts, a granite basement. The main soils are red-brown loams and aeolian sands over sheet and nodular kankar. They support *Eucalyptus* woodland over broomebush/greybush, bluebush and saltbush.

The Southern Cross subregion comprises gently undulating uplands on granite strata and broad valleys with bands of low greenstone hills.

The Eastern Goldfields subregion comprises gently undulating plains interrupted in the west by low hills and ridges of Archaean greenstones and in the east by a horst of Proterozoic basic granulite. The underlying strata are eroded flat and covered with Tertiary sand and gravel soils, scattered exposures of bedrock, and plains of calcareous earths.

Rare species include:

- malleefowl,
- slender-billed thornbill,

- samphire thornbill,
- carpet python,
- western quoll,
- *Tetratheca harperi*,
- *T. aphylla*,
- *T. paynteri*,
- *Gastrolobium graniticum*,
- *Eremophila virens*,
- *Myriophyllum lapidicola*,
- *Pityrodia scabra*,
- *Daviesia microcarpa*, and
- *Eucalyptus platydisca*.

Rare features include:

- Rowles Lagoon,
- Fraser Range,
- Woodline Hills,
- Swan Lake and many ephemeral salt lakes, and
- banded ironstone hill flora.

The region is itself a major biogeographic interzone. Communities of acacia on sandplains and valley floors, and of ephemeral plants on Tertiary sandplains and in valley floor woodlands, are exceptionally rich.

The diversity in its eucalypt woodlands reflects a regional radiation in acacias and myrtaceae. For instance, 170 species of eucalypt occur in the region, and many of these are endemic. Other endemics include *Ctenotus xenopleura*, banded-ironstone hill communities, 21 eucalypt woodland associations, three succulent steppe associations and two acacia associations.

### Overall condition and trend

The Mardabilla and Eastern Goldfields subregions, and the north eastern part of the Southern Cross subregion, are extensively degraded by pastoral activities. The western third of the Southern Cross subregion is cleared for dry-land agriculture, with salinity problems emerging. The region has been affected by mining activities and has weed and feral pest problems resulting in extinctions. Too frequent fires are a problem, especially in scrubs and mallees on duplex, sandy and laterite surfaces. The trend is static, although weed problems are increasing. On a scale of one (awful) to six (near pristine) the Coolgardie's continental stress class is between four and five, with the Southern Cross subregion being two.

## Conservation priorities

Control of weeds, feral herbivores and carnivores is a priority. More ecologically sustainable development of rangelands is needed. The region has medium priority for reserve consolidation, but the system is highly biased with the Eastern Goldfields subregion having only 4.3 per cent of its area reserved.

## Nationally important wetlands

One wetland of national significance is listed. Rowles Lagoon System is only in fair condition (its recovery requires significant management intervention) but its trend is static. Threatening processes include:

- feral rabbits,
- goats,
- foxes,
- cats,
- stray stock,
- weeds (saffron thistle, Bathurst burr, Brome grass, southern liquorice), and
- uncontrolled recreational use.

## Wetlands of regional significance

Most of the 14 wetlands of regional significance are intermittent or seasonally inundated, and most are salt lakes. Two are permanent fresh water wetlands: Swan Lake and Wallagne Soak (an artificial wetland).

These wetlands are important for nomadic species and as a drought refuge for waterbirds. They differ in condition and trend: Swan Lake is surrounded by grazing land and in degraded condition, while Wallagne Soak is situated in uncleared vegetation and is in near pristine condition.

Nearly all wetlands of subregional significance are in good condition and static in trend. Threats affecting wetlands include:

- grazing,
- feral predators and herbivores,
- weeds,
- mining and related changed hydrology, and
- the recreational activities of people.

## Riparian zone

Riparian systems comprise only the headwaters of the now occluded regional drainage system. They are in good condition, static, and would recover if feral herbivores and stock, exotic weeds, changed fire regimes, feral predators and firewood collection could be controlled.

## Ecosystems at risk

A variety of ecosystems are currently proposed for listing as vulnerable, and need significant management intervention if they are to recover.

- Ephemeral wetland communities (saline, brackish and fresh-water) are threatened by exotic herbivores and mining but static at present.
- Succulent steppe (bluebush, saltbush, samphire) communities on calcareous plains are threatened by grazing, weeds and feral predators, and declining as Wards weed spreads.
- Granite outcrops, including apron woodlands, herbfields, moss sheet communities, Jam-Sheoak thickets, ephemeral pools aquatics are declining under pressures from human recreation, and rabbits.
- Twelve flora complexes of banded ironstone, greenstone and other isolated ranges are static, but small, grazed by rabbits and subject to mining.
- Valley-floor woodlands of species such as York and salmon gum are 97 per cent alienated across their Western Australian ranges and the remnants are threatened by fire and feral predators.
- Melaleuca scrubs are 70 per cent alienated but static.
- Three mallee formations are threatened by fire and feral predators.

## Species at risk

- One bird (Carnaby's cockatoo) is endangered, but the Coolgardie bioregion represents the edge of its range.
- Two birds (malleefowl and slender-billed thornbill) and one critical weight range mammal (western quoll) are vulnerable.
- All vertebrates are in a degraded or fair condition and are likely to decline further, with the exception of the western quoll which is thought to be extinct in the bioregion. In fact, more than 40 per cent of Coolgardie's original mammal fauna is regionally extinct.

The threatening processes affecting fauna at risk include:

- feral predators,
- grazing (by stock and rabbits),
- fragmentation and
- changed fire regimes.

Declared Rare Flora (DRF) includes one critical, two endangered and nine vulnerable species. Overall DRF condition is fair to good or is not known, with the trends believed to be static or unknown. Threats affecting flora include:



- grazing,
- fragmentation or lack of recruitment,
- changed fire regimes,
- mining,
- changed hydrology,
- limited distribution and
- a small number of individuals.

## Management responses

### Reserve system

The reserve system comprises 46 reserves, including some of the largest in Western Australia, with three levels of protection:

A-class - three national parks, 11 nature reserves, one conservation park and one state forest.

B-class - one nature reserve.

C-class - 14 nature reserves, one conservation park, nine Section 5(g) reserves and three timber reserves.

In addition, two pastoral leases were recently acquired for conservation. A total of 1.8 million hectares is in this conservation estate, taking in 56 of the region's 106 vegetation associations, and comprising 13.7 per cent of the region's area.

In general, reserves are biased towards sandplains, gravel surfaces, granite outcrops and erosional surfaces high in the landscapes, although saltlake systems and calcareous plains are represented in eastern areas.

Vegetations include scrubs, mallees, mallets, a variety of eucalypt woodlands, samphire and communities with a Greybush understorey.

The Southern Cross and Eastern Goldfields subregions have 21 ecosystems at risk. Seventeen Beard vegetation associations are not currently represented on reserves and are a high priority for acquisition. The Mardabilla subregion has eight unreserved vegetation associations, seven of which are listed as being at risk. Gaps in the conservation estate include:

- ephemeral wetland communities (saline, brackish and fresh-water),
- succulent steppe (bluebush, saltbush, samphire) communities on calcareous plains and broad valley floors,
- granite outcrops, including apron woodlands, herbfields, moss sheet communities, jam-sheoak thickets, and ephemeral pools aquatics,

- flora complexes of banded ironstone, greenstone and other isolated ranges, including various *Allocasuarina cristata*, blackbutt, gimlet and Salmon Gum woodlands, and a variety of shrubland complexes,
- valley-floor and lower-slope woodlands of species such as York and salmon gum, Gimlet and Morrel,
- melaleuca scrubs and mallee communities on dunes peripheral to salt lakes, and
- red mallee and acacia shrublands.

The main constraints on filling gaps in the reserve system are economic — the ironstone and greenstone ranges are mining tenements or exploration leases, and the succulent steppes and wetlands are highly productive for stock.

The region is IBRA Reservation Class 3 (11.3 per cent of its area reserved in IUCN I-IV reserves). Ephemeral fresh water wetland communities, succulent steppe, ironstone and greenstone range and valley-floor woodland communities have priority, especially in the Eastern Goldfields subregion. Only 4.35 per cent of this subregion's area is in reserves and there is a strong bias in the comprehensiveness of its reserve system.

The standard of reserve management is ranked as fair because there are no feral predator programs in place; wildfire management facilities are limited by resources. Even so, fire breaks and fire-access tracks are installed and maintained, mining activities (exploration) are supervised (excepting old exploration drill holes which often remain open), and feral herbivore grazing activities are now minimal (e.g. rabbit populations reduced by Callicivirus and there are few goats). In addition, vegetation and soils are probably stable or regenerating from grazing (now light) and from timber removal early in the twentieth century.

### Off-reserve conservation for species and ecosystem recovery

Main recovery actions required for ecosystems at risk and species include:

- habitat retention by reservation or by agreements with landholders,
- excluding stock from sensitive areas (e.g. Rowles Lagoon, Swan Lake, Fraser Range, Woodline Hills, examples of succulent steppe),
- weed and feral animal control (Wards weed, rabbits, cats, foxes, stock),
- capacity building with industry in the Eastern Goldfields subregion,
- the reintroduction of regionally extinct and declining critical weight range mammals through translocation programmes,

- better inventory and life history data for nearly all species at risk, and
- an understanding of ecological interactions between grazing, fire regime and ecosystem biodiversity.

Limited off-reserve measures for the various species and ecosystem conservation and recovery efforts listed above are needed in all three subregions, but are equally constrained by limited funding, equipment, knowledge base and community capacity.

### Integrated natural resource management (NRM)

Existing natural resource management initiatives include the Wildlife Conservation Act (1950), Pastoral Lands Act (1998) and the Mining Acts (1978). The last two include clauses related to the protection of land and natural vegetation.

Pest management including feral animal control is a priority in threat abatement planning. There are industry Codes of Practice guidelines on the extent of vegetation that should be removed during mineral exploration and restorative actions to mitigate damage.

Opportunities include reviews of the Wildlife Conservation, Pastoral and Mining Acts to strengthen protection of biodiversity, and duty-of-care in relation to mining, pastoral or other activities.

Grazing of arid woodlands and savannas provides only marginal benefits when related to economic, social and environmental costs; initiatives to restructure the pastoral industry under the Gascoyne-Murchison Strategy are better integrating the activities of conservation, pastoral and mining agencies and industries, minimising environmental costs. However, the region's remoteness and absence of infrastructure adds to the costs of implementing natural resource management. Other impediments include the Land Administration Act, the extent of mining leases and tenements, and limited financial and staff resources. These natural resource management priorities apply equally to all subregions.

### Data gaps and research priorities

- No regolith mapping is available.
- Vegetation mapping and surficial lithology resolution is 1:250,000 scale at best.
- Data on biodiversity is sparse.
- Systematic biodiversity survey data is confined to vertebrates and plants at 200 quadrats (400 for plants) across region.
- These quadrats were only positioned on widespread surface-types. There were only three to four quadrats on each surface-type.
- Few quadrats have been sampled on more than three occasions.
- Additional flora quadrats have been sampled on some localised substrates of particular interest.
- There is limited data on the habitat requirements of virtually all invertebrate species, most ephemeral plants, persisting critical weight range mammals, and uncommon vertebrate and plant species.
- There is no data to provide a regional context on life-history (including population-trend) of any species (even rabbits).
- There is no quantitative data on the affect of exotic predators, weed colonisation, fire on biodiversity, and effect of mineral-extraction on greenstone communities.

# Dampierland



Open eucalypt woodland over hummock grassland on calcareous soil plains of Fitzroy Trough, Dampierland Bioregion, W.A. Background is the Napier Range, a stranded Devonian barrier reef.

Photo: N.L. McKenzie

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## Description

Bioregional description and biodiversity values.

There are two subregions: the Fitzroy Trough and Pindanland.

The Fitzroy Trough is the semi-arid northern edge of the Canning Basin and contains the middle and lower catchments of the Fitzroy River. Extensive coastal mudflats are associated with its delta. Devonian limestone barrier reef structures are preserved along the Trough's northern and eastern peripheries.

Quaternary alluvial plains associated with the Permian and Mesozoic sediments of the Fitzroy Trough support *Eucalyptus microtheca* and *Lysiphillum cunninghamii* tree-savannas over *Chrysopogon-Dichanthium* grasslands with scattered forests of river gum and cadjeput along drainage lines. Devonian limestones in the north and east of the Trough support tree steppes with understoreys of *Triodia intermedia* and *T. wiseana* hummock-grass.

Pindanland is the coastal, semi-arid, north-western margin of the Canning Basin. Quaternary sandplains mantle Jurassic and Mesozoic sandstones and support pindan vegetation on the plains and hummock grasslands on hills.

Quaternary marine deposits on coastal plains support mangal, samphire, *Sporobolus* grasslands, *Melaleuca acacioides* low forests, and *Spinifex-Crotalaria* strand communities.

The region has a semi-arid, hot, tropical climate with summer rainfall.

Special values include the stranded remnants of a Devonian barrier reef system at Windjana and Geikie Gorges, Mimbi Caves and Tunnel Creek. The gorges are world-class tourist destinations and Tunnel Creek is the only known example in WA of a river passing through a range via a cave. The Tunnel supports colonies of ghost bat, yellow-lipped cave bat and orange horseshoe bat.

Rainforests and paperbark swamps are associated with organic profiles of mound springs on coastal mudflats and with primary coastal sand dunes on the Dampier Peninsula. Camballin Floodplain is one of the few large floodplains of the Kimberley region, while vast grasslands occur on black soils of the Roebuck Plains.

Enormous numbers of migratory birds are found at Roebuck Bay and Eighty Mile Beach, where palaeoriver (ancient river) systems have produced extensive coastal mudflats. *Keraudrenia exastia* and *Pandanus spiralis* var. *flammeus* are both declared rare species.

## Overall condition and trend

- The Fitzroy Trough subregion has a Continental Stress Class of four (see Glossary), which is appropriate given the threatening processes operating at the landscape scale (grazing pressure and changed fire regime).
- Pindanland was rated as having a stress class of six (near pristine), but this should be reviewed because fire and grazing have contributed to a degradation of the subregion.
- Vegetation cover throughout the region has declined due to an inappropriate fire regime in combination with pastoral use.

## Conservation priorities

The reserve system is biased; many ecosystems of both the Fitzroy Trough and Pindanland are not represented in the system. Improved control of fire, feral herbivores and weeds are other priorities.

## Nationally important wetlands

Ten Dampierland wetlands are listed nationally, including mound springs supporting diverse flora, a cave watercourse, limestone river gorges, a riverine floodplain, a coastal creek system, and palaeoriver systems important for migratory waders.

The paleoriver systems comprise a large bay, extensive coastal wetland plains, an inland wetland complex and a coastal dune and mudflat system. All the palaeoriver systems are Ramsar listed.

Most are in a fair or good condition but declining, while two are near pristine and of unknown trend. Main threatening processes include grazing and trampling by stock, tourist-use, changed hydrology with siltation and altered flows, feral animals, changed fire regimes and impacts due to the proximity of the town of Broome to two sites.

## Wetlands of regional significance

Two other wetlands are important for the maintenance of ecological processes at a subregional scales. The condition of Wollamor claypan is fair and the subterranean soak and creek systems of the Lawford Ranges are near pristine. Threatening processes are:

- weeds,
- grazing by stock and
- tourism.

## Riparian zone

Vegetation along creeks and rivers is currently in good condition but is declining across the bioregion. Threatening processes include changed fire regimes, grazing pressure from stock and feral herbivores, weeds changed hydrology and, in some places, tourism.

## Ecosystems at risk

Six Threatened Ecological Communities (TECs) have been declared vulnerable under State legislation, and an additional 13 are other communities thought to be at risk. The declared TECs include:

- monsoon (vine) thickets on the Dampier Peninsula, and
- an intertidal faunal community on Roebuck Bay mudflats and a variety of mound springs (Disaster Bay, Bunda Bunda, Mandora Marsh and Big Springs).

Threats to these communities are primarily from grazing (usually cattle) and the associated changes to soil structure, and weed invasion. Intertidal mudflats are threatened by human impact and possibly pollution.

Areas associated with water (wetlands, mound spring communities, clay pans, lakes and creeks) also feature heavily in the ecosystems at risk and are threatened by:

- grazing,
- changed fire regimes,
- urbanisation,
- ground water extraction and
- feral animals.

Most ecosystems at risk have relatively little known about their condition and trend. TECs are generally in fair condition and trend is declining or unknown.

## Species at risk

More than 10 per cent of Dampierland's original mammal fauna is regionally extinct.

One bird and two reptiles (both turtles) are listed as endangered, and one mammal, two birds, and four reptiles (also all turtles) are declared as vulnerable under State legislation.

The threatening processes for most vertebrate species are poorly understood or unknown. The bilby and Gouldian finch are both affected by changed fire regimes and grazing pressure operating at the landscape scale.

The bioregion has one critically endangered and one endangered plant listed. The condition of both is unknown but their trend appears to be static or improving. Threatening processes are:

- urbanisation,
- grazing and
- weed invasion.

## Management responses

### Reserve system

Regional conservation lands include:

- three small national parks (Windjana Gorge, Geikie Gorge and Tunnel Creek),
- one large and one small conservation park (Devonian Reef and Brooking Gorge) and
- one small nature reserve (Point Coulomb).

These reserves comprise one per cent of the bioregion and include examples of only 17 of the region's 86 vegetation associations. The reserve system is highly biased with significant gaps. The management standard is rated as fair for the Devonian Reef national parks (Windjana and Geikie Gorges) where there is a ranger presence. However the impact of weeds, fire and feral animals on these parks is poorly documented. The management standard for all other reserves is poor because the effects of threatening processes are not documented and management is limited to occasional visits.

Fifty-two of the unreserved vegetation associations and 12 partially-reserved associations have a high priority for acquisition or further reservation. They include:

- grasslands,
- grasslands with associated woodlands,
- hummock grasslands,
- shrublands,
- woodlands,
- mosaic communities,
- bare areas,
- succulent steppe and
- mangroves.

Nineteen ecosystems are either “*unreserved and subject to threats*” or “*too little is known about them to make statements of levels of reservation and priority*”.

Constraints on reserve acquisition are mainly pastoral land-use and the cost of purchasing pastoral leases.

## Off-reserve conservation for species and ecosystem recovery

A number of recovery actions are required for threatened mammal, bird, turtle and plant species.

- Research is needed on the overall condition, trend and impact of threatening processes.
- Frequent, broad-scale, hot, late dry-season burning needs to be avoided in savannah.
- Feral stock should be removed from conservation estate, combined with the close-order management of stock on other lands.
- Feral animals (especially cattle, donkeys and pigs) need to be eradicated.
- There is a need for the systematic survey of each of the plant species to better determine population information and conservation actions.

The effects of fire and grazing are major issues in tropical savanna ecosystems generally. Better coordination between the pastoral grazing industry, traditional owners and the broader community, in the context of management research, is essential for action.

A large off-reserve effort is needed over much of the bioregion, yet resources and community capacity are limited. State and regional weed strategies need definite priorities in both an agricultural sense and an environmental context. Resources are required for priorities that have already been identified.

## Integrated natural resource management (NRM)

Existing natural resource management actions include legislation for pastoral lease condition inspections by the Department of Agriculture.

Pastoralists are notified of any problems and, ultimately, the Commissioner for Soil Conservation can resume the lease. In practice, this process does not appear to be very effective. Other actions include:

- threat abatement planning as part of NRM,
- coordinated efforts by the Department of Agriculture to control donkeys, and
- Land Conservation District Committees providing a venue for discussing conservation matters and integrating property and catchment planning.

There is a range of opportunities for NRM.

- Duty of care for biodiversity on pastoral lands needs to be tightened.
- Environmental management systems for controlling weeds, fire and feral animals should be coordinated across a variety of land tenures through Land Conservation District Committees, supported by research into the mechanism and impacts of these threatening processes and cost-effective solutions.
- Shire planning should incorporate biodiversity objectives and acknowledge the worth of the natural environment to tourism and the cost of managing biodiversity and making national parks accessible.
- Catchment and regional plans should be developed collaboratively by all stakeholders.

Constraints include:

- lack of financial resources,
- the small number of people available to implement strategies, and
- that few people recognise biodiversity benefits.

## Major data gaps and research priorities

- Planning requires regional vegetation, soil and environmental geology maps at better than 1:250,000 scale.
- There has been no quadrat based fauna and flora survey of the region to assess species and ecosystem status, condition, trend and the effects of threatening processes such as cats, cattle, donkeys, pigs, fire and weeds.

# Esperance



Proteaceous heath with  
emergent mallee on spongalite  
sandplain in Fitzgerald River  
National Park, Esperance  
Bioregion, W.A.  
Photo: N.L. McKenzie

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## Description

### Bioregional description and biodiversity values

The Esperance Bioregion is made up of two subregions, Fitzgerald and Recherché.

The Fitzgerald subregion has a basement of marine sediments with small outcrops of gneiss and greenstone. It shows variable relief, comprising subdued relief on the sandplains of the coastal region, punctuated with metamorphosed granite and quartzite ranges both inland and on the coastal plain. It lies mainly on the Bremer Sedimentary Basin although its eastern and western sections are within the Albany-Fraser Orogen of the Yilgarn Craton. The subregion is dominated by yellow plains of duplex soils as well as deep and shallow sands. Shallow sandy soils occur on the mountain ranges. Sand sheets show varying levels of lateritisation. Vegetations include scrub heath, mallee heath characterised by *Eucalyptus tetragona*, coastal dune scrub, mallee, woodlands on greenstone, Yate and York gum woodlands on alluvials, and jarrah/marri woodlands in the west. Vegetation on abrupt granite and quartzite ranges that rise from the plain comprises herbfields and heaths (rich in endemics) with woodlands of *E. redunca*, *E. incrassata* in gullies and alluvial foot-slopes. The subregion has a temperate Mediterranean climate with a 600 to 800mm annual rainfall.

The Recherché subregion has variable relief. It comprises Quaternary coastal sandplains and dunes overlying Proterozoic gneiss and granite, as well as Eocene and more recent coastal limestones. Numerous granitic islands occur in the near-shore area of this subregion. Vegetation comprises heaths, coastal dune scrubs, mallees, mallee-heaths and granite heaths. Its climate is temperate Mediterranean, with a 400 to 700mm annual rainfall.

Major land uses include grazing of improved pasture and cultivation (dry-land agriculture). Smaller areas are used for conservation and other Crown reserves.

Special values include off-shore islands and archipelago (Bald, Glassy, Doubtful, Middle, Woody, Sunday and Investigator Islands, and the Recherché) that are refugia for seals, sea lions, and Quokkas, breeding sites for birds such as Cape Barren Geese and successfully translocated Noisy Scrub-bird. They also have distinctive vegetation including plant species restricted to islands. The Recherché Archipelago Nature Reserve incorporates some 105 islands totalling 9720 hectares.

Several rare ecosystems are contained in the bioregion, including:

- the Stirling Range Montane thicket,
- heath of the South West Botanical Province,
- Ravensthorpe Range,
- Pink Lake,
- Esperance sandplain, and
- mixed thicket complex of the Russell Range.

There is also a wide variety of rare, endangered or specially protected flora and fauna found within the bioregion.

### Overall condition and trend

The condition of the region is fair to poor with a generally declining trend. Wetlands are in particularly poor condition. Threatening processes include vegetation clearing and fragmentation for agriculture, hydrological changes and salinity, feral predators and herbivores, grazing by stock and weeds. Many communities and species are localized in occurrence and vulnerable to fire events. *Phytophthora* fungi are changing the composition of coastal heath and scrub communities. The reserve system is nearly comprehensive.

The Fitzgerald subregion has a continental stress class of three (medium), while the Recherché subregion is listed as five (see Glossary). Given the level of clearing, and collateral problems, the Recherché subregion should have a stress class of three.

### Conservation priorities

- The effect of salinity, inundation and root-fungus on reserves and remaining vegetation fragments needs to be restricted.
- Cats, foxes, weeds and fire on and off-reserves needs to be controlled.
- Low Moort Forest needs to be added to the reserve system.

### Nationally important wetlands

There are eight wetlands of national significance in the Esperance bioregion. They range in condition from degraded to fair or good.

- Altered water flow or water quality is one of a variety of processes threatening these wetlands.
- Vegetation clearing and fragmentation, as well as changes to fire regimes, and encroachment from urban and agricultural areas are also problems.



- The Yellilup Yate Swamp System is predicted become extinct due to inundation, eutrophication, siltation and increased salinity in the water.

## Wetlands of regional significance

Fifty-two wetlands of subregional significance are listed. All except seven are breeding, feeding, roosting, nursery areas and/or refugia for animal taxa, and significant for maintaining ecological processes or supporting a high diversity (in some cases including rare or threatened species). Their condition ranges from fair to good, with a declining or static trend. Threatening processes are similar to wetlands of national importance. These include:

- salinisation,
- eutrophication,
- siltation,
- weed invasion and
- vegetation clearing/fragmentation.

## Riparian zone

Fourteen rivers, each with a catchment of the same name, occur in the bioregion. Most riparian zone vegetation is in poor or fair condition. However, if in reserves, vegetation and rivers are often in good condition while adjacent sections in surrounding agricultural land are degraded. Most river systems are expected to either remain static or decline, sometimes rapidly. Threatening processes include:

- changes to salinity and flow in the river,
- invasion of exotic weeds,
- drainage from agricultural lands,
- feral animals,
- vegetation clearing and
- habitat fragmentation.

## Ecosystems at risk

One Threatened Ecological Community has been declared as critically endangered under WA State legislation (Montane thicket of the eastern Stirling Ranges), one is endangered (Montane Mallee Thicket Community) and two are vulnerable. Twenty-nine other ecosystems are considered to be at risk. Eight of these are mallee associations, and six are other *Eucalyptus* associations. Others are associated with lakes, wetlands and river zones, or are uplands of the Stirling, Porongurups, Ravensthorpe, Mt Manypeaks and Russell Ranges. They vary widely in condition, from near pristine to degraded, and most trends are declining or static. One ecosystem is improving – Cocanarup Timber Reserve – which comprises *Eucalyptus salmonophloia* over *Acacia acuminata* woodland on red loams.

Vulnerability can be inherent to communities at risk. For instance, the North Porongurup Ironstone community is vulnerable because of the small area and restricted distribution of the substrate it grows on. However the majority of these ecosystems are afflicted by a wide range of processes.

Wetland, lake and river ecosystems are threatened with changed hydrology and salinity level, changed fire regimes, weeds and urban encroachment by the town of Esperance.

Woodland areas are reduced and simplified by clearing and fragmentation of remnant bushland, feral animals, exotic weeds and changed fire regimes. Hilly areas tend to be threatened by mining activities, clearing and fragmentation of remnant bushland, pathogens (such as *Phytophthora* sp.) and human recreational activities.

## Species at risk

More than 25 per cent of the Esperance bioregion's original mammal fauna is now regionally extinct.

Eighteen plant species have been declared as critically endangered. Thirty plants, two mammals, three birds and two invertebrates are endangered. Thirty four plants, seven mammals and six birds are declared as vulnerable under State legislation.

Species that are occasional visitors have not been included in these counts (above) but three whales, six sea birds and two sharks are also included as species at risk.

The threatening processes affecting flora almost always include restricted distribution in combination with the small number of individuals or populations (some such as *Acacia rhamphophylla*, *Chordifex abortivus*, *Nemcia luteifolia* and *Xyris exilis* are known from a single population only). Other common threatening processes for plants include pathogens (in particular *Phytophthora* fungi), exotic weeds, changed fire regimes, feral animals, and road works.

Mammal species are threatened by feral predators, changed fire regimes, pathogens, vegetation fragmentation, and small population sizes. Whales are potentially at risk from whale watching ecotourism. Sea birds and sharks are at risk from commercial fishing practices – overfishing, use of long lines, bycatch and direct control measures (sharks only). Two invertebrate species are affected by climate change and changed fire regimes.

# Management responses

## Reserve system

There are eight national parks (Stirling Ranges, Cape Arid, Cape Le Grand, Stokes, Waychinicup, Hassell, Fitzgerald River and Red Island), 61 nature reserves and one timber reserve in the Esperance region. Some are extensive, particularly the Fitzgerald River Biosphere and Cape Arid National Park. Although half of the area of both subregions has been cleared (51 per cent in the Fitzgerald subregion and 49 per cent in the Recherché subregion), more than half of the remaining area of vegetation is reserved for nature conservation (54 and 58 per cent respectively).

Fifteen of 63 vegetation associations in the Esperance region are not represented in the reserve system, and although priorities have not been allocated, the most threatened of these is the Low Moort forest. A priority in the Recherché subregion is to extend Nuysland Nature Reserve northwards to the Eyre Highway. The Macro-Corridor project is a priority activity in the bioregion and attempts to link reserves to maximise conservation value.

Many reserves in the Esperance bioregion, particularly in the higher rainfall western end, are subject to loss of biodiversity due to impact from *Phytophthora cinnamomi* and minor agricultural weed invasion on sandy soils along western and northern boundaries of conservation reserves.

Wildfire management facilities beyond fire breaks and fire-access tracks are limited by resources and isolation though some prescribed fuel reduction burning is undertaken on larger reserves (Manypeaks, Waychinicup, Stirling Range, Corackerup, Fitzgerald River, Cape Arid National Park, Cape Le Grand National Park and Stokes National Park).

Feral predator control takes place on Manypeaks, Waychinicup, Stirling Range, Corackerup, Fitzgerald River, Cape Arid National Park, Cape Le Grand National Park, Stokes National Park, and Lake Shaster Nature Reserve. Feral herbivore grazing (e.g. rabbits) occurs across most reserves, although goats appear to be confined to Fitzgerald River National Park.

Constraints relate mainly to competing land uses. Major components of the landscape are covered by mines, mining tenements or exploration leases and some areas are used for grazing. Few options remain for increasing the comprehensiveness and representativeness of the reserve system, as a result of past clearing.

Most reserves are relatively well managed, with major biodiversity issues identified and being addressed. However, management of several reserves was assessed as 'fair' because biodiversity or management issues are

poorly identified, but degradation is considered to be retrievable. In three cases (Stirling Ranges, Arpenteur, and Cape Le Grand) management standard was classed as poor because of high visitor numbers, unmanaged threatening processes and the likelihood that permanent degradation will occur.

## Off-reserve conservation for species and ecosystem recovery

Many of the species and ecosystems considered to be at risk in the bioregion already occur in reserves. Their degrading processes are either inherent, due to their highly localised and restricted occurrence, or they are caused by clearing, pathogens, ferals and weed invasion issues in the broader landscape. These issues affect plants and animals alike. Island ecosystems, restricted communities associated with hills and ranges, wetlands and riparian zones, and valley floor woodlands in farming land all require different actions. Recovery actions for the last two categories confront broad landscape processes that require a coordinated response by government agencies and rural communities, with whole-of-landscape management plans being implemented that value the benefits of biodiversity.

Restrictions on further clearing, programmed replanting of deep-rooted perennial plants, *Phytophthora* quarantine and fire-control programs need to be rigorously implemented, together with monitoring and eradication of invasive weeds and feral animal control. Islands and uplands require specific fire and pest control programs by the State conservation agency to continue.

## Integrated natural resource management (NRM)

Natural resource management actions include fencing subsidies to protect remnant vegetation (moderately effective) and private land conservation covenants.

The Soil and Land Conservation Act 1995 and the Wildlife Conservation Act are relevant, but not always enforced, and need to be replaced with comprehensive biodiversity protection legislation.

Threat abatement planning has been relatively successful (e.g. Western Shield fox control has allowed some mammals and birds to recovery, and Callicivirus has reduced rabbit populations). Industry Codes of Practice have led to revegetation in the Ravensthorpe area.

The introduction of sandalwood plantations on private land for essential oil production has resulted in ecological sustainable product marketing. Land Conservation District Committees in most areas of the bioregion provide opportunities for public participation in conservation projects (e.g. revegetation

of catchments and damaged land has been variably effective in addressing salinity and erosion problems). Local government planning, Salinity Action Plan and Ribbons of Blue projects are in place.

NRM opportunities include:

- revising Wildlife Conservation legislation to address current issues and problems of biodiversity protection more effectively;
- rural reconstruction and new management systems incorporating agroforestry, oil mallees and other specialty crops to make better use of cleared land and relieve commercial pressure on native flora;
- greater tax incentives are necessary to protect remnant vegetation on private land;
- management systems to coordinate management of feral animals and weeds across all land tenures;
- acknowledgement of the intrinsic environmental values of uncleared lands through public awareness education and
- property management planning.

The last initiative is being promoted through the South Coast Regional Initiative Planning Team (SCRIPT), an interagency environmental and conservation planning approach or Landcare groups.

Biodiversity conservation is impeded by:

- outdated legislation,
- confusion over cost-effective methods and
- lack of staff to increase community awareness.

## Major data gaps and research priorities

- There is a lack of region-wide vegetation, environmental geology or soil mapping at better than 1:250,000 scale.
- Systematic flora or fauna survey quadrats are localised, and the current LTERM quadrat program is incomplete, confined to reserves and unfunded.
- There is little data available on habitat requirements of virtually all invertebrate species, most ephemeral plants (except some Declared Rare Flora), some persisting and translocated CWR mammals, and some persisting Endangered/Vulnerable birds.
- There is no data to provide a regional context on life-history (including population-trend) of most species, including foxes, except baseline information on CWR mammals at Stirling Range National Park and Fitzgerald River National Park (data collected during Western Shield Monitoring).
- The effects of *Phytophthora* sp. fungus, exotic predators, weed colonisation, fragmentation, farm clean-up and fire on flora and fauna are generally not known.
- There is no data available on the effect of mining (exploration) on greenstone communities in Ravensthorpe Range, the effect of rising water table on species composition of communities remaining within the agricultural landscape, the impact of reduced rainfall on vegetation, and no comprehensive biological survey of island biota.

# Gascoyne



*Acacia* low open woodlands on footslopes of the Collier Ranges.  
Photo: N.L McKenzie

## Description

### Bioregional description and biodiversity values

The bioregion is underlain by the Ashburton Basin (shales, sandstones and conglomerates), Capricorn Orogen and Marymia and Sylvania Inliers (on the northern margin of the Yilgarn Craton), and the north-western and south-eastern parts of Bangemall Basin (sandstone, shale, carbonates).

Rugged low Proterozoic sedimentary and granite ranges are divided by broad flat valleys associated with the catchments of the Ashburton and Gascoyne River systems and headwaters of the Fortescue River. Open mulga/snakewood low woodlands occur on shallow earthy loams over hardpan on the plains, with mulga scrub and *Eremophila* shrublands on the shallow stony loams of the ranges. There are extensive areas of hummock grass. The climate is arid with winter and summer rainfall.

There are three subregions – Ashburton, Augustus and Carnegie. The Carnegie Salient, in the east, is characterised by extensive salt lake features supporting samphire and saltbush steppes.

The area has many special values.

- There are spectacular exposures of banded sedimentary formations.
- Gorges of the Barlee Range Nature Reserve contain spring-fed streams, waterfalls and pools with relictual/refugial species of landsnail, frog, plants and the bat *Rhinonictis aurantius*.
- The Lake Carnegie system is a breeding site for water birds. Unique flora of claypans such as Yadjiyugga. Minnie Spring (on the Henry River) and the Irragully Creek (Wanna Station) are permanent refugia.

There are several rare species including:

- the Great Desert skink, *Ctenophorus yinnietharra*, *Diplodactylus kenneallyi*,
- mallee fowl,
- Alexandra's Parrot,
- Mulgara,
- two reptiles (*Diplodactylus wilsoni* & *Lerista stictopleura*),
- elements of two stygofaunas,
- endemic species of *Eremophila* on Landor Station and 12 vegetation associations and
- a diverse *Lerista* fauna.

### Overall condition and trend

The continental stress class ranges from three to five (see Glossary) across the bioregion but weed invasions, extensive hot fires, grazing by introduced herbivores, and ubiquity of foxes and cats are causing a general loss of fertility, vegetation cover and simplification of ecosystem species composition.

Erosion from increased runoff velocities has occluded even major drainage lines. Land uses in the bioregion include grazing, unallocated Crown land and Crown reserves, and conservation.

### Conservation priorities

The reserve system needs to be more comprehensive and representative. Pastoral lands need to be managed along ecologically sustainable development principles. Weed and fire control is a priority.

### Nationally important wetlands

There are four nationally important wetlands including a gorge system, a spring, a claypan and a salt lake system. They include populations of threatened species and ecosystems; three are drought refuges. Their condition is poor to fair and, on average, declining. Windich Spring and Kookhabinna Gorge require significant management. However, the others should recover with minimal intervention if protected from grazing pressure and weeds.

### Wetlands of regional significance

Eight wetlands or wetland-types of regional significance as drought refuges and sites of threatened species and communities are identified (three springs, three pools, a creek, and all major pools along the Ashburton and Hardy rivers). The river pools are degraded, Irragully Creek and Minnie Spring require significant management intervention to recover, but the others will recover with minimal intervention if grazing pressure by (cattle, goats and donkeys) is removed and weeds (especially buffel grass) are controlled.

### Riparian zone

Vegetation of riparian zones associated with the Ashburton and headwaters of the Fortescue River systems is in only fair condition, continuing to degrade, and requires significant management intervention to recover. The catchments of the Gascoyne and Lyons Rivers are degraded. All are infested with weeds such as buffel grass and affected by grazing (mainly cattle) and feral animals.

## Ecosystems at risk

Most of the 28 threatened ecosystems/taxonomic groups are low in the landscape. They comprise alluvial plains, drainage lines, river pool aquatic invertebrate communities, springs, claypans, a salt lake system and stygofauna of calcrete aquifers.

Higher in the landscape are communities found on geological intersections, and declared rare plant communities of Robinson Range and Landor Station.

Most are degrading or static, being suppressed by grazing pressure. Drainage line communities are infested with buffel grass.

## Species at risk

Thirty per cent of the Gascoyne's original mammal fauna is now regionally extinct due to habitat change and predation.

One bird, two critical weight range mammals and one bat, two lizards and one plant are listed as vulnerable. In addition a further two bird species, one fish, two mammals, one lizard and a variety of Priority plants are identified as being at risk. Their populations require significant management intervention if they are to recover from the habitat changes (feral herbivore and fire) and fox and cat predation suppressing their populations. Barbed-wire fences are known to kill ghost bats. Grazing, particularly by cattle and goats, and invasive weeds are affecting the plant populations

## Management responses

### Reserve system

Regional conservation lands comprise one large nature reserve (Barlee Range), two large national parks (Mount Augustus Collier Range) and two recently purchased areas of pastoral lease (Earaheedy and Lorna Glen).

A total of 2.1 million hectares (21 of the region's 80 vegetation associations) is in this conservation estate, which is 10.4 per cent of the region's area. Management standard in all cases is classed as poor to fair because:

- no weed or feral predator controls are in place,
- they are seldom visited, and
- (while firebreaks are in place in two) there are few resources for wildfire suppression.

Feral herbivores are culled periodically only on Barlee Range Nature Reserve. The reserves cover large tracts of country, but focus on ranges country, uplands and sandy plains unsuitable for pastoral use. The recently purchased leases are lowland areas, but on the margin of the desert.

Twenty-five vegetation associations, and 13 ecosystems at risk (discussed above) have high priority for acquisition and are not on reserves. The associations include:

- woodlands of coolibah, river gum and waterwood,
- low open acacia woodlands,
- shrublands of various acacias, eremophilas and cassias,
- hummock grasslands with scattered tree, mallees and shrubs,
- sedgeland, and
- succulent steppes of samphire and saltbush.

Ecosystems at risk are:

- three river pools,
- *Eremophila* shrublands on Robinson Range and Landor Station,
- two chenopod plains,
- stygofauna of a calcrete aquifer,
- a claypan,
- geological intersections,
- alluvial plains and Erong Springs.

They are also unreserved; therefore it remains a priority to reserve them.

Overall, riparian river pool, claypan, spring, and alluvial plains with tree, shrub and acacia communities, have the highest priority. The main constraints are the cost of land and its subsequent management. More than 70 per cent of the region is pastoral lease and gaps in reserve system are often productive mosaics of high commercial value, or geologically prospective for mining.

The region was ranked as Reservation Class 2 because only 1.92 per cent of its area is in strict conservation reserve (IUCN I-VI), but 10.4 per cent is under some form of conservation tenure due to land purchases in the Augustus subregion.

Priorities for acquisition are now in Ashburton (2.88 per cent in IUCN I-IV) and Carnegie (2.5 per cent in IUCN I-IV). There is strong bias in the reserve system's comprehensiveness, even at the regional level.

### Off-reserve conservation for species and ecosystem recovery

In relation to rare species, there is a need for basic survey to determine status, and research into life history, so that threatening processes (if any) can be identified for:

- two birds (*Ardeotis australis* and *Burhinus grallarius*),
- a fish (*Leiopotherapon ahenius*),
- two bats (*Macroderma gigas* and *Rhinonicteris aurantius*),

- a ground-dwelling mammal (*Sminthopsis longicaudata*), and
- 17 ephemeral plants and grasses (*Eremophila rigens*, *Euphorbia drummondii* subsp. *Pilbara*, *Gonocarpus ephemerus*, *Goodenia berringbinensis*, *Helichrysum oligochaetum*, *Hemigenia* sp., *Homalocalyx chapmanii*, *Pityrodia augustensis*, *Ptilotus astrolasius* var. *luteolus*, *Ptilotus lazardii*, *Ptilotus trichocephalus*, *Rhodanthe frenchii*, *Rhodanthe sphaerocephala*, *Sida* sp. Barlee Range, *Stylidium weeliwolli* & *Wurmbea saccata*).

Habitat retention through reserves, on other State lands or on private lands is required for these plants as well as for seven rare perennial plants (*Acacia wilcoxii*, *Eremophila arguta* ms, *Eremophila flaccida* subsp. *attenuata* ms, *Eremophila gracillima* ms, *Eremophila lanata* ms, *Eremophila micrantha* ms, *Eremophila prolata* ms and *Eremophila rigida* ms). For nearly all plants above, herbivores and invasive weeds may pose a direct threat.

Specific recovery actions have been identified for:

- three birds (*Acanthiza iredalei iredalei*, *Falco peregrinus* and *Polytelis alexandrae*),
- two critical weight range mammals (*Dasyercus cristicauda* and *Macrotis lagotis*) and
- three lizards (*Ctenophorus yinnietharra*, *Diplodactylus kenneallyi* and *Egernia kintorei*).

Recovery requirements are already published for two of the birds, both mammals and two of the reptiles. *Dasyercus cristicauda* requires a specific fire age spinifex habitat; the *Macrotis* is extinct in the region and requires a translocation project. The *Ctenophorus* has a restricted range and reservation is required. In general their problems are caused by habitat degradation through fire, grazing pressure and by feral herbivores, and for the mammals, its conjunction with feral predators.

Main recovery actions required for ecosystems at risk are habitat retention in conservation reserves, on other State lands (including pastoral leases) or on private lands. Other needs, both on and off reserves, include:

- fencing to keep stock away from sensitive areas (especially in selected examples of highly palatable communities like blue-bush and salt-bush);
- weed and feral animal control (date palms, buffel grass, cats, foxes, goats, camels, donkey and feral cattle);
- specific fire programs to encourage a mosaic fire/age distribution;
- research into troglifaunas, and
- capacity building with industry.

The various species and ecosystem conservation/recovery efforts listed above are needed in all three subregions, but are equally constrained by limited funding, equipment, knowledge-base and community capacity.

## Integrated natural resource management (NRM)

Current NRM actions include:

- There has been institutional reform through the Gascoyne Murchison Strategy, including the purchase of productive land mosaics for conservation estate, and ecologically sustainable management on pastoral lands.
- Threat abatement planning – for example, vegetation management plans, feral animal control (mainly feral herbivores) and weed control – is occurring.
- Industry codes of practice are needed in relation to pastoral, mining and exploration activities.
- Integration of property management planning with catchment planning and Landcare through Land Care District committees is occurring throughout the region.

Opportunities:

- There is a need for legislated ‘duty of care’ for pastoral leases, Aboriginal lands, and mining areas – e.g. feral herbivore control on pastoral lands. Much of the bioregion is severely degraded through past agricultural practices (primarily sheep and cattle grazing) and feral herbivores, yet the Pastoral Land Act requires leases to maintain stock levels that may can conservation values.
- Conservation should become part of local government planning (e.g. National Action Plan for Water Quality and Salinity).
- Pastoralists require more Government support for attempting to identify and implement ecologically sustainable practices.

Constraints:

- There is a lack of funds to adequately manage our existing reserves and control weeds, feral herbivores and predators.
- The extent of mining leases and tenements limits conservation through reservation.
- There is a need for resources for biodiversity survey and research on threatened species.

A reserve purchase program, better feral animal and weed control and ecologically sustainable pastoral practices should be priorities in all subregions.

## Major data gaps and research priorities

- There is no region-wide coverage by environmental geology/regolith mapping at better than 1:250,000 scale.
- There has been no quantitative (quadrat-based) regional survey of flora or fauna, so regional flora and fauna is poorly known. Only small, local areas have been examined in detail by biologists, usually for industrial development.
- There is little detailed data on the ecological requirements and life histories of virtually all invertebrate species, plants, persisting critical weight range mammals, uncommon vertebrate and plant species, and ecologically dominant plant species (e.g. hummock grasses).
- There is little data to provide a regional context on population-trends for even ecologically significant species such as native rodents, dasyurids, spinifex reptile communities, termites, ants, weeds such as buffel grass, kapok bush and ruby dock.
- There is no quantitative data on the impact of weed colonisation, fire in hummock grasslands, exotic herbivores on aquatic and terrestrial communities and long term effect of mining on stygofaunas.



# Geraldton Sandplains



*Callitris* scrub on dunefield of yellow sandplain in the north end of the Geraldton Sandplain Bioregion, W.A.  
Photo: N.L. McKenzie

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## Description

### Bioregional description and biodiversity values

The Geraldton Sandplains bioregion comprises the central and northern Perth Basin, the Pinjarra Orogen, and the south end of the Carnarvon Basin. Outcrops of Jurassic siltstones and sandstones can be heavily lateralized.

Extensive proteaceous heaths and scrub-heaths often with emergent mallees, *Banksia* and *Actinostrobos*, occur on an undulating, lateritic sandplain mantling Permian to Cretaceous strata. These heaths are rich in endemics.

Sandplains are most extensive in the north and south-east where the region overlaps the edges of the Carnarvon Basin and Yilgarn Craton respectively.

Extensive York gum and acacia woodlands occur on alluvial outwash plains associated with drainage and with valleys in the hill country. Areas of coastal aeolian sands and limestone support proteaceous heath and *Acacia* scrubs.

The bioregion includes the Houtman Abrolhos and Dirk Hartog Islands. The climate is semi-arid warm Mediterranean. There are three subregions - Edel, Geraldton Hills and Lesueur Sandplain.

The bioregion contains a high percentage of rare and endemic plants with over 250 plants endemic to the Lesueur Sandplain alone, while 16 species of the genus *Scholtzia* are endemic to the Geraldton Hills. There are also Moresby Ranges communities with rare plants such as the mallee species *Eucalyptus blaxellii*, Mallee Box (*Eucalyptus cuprea*), heath, Moresby Range Drummondita (*Drummondita ericoides*) and orchid *Caladenia hoffmanii hoffmanii*. Mount Lesueur supports a large number of distinct, species-rich and geographically restricted communities. The Houtman Abrolhos islands are home to Tammar wallabies, rare breeding seabirds and sea lion colonies while Dirk Hartog Island is the largest Western Australian nesting site of loggerhead turtles (*Caretta caretta*) and a major nesting site for green turtles and reptiles found nowhere else, especially in *Lerista*, *Ctenotus* and other genera of small lizards. Endemic animals include the sandhill frog (*Arenophryne rotunda*).

The main land uses, ordered in terms of their extent, are: cultivation (dry land agriculture), conservation lands, grazing of native pastures and other Crown lands.

### Overall condition and trend

Two regions have a Continental Stress Class of four and one has a Stress Class of three. The regional stress class should be between two and three because reserves are on its coastal or inland margins or generally small and threatened by salinity. In many aspects its condition and trend resemble the Avon Wheatbelt bioregion, and reserves are mainly on agriculturally unproductive lands.

### Conservation priorities

Numerous vegetation associations and ecosystems at risk need to be reserved. This also applies to populations of a wide variety of threatened species. Feral animal control is a priority across all lands.

### Nationally important wetlands

Three wetlands are listed as important nationally and include:

- a coastal intermittent saline lake,
- a river and estuarine system and
- a seasonal freshwater to permanent saline lake system.

All but one are in fair condition and static; the Logue-Indoon System is rapidly declining. All are affected by weeds, changing hydrology (rising water tables, increasing sediment load and salinity, respectively), and grazing by goats, rabbits and/or stock. Aquaculture and mining are also threats.

### Wetlands of regional significance

There are four wetlands of regional significance – deep freshwater pools in the bed of the Greenough River, freshwater springs in the Northampton area, White and Green Lakes and the saline lakes of Coolimba-Jurien.

They support a significant number of taxa and contain rare or threatened species/ecosystems. Conditions range from degraded to good and likewise, trends vary from rapidly declining to static.

Threatening processes include:

- salinity,
- pools filling with sand,
- grazing pressure and
- exotic weeds such as glossy nightshade, saffron thistle, soursob, lupin and wild oats.

## Riparian zone

There are 11 riparian zones, most of which are degraded. All river systems are declining, some rapidly. Threatening processes are:

- salinity,
- increased flow,
- ferals (foxes, cats, rabbits and goats) and
- weeds (caster oil bush, box thorn, wild oats, soursob and, lupins).

## Ecosystems at risk

Six Threatened Ecological Communities (TECs) have been declared under WA State legislation comprising one critically endangered community, four endangered communities and one vulnerable community. Those in the Lesueur Sandplain are in a fair or good condition but two in the Geraldton Hills region are in degraded condition.

Clay flat assemblages of the Irwin River are already presumed totally destroyed, while the trends of other TECs are to either decline or remain static. Threatening processes are:

- grazing (particularly by goats and rabbits),
- changed fire regimes,
- salinity,
- changed hydrology and
- fragmentation of vegetation.

Twenty-six other ecosystems are also considered to be at risk. These ecosystems are broadly described as:

- shrublands,
- acacia and eucalypts forests and woodlands,
- a mixture of woodlands and shrublands,
- mixed chenopod,
- samphire and forblands,
- mangroves,
- tidal mudflat and coastal samphire,
- undescribed vegetation associations in the Lesueur area,
- cave invertebrates,
- spring communities,
- reptile and mammal communities and
- gypsum dune associations.

Three 'at risk' ecosystems are in degraded condition. Most are in fair or sometimes good condition but the trends of many ecosystems are unknown.

The main threatening processes are:

- feral animals, primarily the rabbit but also goats and pigs,
- grazing pressure,

- changed fire regimes,
- increasing fragmentation of the landscape,
- exotic weeds,
- human recreation activities and
- to a lesser extent, various forms of changed hydrology.

## Species at risk

More than 40 per cent of the bioregion's original mammal fauna is now regionally extinct.

Under State legislation:

- 25 plant species have been declared as critically endangered,
- 23 plants, three mammals, three turtles and two bird species have been declared as endangered, and
- 17 plants, five mammals, seven birds and two reptiles are vulnerable.

The plants comprise ephemerals and perennials, including a wide variety of eucalypts, acacias and grevilleas. Reptiles include small skinks and marine turtles, while birds include a quail, a cockatoo and small passerines such as wrens.

Many mammals and birds at risk in the Edel region are from islands that occur off the coast. Most taxa are declining as a result of:

- broadscale vegetation clearing and ongoing loss of remnants,
- grazing pressure by stock, feral pigs, goats and rabbits,
- competition from exotic weeds, and
- changed fire regimes.

Vertebrate populations are under additional pressure from fox and cat predation (the marine turtles and Carnaby's cockatoo through increased predation on their eggs and hatchlings). Two pythons have special protection under State legislation.

## Management responses

### Reserve system

The 745,000 hectare conservation estate comprises 16.4 per cent of the bioregion and encompasses samples of 125 of the 151 vegetation associations.

There are five large national parks (Lesueur, Alexander Morrison, Kalbarri, Badgingarra and Nambung), six large nature reserves (Pinjarega, Beekeepers, Southern Beekeepers, Wandana, Toolonga and Zuytdorp), a single conservation park (Coalseam) and more than 200 smaller reserves.

Management standard is classed as poor with many reserves becoming saline or encountering rising water tables. Wildfire management facilities are limited by resources, except for firebreaks and fire access tracks which are installed and maintained (except on areas of the Beekeepers Nature Reserve and nature reserves smaller than 200 hectares).

Feral herbivore grazing activities are widespread and feral predator control systems are in place on only three large national parks. The reserve system is strongly biased. For instance, 88 per cent of the conservation estate in the Geraldton Hills region is confined to agriculturally unproductive surface-types on its northern periphery.

Twenty-three vegetation associations and five ecosystems at risk are not on reserves and have a high or medium priority for acquisition. A further 48 vegetation associations and 10 ecosystems are at risk, and have a high priority for further acquisition. The Beard vegetation associations include:

- shrublands of *Melaleuca*, *Acacia*, *Banksia*, and *Allocasuarina*,
- woodlands of York gum, wandoo, mallee and Salmon gum and
- low forest of *Acacia rostellifera*.

The ecosystems at risk are:

- Moresby Range thicket,
- *Eucalyptus macrocarpa* sandplain community,
- Irwin River assemblages,
- Hutt Lagoon assemblages,
- Moresby Range *Verticordia* dominated heath,
- Moresby Range *Allocasuarina/Melaleuca* thicket,
- *Acacia/Eucalyptus* scrub,
- Burma Road sandplain,
- Lesueur-Coomallo area,
- chert hill heaths,
- coastal lakes,
- three island communities,
- herbaceous plant of lake beds,
- spring communities and
- cave communities.

Priority acquisitions are remnants of ecosystems on agriculturally productive alluvial soils in the Lesueur Sandplain and Geraldton Hills regions, springs and soaks, succulent steppes and hill-top communities.

Competing land-use is the primary issue because cleared farming land occupies 49 per cent of the bioregion. Economic constraints include the purchase price of land and the cost of subsequent management. There are difficulties in identifying biodiversity values in some areas because biodiversity data lacks resolution

and the level of degradation due to agricultural practices and the impacts of feral herbivores is high.

## Off-reserve conservation for species and ecosystem recovery

For most of the threatened species, the main recovery actions are:

- habitat protection,
- feral animal control,
- translocations,
- fire management and
- monitoring of populations.

The first two actions are relevant to birds and turtles. Habitat protection is best achieved through reservation and protection on other State lands. Protection on private lands may be essential in some cases.

Similar actions are required for ecosystem recovery, along with fencing of sensitive areas where there are heavy goat and/or rabbit numbers, and weed control. A large off-reserve effort is required in the Lesueur Sandplain and Geraldton Hills subregions, where agriculturally productive ecosystems are now fragmented and alienated, and salinity is a problem. Remaining vegetation fragments are few, small, and mostly degraded.

## Integrated natural resource management (NRM)

Existing actions are:

- legislation through soil conservation and
- land clearing legislation.

However these are not always effective. Institutional reform through the Gascoyne Murchison Strategy and the purchase of leases for conservation estate are effective in the northern part of the region.

A variety of planning programs are in place, including:

- threat abatement planning (vegetation management plans, pest management),
- pastoral and mining industry codes of practice,
- capacity building through the Bushcare Program,
- property and catchment planning via a number of Land Conservation District Committees and the Northern Agricultural Integrated Management Strategy, and
- other planning opportunities such as the Batavia Coast Regional Strategy and local government strategies for controlling development and assessing proposals.

Opportunities include:

- legislation for more rigorous control of planning ideals,
- tradeable rights through carbon credits to provide impetus for new revegetation efforts,
- local government and National Action Plan planning the for water quality and salinity, and increasing the role of NRM in agricultural management, catchment planning and Landcare.

Constraints:

- The current role of Government departments in NRM and policing of activities such as land clearing is fragmented and unclear.
- Departments that have responsibility for resource exploitation may also have resource protection roles.
- Penalties for undertaking activities such as land clearing are comparatively minor and do not have the support of the greater rural community.
- There is a general lack of awareness of biodiversity benefits.
- The Land Administration Act needs to be reviewed to ensure requirements on pastoral leases operations are optimised for ecologically sustainable development.

Major data gaps and research priorities

- No region-wide vegetation, environmental geology or soils mapping is available at better than 1:250,000 scale.
- Systematic survey data are confined to flora, vertebrates and selected invertebrate taxa, is sparse and patchy.
- Most reserves don't have long-term survey data on species present, even for vertebrates.
- Currently little data is available on habitat requirements of most plants, uncommon vertebrates and virtually all invertebrate species.
- There is no data to provide a regional context on life-history (including population-trend) of most species, including rabbits, cat and fox.
- There is no quantitative data on the effects of exotic predators, weed colonisation, fragmentation, farm clean-up, fire and mineral-extraction on gypsum and lime surfaces.

# Gibson Desert



Undulating buckshot plains supporting hummock grassland with Mulga scrub overstorey in valleys dominate the Gibson Desert Bioregion, W.A.  
Photo: N.L. McKenzie

## Description

### Bioregional description and biodiversity values

The bioregion comprises solitic gravelly sandplains and laterised upland on flat-lying Jurassic and Cretaceous sandstones of the Canning (Gunbarrel) Basin.

Vegetation is described as ‘Carnegie Botanical District’, Mulga parkland over *Triodia basedowii* on lateritic “buckshot” plains.

There is mixed shrub steppe of *Acacia*, *Hakea* and *Grevillea* over *Triodia pungens* on red sand plains and dune fields. The lateritic uplands support shrub steppe in the north and mulga scrub in the south. Quaternary alluvia, associated with palaeo-drainage features, support Coolibah woodlands over bunch grasses.

The climate is arid, with mainly summer rainfall, 200mm annually. The two subregions are the Lateritic Plain, a monotonous, gently undulating plain with a few sandstone mesas, and the Dune Field, dominated by red dune fields mantling Permian strata of Gunbarrel Basin.

Rare species include:

- night parrot,
- marsupial mole,
- bilby,
- black-footed rock wallaby,
- malleefowl,
- princess parrot,
- woma python,
- mulgara,
- *Eremophila viscimarginata*,
- *Melaleuca apostiba*,
- *Neurachne lanigera* and
- *Philotheca eremicola*.

There are:

- 12 hummock grassland associations,
- three shrublands,
- two sedgeland,
- two low woodlands,
- two succulent steppes,
- two mosaics (including various forms of hummock grasslands and sparse woodland),
- gorge communities and
- a wooded coolibah freshwater wetland.

Rare features include Lake Gruszka, and the Gibson Desert gnamma holes. The region is rich and diverse in both its flora and fauna however most species are wide ranging and usually occur in at least one, and often several, adjoining deserts. Over 90 per cent of three vegetation associations occur in the Lateritic Plain and could be considered endemic to the region.

### Overall condition and trend

There is considerable mineral exploration interest, but there are no major mines in this bioregion.

Numerous critical weight range mammal species have become extinct, while persisting populations of other mammals have declined and are under pressure from foxes and cats.

Feral herbivores (camels and rabbits) are degrading wetlands and other vegetation. Large, intense summer wildfires degrade hummock grasslands and mulga woodland communities. The trend is static. The continental stress class is six (near pristine).

### Conservation priorities

Management priorities are:

- the control of feral herbivores and carnivores,
- the introduction of fire management to reduce the size and impact of summer wildfires and
- gaining more knowledge of the bioregion’s biota.

In reserve acquisition terms, the reserve system is highly biased because none of the Dune Field subregion is reserved.

### Nationally important wetlands

Two wetlands of national significance are listed. The Gibson Desert gnamma holes are in good condition (recovery requires minimum intervention), and have a static trend. Lake Gruszka is in near pristine condition with a static trend.

The Gibson Desert gnamma holes’ greatest threat is siltation, as the site is no longer regularly maintained by traditional owners. Feral animals such as camels, foxes, rabbits, goats, and cats are a threat to both wetlands. There are no wetlands of national or regional significance identified in the Dune Field subregion.

## Wetlands of regional significance

Six wetlands are regionally significant. One is an ephemeral stream and five are seasonal intermittent freshwater lakes/floodplain lakes. All are in near pristine condition with a static trend. Threatening processes are a changed fire regime and feral animals such as camels, rabbits, foxes and cats.

## Riparian zone

The riparian zones follow ephemeral creek lines because no permanent rivers exist in the bioregion. The catchment is divided between the Sandy Desert Basin and the Mackay Basin. No true riparian vegetation exists in the Dune Field subregion.

The riparian vegetation across the region is in a good condition with a static trend. Threatening processes include:

- grazing (camels and rabbits),
- changed fire regimes,
- feral animals indicated previously, and
- exotic weed invasion from buffel grass.

## Ecosystems at risk

A variety of ecosystems are proposed to be listed as vulnerable, although none are declared. Generally their condition is good to near pristine and requires minimal management intervention if they are to recover. Ecosystems at risk are of three types:

- Gorge communities in the desert ranges are of static trend but are threatened by grazing pressures, changed fire regimes and feral animals such as foxes, camels and cats.
- The hummock grassland communities have a static trend but are threatened by grazing, changed fire regimes and feral camels.
- The wooded (coolibah) freshwater wetland of Lake Gruszka has a static trend but is threatened by grazing pressures, changed fire regimes and feral animals such as foxes, camels and cats.

## Species at risk

More than 40 per cent of the Gibson Desert's original mammal fauna is now regionally extinct.

The night parrot is critically endangered, and the northern marsupial mole is endangered. Three mammals, two birds and a skink are listed as vulnerable under the State legislation. All species are threatened either by:

- grazing pressures,
- changed fire regimes or
- feral animals such as foxes and cats.

The condition of all species at risk is fair to degraded and all are declining. No flora species are listed as declared rare or endangered.

## Management responses

### Reserve system

The bioregion has two Class-A Nature Reserves – the Gibson Desert Nature Reserve and Mangkili Claypan Nature Reserve.

More than 1.8 million hectares (12 per cent) is in the conservation estate, covering 11 of the region's 24 vegetation associations.

However, this reserve system is highly biased, with no reserves at all in the Dune Field subregion. Reserved vegetations include hummock grasslands, scrublands, low *Acacia* woodlands, sedgeland, mosaic areas, and gorge communities.

Four vegetation associations and many of the 'at risk' communities described above are not on reserves and have a high priority for acquisition. Gaps include:

- low woodland mulga between sandridges,
- hummock grasslands and shrub steppe of acacia and grevillea over *Triodia basedowii*,
- hummock grassland and shrub steppe of mixed herbs over spinifex between sandhills, and
- hummock grasslands and steppe woodland of desert oak and soft spinifex between sandhills.

A total of 12 per cent of the Gibson Desert bioregion is reserved in IUCN I-IV reserves, so it is classified as IBRA reservation Class 4. The Lateritic Plain has 14.7 per cent reserved. The Dune Field subregion has no reserves.

Even so, the Lateritic Plain subregion remains as IBRA reservation Class 4, and the Dune Field subregion as Class 3. The reserve system is highly biased because it is not comprehensive or representative in terms of ecosystem representation. A higher rating is not considered appropriate as threatening processes (fire and ferals) are not as significant as they are in other bioregions.

Reserve management standard is ranked as fair because:

- some resource degradation is occurring though it is retrievable;
- wildfire management is non-existent;
- mining exploration activities are supervised;
- impacts of feral herbivores are likely to be considerable although not quantified; and
- no feral predator control programs exist in the region.



## Off reserve conservation for species and ecosystem recovery

The main recovery actions required for 'at risk' ecosystems and species include habitat retention by reservation or by agreements with landholders.

There are no major conflicting land uses as much of the Gibson Desert is unallocated Crown land, Aboriginal reserve or conservation reserve. However, capacity building with community and landholders concerning Aboriginal reserves is required.

Fire management needs to be introduced to reduce the impact of large intense, summer wildfires on habitat and fauna populations, and further research is required to determine threatened species status, distributions and general understanding of species ecology.

Feral animal control would assist with critical weight range species recovery. A major constraint of off-reserve conservation is insufficient resources to implement management activities.

## Integrated natural resource management (NRM)

The existing NRM initiative involves industry Codes of Practice guidelines on the extent of vegetation that should be removed during mineral exploration and restorative actions to mitigate damage. Opportunities include:

- legislation for duty of care for leasehold and other lands,
- capacity building in particular developing relationships with Aboriginal communities, and
- NRM threat abatement plans which are necessary for vegetation and threatened species, pest control and fire management.

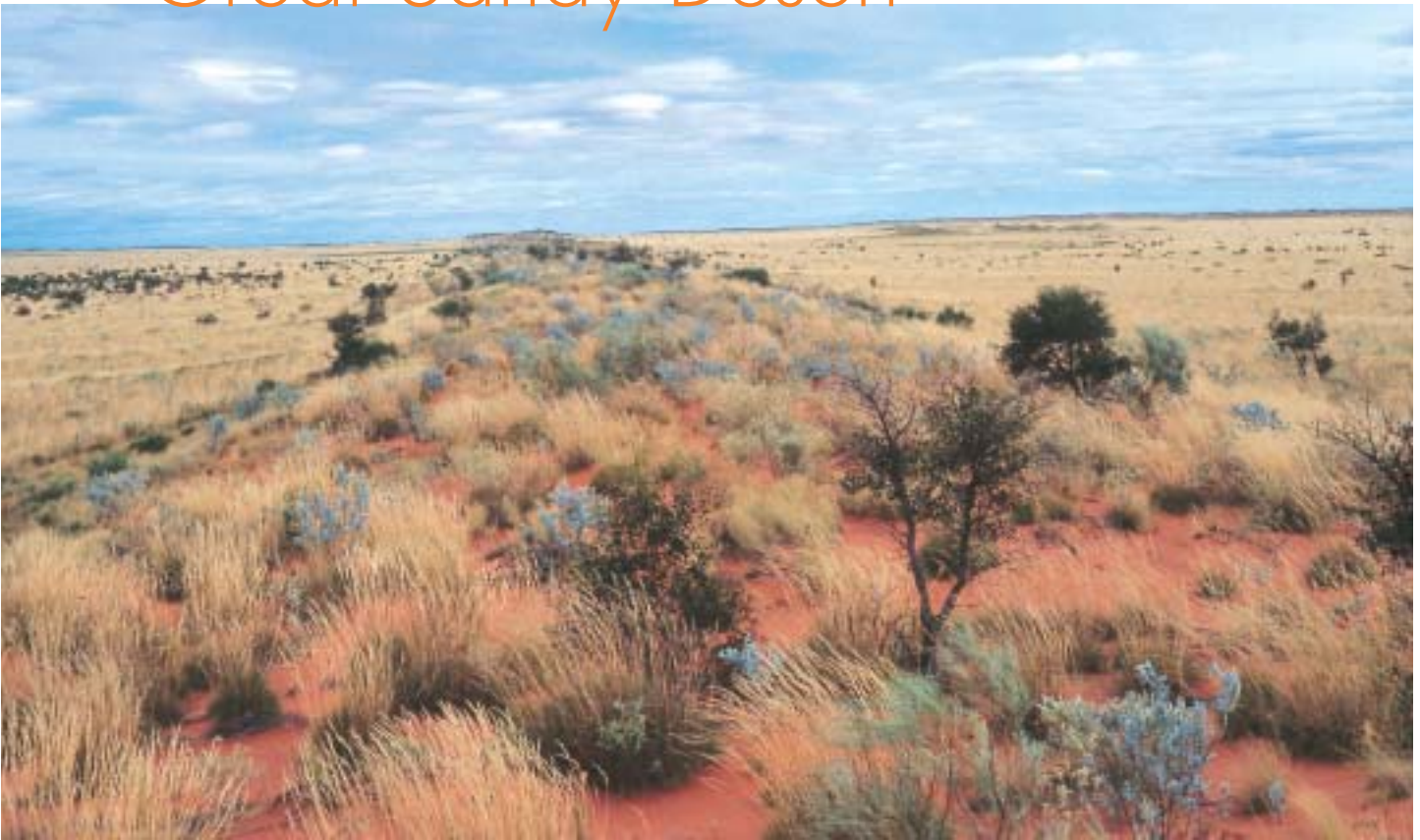
Impediments to NRM include:

- the Land Administration Act,
- operations of the Pastoral Lands Board,
- conservation through reserves could be limited by mining leases and tenements,
- there is a need to increase awareness of conservation values through education of various industries and the public in general,
- limited financial and staff resources, and
- the remoteness of the subregion.

## Major data gaps and research priorities

- There has been no bioregional survey of flora and fauna.
- No systematic fauna survey has been completed, and survey work has been confined to individual species and opportunistic collection.
- Floristic survey is also restricted to opportunistic collections, mostly confined to access routes.
- There is little data on the habitat requirements of virtually all invertebrate species, most ephemeral plants, persisting critical weight range mammals, and uncommon vertebrate and plant species.
- There is no quantitative data on the affect of exotic predators/herbivores, weed invasion, fire, mineral extraction or other threatening processes.

# Great Sandy Desert



Shrubs and hummock grass  
along the top of a red sand  
dune in the Great Sandy  
Desert Bioregion, W.A.  
Photo: N.L. McKenzie

## Description

### Bioregional description and biodiversity values

The Great Sandy Desert in Western Australia comprises the McLarty and Mackay subregions, and is mainly a tree steppe in the north grading to shrub steppe in south. The climate is arid tropical with summer rain.

The bioregion is dominated by Quaternary red longitudinal sand dune fields overlying Jurassic and Cretaceous sandstones of the Canning and Armadeus Basins. Vegetation comprises open hummock grassland of *Triodia pungens* and *T. schinzii* with scattered trees of Desert Walnut and Bloodwoods, and shrubs of *Acacia* spp, *Grevillea wickhamii* and *G. refracta*. *Casuarina decaisneana* (Desert Oak) occurs in the far east of the region.

Gently undulating lateritised uplands such as the Ankatell Ridge support shrub steppe such as *Acacia pachycarpa* over *Triodia pungens* hummock grass. Calcrete and evaporite surfaces are associated with occluded palaeo-drainage systems that traverse the desert and these include extensive salt lake chains with samphire low shrublands, and *Melaleuca glomerata* - *M. lasiandra* shrublands.

Monsoonal influences are apparent in the McLarty subregion. Its dunefields of red-brown sand support savannas that have a greater proportion of bunch grasses than the Mackay subregion, with emergent Desert Walnut trees rather than Desert Oak or Bloodwood.

Dominant land uses are unallocated Crown land, nature conservation and Aboriginal lands.

The region also contains a number of rare features such as Mandora Marsh, Dragon Tree Soak, Salt Creek (inland mangroves), Rudall River, as well as various soaks and rockholes that are significant local sources of water and serve as seasonal refugia.

Endemic troglobitic faunas are almost certainly associated with calcrete systems along palaeo-drainage lines. The bioregion's arid ecosystems are rich in reptiles, particularly in species of *Ctenotus* and *Lerista*.

### Overall condition and trend

Both subregions have a continental stress class of five, which is better than most other bioregions. However, historical information on the region's biota is scant, and the effects of fire and exotic herbivores (camels and

rabbits) and predators (foxes and cats) on productivity and biomass of mammal and vegetation structure are overt. Therefore, the condition is unknown and the trend is considered to be declining. Herbivores (feral and stock) have visibly degraded wetlands.

### Conservation priorities

Land acquisition and management issues are overshadowed by native title legislation and partnership arrangements with Aboriginal communities. A large off-reserve conservation effort is needed to preserve biodiversity, but examples of vegetation associations that are subject to threatening processes also need to be reserved. Reducing the effects of inappropriate fire regimes is a priority. The biggest constraint on effective land management is the absence of data on the composition and status of most of the region's biota.

### Nationally important wetlands

There are four wetlands of national importance – Dragon Tree Soak, Mandora Salt Marsh, Rock Pools of the Breaden Hills and Lake Dora at Rudall River.

Their condition is currently fair to good, though all wetlands areas are declining (except Rock Pools of the Breaden Hills which is unknown). Threatening processes are:

- damage and grazing pressure by feral animals (camels),
- changed fire regimes and
- exotic weeds (particularly buffel grass).

Lake Armadeus is a DIWA listed wetland in the Northern Territory which occurs in the Mackay subregion (though the majority is in the Kintore subregion of the Northern Territory, which does not extend into Western Australia).

### Wetlands of regional significance

Minor spring wetlands of Percival and other lake systems, soaks that were previously used by Aboriginal people (no longer maintained), salt lakes and underground aquifers are scattered throughout the region. They are regionally important.

In most cases they are the only sources of fresh water for great distances and are therefore vital as refuges as well as for the wetland ecosystems they support. Most surface wetlands are threatened by camels, in fair

condition but are declining or declining rapidly. Very little is known of the stygofauna of calcrete aquifers. Another two wetlands of subregional significance occur in the Northern Territory.

### Riparian zone

The Rudall River is the primary riparian area in the Western Australian part of the bioregion. Its riparian zone vegetation is currently in fair condition and declining. Threatening processes are:

- changed fire regimes,
- weeds (particularly buffel grass),
- grazing by feral animals (camels) and
- changed hydrology.

Other vegetation exists around some ephemeral creek lines in the Northern Territory.

### Ecosystems at risk

There is one Threatened Ecological Community, the organic mound spring community of Dragon Tree Soak.

In addition, there are nine ecosystems considered to be at risk in the West Australian part of this bioregion. All except one of these ecosystems are relatively small and isolated. They include mound springs, wetlands, mangroves, riparian habitats, and salt lakes which are vital to biota in a very dry environment.

Other ecosystems facing particular threat are those that are sensitive to changed fire regimes. The trend of all ecosystems in this region is either not known or in decline. Key threatening processes include:

- grazing pressure from stock and feral animals (camels, donkeys, goats), and
- changed fire regimes.

### Species at risk

No plant species have been declared as critically endangered, endangered or vulnerable under WA State legislation. However there are five priority species listed for the Great Sandy Desert. Further, two mammals (northern marsupial mole and ampurta) and one bird (night parrot) are listed as endangered, while one mammal (bilby) and one reptile (great desert skink) are vulnerable.

More than 30 per cent of the desert's original mammals and a few of its birds are now regionally extinct. In all cases, the trend for species at risk is unknown and the threatening processes include predation by cats and foxes and changed fire regimes.

## Management responses

### Reserve system

There are 41 vegetation associations which are not reserved or poorly represented in reserves in the bioregion. They include:

- bunch-grass savanna,
- sedgelands,
- samphire,
- *Coolibah*, *Melaleuca* spp,
- shrublands or hummock grasslands including *Triodia pungens*, *T. basedowii*, *T. intermedia*, *T. wiseana* and *T. bitextura*,
- *Owenia reticulata*,
- *E. brevifolia*, *E. setosa* and *E. dichromophloia*,
- *Acacia aneura*, *A. pyrifolia*, *A. delibrata*, *A. pachycarpa* and *A. coriacea*,
- *Grevillea refracta*,
- *Hakea* spp,
- *Allocasuarina decaisneana*, and
- *Plectrachne schinzii*.

They include communities on red sand, laterite, alluvial foot-slopes and plains, saltflats, clay plains and claypans. Five of the ecosystems at risk, including a Threatened Ecological Community, remain unreserved. Water is central to all these ecosystems (springs, inland mangroves, microbialite communities and permanent or ephemeral wetlands).

The primary constraint to adding examples of these vegetation associations and ecosystems to the formal reserve system is competing land uses. Many areas are now subject to native title claims. In addition, 27 vegetation associations are not reserved in the Northern Territory part of the Mackay subregion.

Major reserves in the region include Rudall River National Park and Dragon Tree Soak Nature Reserve. McLarty Hills Nature Reserve is very remote and is rarely visited by CALM staff or anyone else.

The Great Sandy Desert bioregion has a ranking priority of two for reserve consolidation (see Glossary). Both of its Western Australian subregions have inadequate and biased reserve systems.

Reserve management in the Western Australian part of the bioregion is ranked as poor because:

- there are no management plans,
- there are no on-site staff (even in parks with high tourist visitation and containing Aboriginal communities),
- there are no feral animal control programmes,
- no prescribed burning takes place,

- stock have uncontrolled access in parks, and
- the extent of other threatening processes (for example weeds) has not yet been determined.

### Off-reserve conservation for species and ecosystem recovery

Priority species are critical weight range mammals and granivorous birds. Priority ecosystems include wetlands damaged by feral herbivores and vegetations adversely affected by fire. Little is known of the distribution, status and impact of weed species.

Species recovery actions include:

- detailed fire research and a move towards biodiversity-driven fire management strategies,
- a survey of a wide range of species and communities,
- weed control, and
- the removal of feral stock from the conservation estate.

Links need to be established between Government agencies, traditional owners and the broader community in order to effectively manage and research the bioregion.

Most of the bioregion requires a large off-reserve effort, although limited measures in areas such as Mandora Marsh would result in significant conservation gains.

### Integrated natural resource management (NRM)

There are only a few natural resource management actions taking place in the WA section of the bioregion. The La Grange groundwater management committee was established, which may be an important capacity building resource, and some threat abatement planning occurs in the form of pest management.

The Northern Territory has legislation to help with fire management and tourist pressure at Uluru and Kata Tjuta.

Opportunities for NRM to address biodiversity issues include:

- research on the mechanism and impacts of threatening processes,
- threat abatement via pest control,
- improved implementation of existing legislation,
- improved communication between all stakeholders,
- acknowledgement of differing land management objectives,
- development of catchment and regional plans involving all stakeholders, and
- capability building through Aboriginal communities.

Limited financial resources, the low number of people available to implement strategies, recognition that native title will require cooperative work with desert Aboriginal communities, and the need to increase awareness of conservation values throughout the community are major constraints. The NRM rank is two

### Major data gaps and research priorities

The major research priorities are:

- vegetation and ecosystem mapping, including fauna and habitat data,
- the effects of feral animals (particularly camels) on wetland areas,
- fire ecology, and population trends even for relatively common species (e.g. native rodents, dasyurids, spinifex reptile communities, termites, ants, and weeds such as buffel grass).

# Great Victoria Desert



Low open woodland of  
Bara gum and mulga over  
spinifex hummock grassland in  
southern Great Victoria Desert  
Bioregion, W.A.  
Photo: N.L. McKenzie

## Description

### Bioregional description and biodiversity values

This is an active sand-ridge desert of deep Quaternary aeolian sands with a tree steppe of *Eucalyptus gongylocarpa*, Mulga and *E. youngiana* over hummock grassland, dominated by *Triodia basedowii*.

The climate is arid, with summer and winter rain averaging between 150 and 190mm annually. Landforms consist of red sand plains with patches of aeolian dunefields, salt lakes on major valley floors with lake derived dunes, and silcrete-capped mesas and plateaus (breakaways).

There are three subregions – Shield, Central and Maralinga.

Shield – the western end – is underlain by Yilgarn Craton and has the highest proportion of sandplains.

Central is active sand-ridge desert with extensive dune fields of deep Quaternary aeolian sands overlying Permian strata of the Gunbarrel Basin.

Maralinga is the eastern end, crossing the State borders to South Australia, and is underlain by Devonian sediments of the Gunbarrel Basin with extensive sandplains of deep Quaternary aeolian sands.

A tree steppe of *Eucalyptus gongylocarpa*, spinifex (*Triodia* spp) and mallee (*Eucalyptus kingsmillii*, *E. youngiana*) over hummock grassland dominated by *Triodia basedowii* occurs on the aeolian sands, with *Acacia*, mulga and *Eremophila* and *Santalum* spp. occurring on the colluvial soils. Scattered marble gum (*E. gongylocarpa*) and native pine (*Callitris* spp) occur on the deeper sands of the sand plains. Halophytes such as salt bush (*Atriplex*), bluebush (*Kochia*), and samphire (*Arthrocnemum*) occur near the salt lakes and in saline drainage areas.

Rare species include the:

- princess parrot,
- samphire thornbill,
- sandhill dunnart,
- marsupial mole,
- mulgara,
- rock wallaby,
- *Lerista puncticauda*,
- *Egernia kintorei*,
- *Conospermum toddii*,

- *Calytrix warburtonensis*,
- *Dampiera ramosa*,
- *Dicrastylis nicholasii*,
- *Eremophila aureivisca*,
- *Eucalyptus articulata*,
- *E. undulata*,
- *Labichea deserticola*,
- *Micromyrtus helmsii*,
- *Olearia arida*,
- *Ptilotus stipitatus*, and
- *Thryptomene wittveri*.

Threatened Ecological Communities include the yellow sandplain communities of the Great Victorian Desert, assemblages of Queen Victoria Spring and the Mirramiratjarra dune field. One hummock grassland vegetation association is confined entirely to Shield and more than 85 per cent of two vegetation associations are confined to the Central subregion.

### Overall condition and trend

Condition is good, apart from the western fringes of the Shield, which have been degraded by grazing stock. Critical weight range species have declined or become extinct. Feral herbivores (camels and rabbits) and large, intense summer wildfires have reduced vegetation biomass throughout the region, although the grazing effects are more pronounced in wetlands. The continental stress class is between five and six (near pristine). The Shield and Maralinga subregions are both six, while the Central is five.

### Conservation priorities

Management priorities are:

- feral herbivore and carnivore control,
- fire management regimes that reduce the size and impact of summer wildfires, and
- ecological surveys to gain more knowledge of the bioregion.

Resourcing and isolation are major constraints to management activities. However, increasing interests in mineral prospects and the possibility of mine development will require management.

The bioregion has a medium priority for reserve consolidation with 9.4 per cent in IUCN I-IV reserves, with a minimal regional bias.

## Nationally important wetlands

The Yeo Lake and Lake Throssell complex has national significance. These lakes are in good condition with recovery expected in the short term with minimal intervention. Both are old pastoral leases. Yeo Lake is now a nature reserve and Lake Throssell was never taken up or developed as a pastoral lease and is a proposed reserve. The trend is condition improving, with the removal of stock aiding in the recovery. The threatening process is mainly feral animals, including rabbits, goats, foxes, cats and stray stock.

## Wetlands of regional significance

There are two wetlands of regional significance: Lake Minigwal and Lake Rason. Both are significant for the maintenance of ecological processes.

Lake Minigwal is a seasonal intermittent saline lake with a static trend and in good condition. Threatening processes include feral animals and a changed hydrology due to de-watering of mine sites and discharge of hypersaline water into lake beds.

Lake Rason is also a seasonal intermittent saline lake with a static trend, but it is in near-pristine condition. Mineral exploration and feral animals are threatening processes.

## Riparian zone

The bioregion has no external drainage. Riparian vegetation is confined to major creek systems that only flow intermittently, and are of limited extent. Riparian zone vegetation is degraded on pastoral leases on the western edge of the bioregion but it is near-pristine in remaining areas. The trend is declining on pastoral leases and static for the remainder. Threatening processes include:

- grazing pressure on pastoral lease areas in the western section,
- feral animals,
- changed fire regimes, and
- changed hydrology from de watering of mines and lowering of water tables.

## Ecosystems at risk

Three ecosystems are considered vulnerable – the yellow sandplain communities, assemblages of Queen Victoria Spring and the Mirramiratjarra dune field.

The yellow sandplain communities of the Great Victoria Desert have diverse mammal and reptile faunas. Their distinctive plant communities are threatened by grazing, feral animals, mining and changed fire regimes.

The assemblages of Queen Victoria Spring are threatened by grazing, feral animals and changed fire regimes while the Mirramiratjarra dune field is an unique dune formation with a vegetation and drainage system threatened by grazing pressures and feral animals.

## Species at risk

Forty per cent of the Great Victoria Desert's original mammal fauna is now regionally extinct.

The southern marsupial mole, princess parrot and two plants (*Eucalyptus articulata* and *Conospermum toddii*) are considered endangered. One bird species, one skink, four mammals and one plant are considered vulnerable. Other flora species are listed either priority one or two under WA State legislation. The general condition of fauna is fair and that of plants varies from degraded to good. The trend for many species at risk is unknown. Threatening processes to both fauna and flora include carnivorous and herbivorous feral animals, changed fire regimes, and grazing pressures.

## Management responses

### Reserve system

The existing system comprises seven reserves and includes the Great Victoria Desert Nature Reserve, the largest reserve in WA. There are five A-class nature reserves and one C-class nature reserve with a total area of 1.9 million hectares. They include examples of 17 of the region's 39 vegetation associations – hummock grass, mallee, mulga and various eucalypt communities as well as communities of the Queen Victoria Springs yellow sandplain.

In addition to the ecosystems at risk described above, eight vegetation associations have a high priority for reservation. These are:

- mallee scrub shrublands,
- low Mulga woodlands between sandridges,
- low *Allocasuarina cristata* woodlands,
- mulga and marble gum over hard spinifex,
- succulent steppe with an open low woodland comprising of Mulga over saltbush,
- grassland and shrub steppe of mulga and mallee over soft spinifex,
- succulent steppe of saltbush and bluebush, and
- the Mirramiratjarra dune field complex.

The main constraints on filling these gaps are resource related in terms of management and research, although competing land uses (pastoral industry) and prospective mineral exploration and mining leases are also factors.



Aboriginal Land Agreements will probably enhance biodiversity conservation.

Overall 9.4 per cent of the bioregion is reserved in IUCN I-IV reserves and the bioregion is IBRA reservation Class five. However the Maralinga region is considered Class four. The three subregions have the following percentages in IUCN I-IV reservations – Shield 7.8 per cent, Central 10.3 per cent and Maralinga 8.4 per cent. This data is for the WA regions.

Reserve management standard is ranked ‘fair’ because biodiversity values and management issues are poorly identified and some resource degradation is occurring, although retrievable.

Predator control through aerial dog baiting programs has occurred in pastoral areas, and the impact of feral herbivores is unknown. Wildfire management is non-existent although mining exploration activities are supervised.

### Off-reserve conservation for species and ecosystem recovery

The main recovery actions required for ecosystems and species at risk include habitat retention, if not by reservation then by agreements with landholders.

Fire management to reduce the effect of large intense, summer wildfires on biota is a high priority.

Feral animal control is also required, as it will assist in the recovery of critical weight range mammal species.

Further research is needed to determine species status and distribution, which will help to increase knowledge of the biodiversity values and conservation issues in the region.

Limited off-reserve measures for the various species and ecosystem conservation/recovery efforts listed above are needed in all three regions. There are few major conflicting land uses because much of the desert is unallocated Crown land, Aboriginal reserve or conservation reserve.

Pastoral industry, mineral exploration and possible mine establishment are considered the main conflicting land uses, but these are localised. Once the ‘Spinifex Agreement’ with Indigenous peoples is implemented, extensive areas of the desert will be managed for conservation.

### Integrated natural resource management (NRM)

Existing natural resource management initiatives include the Wildlife Conservation, Pastoral Lands and Mining Acts. The last two include clauses related to protection of land and natural vegetation. Pest

management including feral animal control is a priority in threat abatement planning. There are industry codes of practice guidelines on the extent of vegetation that should be removed during mineral exploration and restorative actions to mitigate damage.

Opportunities include:

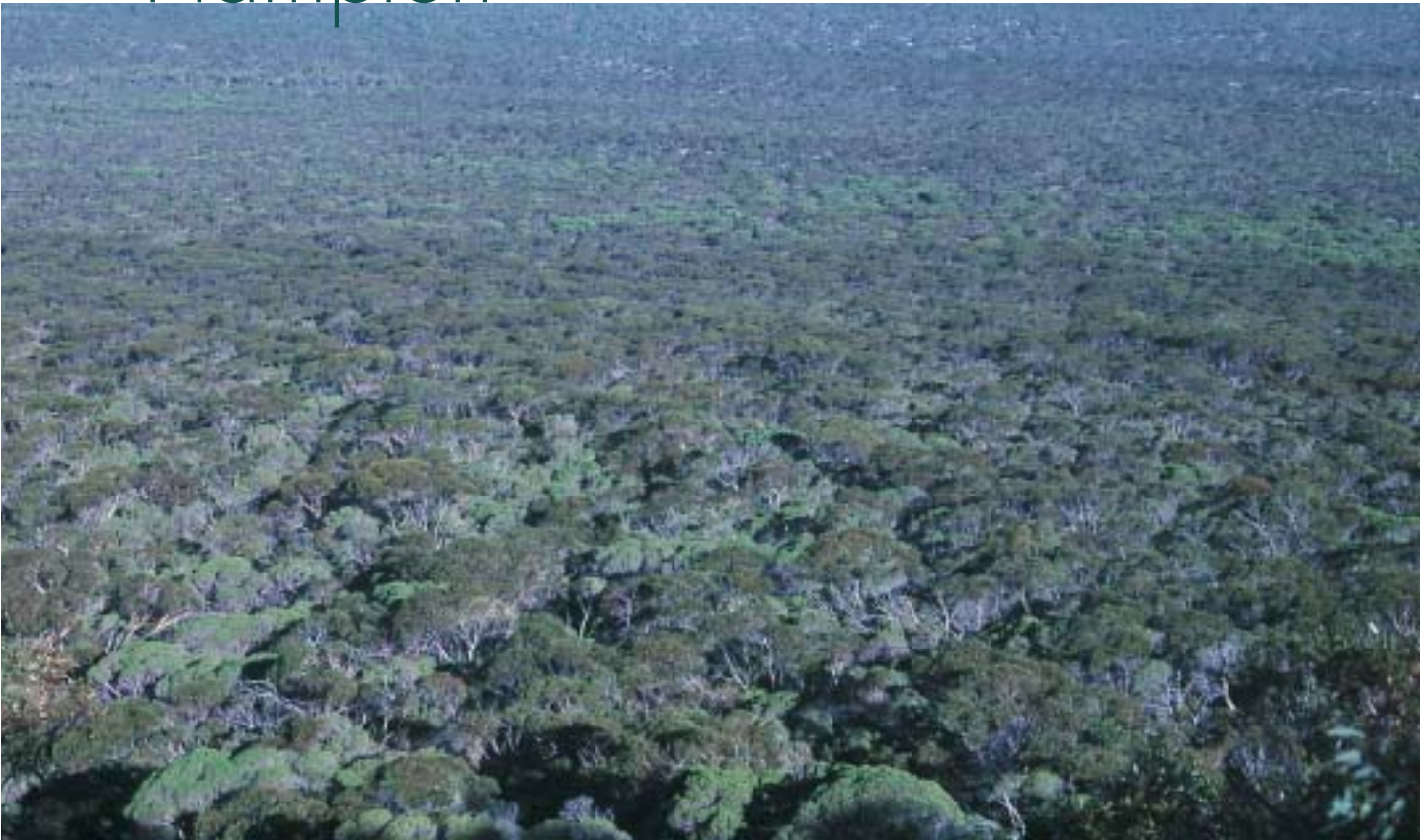
- reviews of industry codes of practice to strengthen protection of biodiversity, and duty of care for leasehold and other lands;
- threat abatement planning in relation to vegetation and threatened species management plans,
- pest management and
- fire management plans.

Capacity building with the community, landholders, industry and institutions is another opportunity for NRM. However the region’s remoteness and absence of infrastructure adds to the costs of implementing NRM. Other impediments include the Land Administration Act, the extent of mining leases and tenements, and limited financial and staff resources. These NRM priorities apply equally to all Great Victoria Desert subregions.

### Major data gaps and research priorities

- Regolith mapping is unavailable at better than 1:25,000 resolution.
- No systematic biological survey has been made of the region, although there has been some assessment of biota on proposed and current reserves and a number of localised studies have been completed.
- There is little fine scale floristic data available for the subregion.
- There is little data on habitat requirements of virtually all invertebrate species, most ephemeral plants, persisting critical weight range mammals and uncommon vertebrate and plant species.
- There is no data to provide a regional context on life-history (including population trend) of any species, even rabbits, and no quantitative data on the affect of exotic predators, introduced herbivores or weed colonisation.

# Hampton



Mallee and *Melaleuca* low woodlands on footslopes of the Hampton scarp and coastal sand ridges of the Roe Plain near Eucla in the Hampton Bioregion, W.A. Photo: G.J. Keighery

## Description

### Bioregional description and biodiversity values

The Hampton Bioregion comprises Quaternary marine dune systems fringing a coastal plain of the Eucla Basin that is backed by a stranded limestone scarp. Areas of marine sand are also perched along the top edge of the scarp. Various mallee communities dominate the limestone scree slopes and pavements, as well as the sandy surfaces. Alluvial and calcareous plains below the scarp support eucalypt woodlands and Myall open low woodlands. There are no subregional divisions within Hampton.

The limestone caves of the Eucla Basin are one of the largest karst systems in the world, including underground networks of caves, blowholes and subterranean streams. A unique stygofauna inhabit the cave systems, including some threatened invertebrates (Gondwanan relicts) and sub-fossil remains. High levels of endemism are found in stygofauna as dispersal mechanisms between individual aquifer systems are limited, and faunas have evolved in isolation (e.g. *Tartarus mullamullangensis*, *T. nurinensis*).

Coastal dunes of the region support three endemic reptile species (*Pseudemoia baudini*, *Lerista arenicola* and *L. baynesi*) and one endemic subspecies of reptile (*Ctenotus brooksi euclae*).

A variety of coastal dune plants also occur nowhere else (*Scaevola crassifolia*, *Atriplex cinerea* and *Euphorbia paralais*). These dune communities are noted for their high species diversity.

Land use is mainly unallocated Crown land, pastoral lease, and conservation reserve.

### Overall condition and trend

The wetlands in the bioregion are caves with locally endemic faunas. The karst systems and stygofauna are thought to be in near pristine condition but threatened by unrestrained recreational access. Several of the plain's ecosystems and species are believed to be at risk from feral predators and stock grazing.

## Conservation priorities

Reserve management in the bioregion is fair to good but the major constraint on both off-reserve conservation and natural resource management is the cost associated with the remoteness of the location.

### Nationally Important Wetlands

There are no wetlands of national importance in the Hampton Bioregion.

### Wetlands of regional significance

Four wetlands have significance; all are in caves: Weebubbie, Nurina, Pannikin Plains and Winbirra Caves. These caves are all in good or near pristine condition, but the future trend is unknown. The threatening process for all caves is uncontrolled recreational use.

### Riparian zone

There are no true riparian ecosystems in the Hampton Bioregion.

### Ecosystems at risk

None are listed under State legislation. However, Tallerack mallee-heath shrublands, Bluebush succulent steppe and drift sands are thought to be at risk. Their condition is fair or good, but the trend is declining and unknown. The primary threatening processes are feral animals (cats and dogs) and grazing (rabbits and sheep).

### Species at risk

More than 60 per cent of the Hampton's original mammal fauna is now regionally extinct.

Three birds are declared vulnerable under State legislation. One, an albatross, is an occasional visitor to the coastal section of the region.

The general condition of birds is fair and an overall trend is unclear. The albatross is threatened by commercial fishing activities and the other birds are threatened by grazing, weeds, foxes, clearing and possibly a change in fire regimes.

Three spiders and one isopod are all threatened by habitat disturbance by cavers and hydrological change. Condition and trend information is not known for any cave invertebrate.

## Management responses

### Reserve system

There are two A-class reserves in Hampton – Nuytsland Nature Reserve and Eucla National Park. The reserve management ranking is fair to good for both. Six of the nine vegetation associations in the region are represented in conservation reserves, and the reserve system occupies 10.9 per cent of the subregion.

Salt lakes and bluebush succulent steppe are not currently represented in CALM conservation estate and have high priority for acquisition. The constraint is land availability because most of the region is held as pastoral leases. Hampton has a reservation priority class of four (low).

### Off-reserve conservation for species and ecosystem recovery

The priority groups are critical weight range mammals, samphire thornbill and malleefowl, and chenopod communities.

A number recovery actions are necessary, including:

- capacity-building in pastoral industry to optimise chenopod grassland biomass and productivity,
- research into controlling Wards weed,
- monitoring rabbit numbers following the population reduction caused by callicivirus,
- fire protection of existing reserves, and
- examination of historical records of original mammal fauna with the view to re-introductions that reconstruct original critical weight range mammal communities.

Hampton's priority for off-reserve conservation is ranked as six (limited off-reserve measures are required).

The major constraints are competing land use (pastoral industry) and the high cost associated with conducting management so far from population centres.

## Integrated natural resource management (NRM)

A number of natural resource management actions are currently happening. They include:

- changes to legislation relating to conservation, environmental protection, pastoral activities, sandalwood collection and mining;
- institutional reform (rural reconstruction, industry reconstruction new tenure and management arrangements); and
- some rabbit and fox controls as part of threat abatement planning actions on pastoral leases.

Opportunities to expand NRM actions include:

- the establishment of conservation areas to fully represent salient features of the Hampton escarpment and Roe Plains, and
- planning with local governments and National Action Plan for water quality and salinity.

The main constraints are:

- the high cost associated with remoteness,
- that the Land Administration Act in relation to pastoral operations is not always consistent with conservation goals, and
- the generally poor awareness of biodiversity values.

## Major data gaps and research priorities

As a benchmark for long-term monitoring, 12 quadrats, positioned to sample one or two points within each of the region's main landform units, were surveyed for plant and vertebrate animals in 1984.

More information, survey and mapping is required of soils, fauna (available data includes bird atlas, specific threatened bird distributions and limited monitoring sites for mammals), flora (subsequent data is confined to specific threatened flora on a few large reserves), habitat requirements and population trend of nearly all species (including feral animals) and on the effects of disturbance by as exotic predators, weed colonisation and fire.

# Jarraah Forest



Jarraah (*Eucalyptus marginata*)  
understorey community in fire-  
managed forest near Collie,  
Jarrah Forest Bioregion, W.A.  
Photo: G.J. Keighery

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## Description

### Bioregional description and biodiversity values

The Jarrah Forest Bioregion is dominated by a duricrusted plateau of the Yilgarn Craton and characterised by jarrah-marri forest on laterite gravels and, in the eastern part, by marri-wandoo woodlands on clayey soils.

Eluvial and alluvial deposits in the south support *Agonis* shrublands. In areas of Mesozoic sediments, jarrah forests and various species-rich shrublands occur in a mosaic.

The climate is classified as warm Mediterranean. There are two subregions within the bioregion – the Northern Jarrah Forest and the Southern Jarrah Forest.

The Northern Jarrah Forest overlies Archaean granite and metamorphic rocks capped by an extensive lateritic duricrust that has been dissected by later drainage. It is also interrupted by occasional granite outcrops in the form of isolated hills. The lateritic plateau has an average elevation of 300m, and is so deeply dissected in the east that it occurs as isolated hills. Rainfall ranges from 1100mm on its western edge (the Darling Scarp) to 700mm in the east and north. Vegetation comprises jarrah-marri forest in the west (with bullich and blackbutt in the valleys), and grades into wandoo woodlands in the east with powder bark on breakaways. There are extensive but localised sand sheets with *Banksia* low woodlands. Heath is found on granite rocks and as a common understorey of forests and woodlands in the north and east.

The lateritic plateau broadens in the Southern Jarrah Forest and slopes gently to the south coast. In the south-east it is almost entirely mantled by sands and is virtually level, which causes poor drainage and numerous wetlands, including Lake Muir. Rainfall is from 1200mm in the south west to 500mm in the east. Vegetation comprises jarrah-marri forest in the west grading to marri and wandoo woodlands in the east. Extensive areas of swamp in the south-east are dominated by paperbarks and swamp yate. The forest and woodland understorey reflects the more mesic nature of this area.

Major landuses in the Northern Jarrah Forest region are forestry (native forest and plantation) and conservation, while grazing of improved pastures and dry land agriculture are more prevalent in the Southern Jarrah Forest. Other significant land uses include mining, rural residential, easements for roads and power lines, urban areas and irrigated horticulture.

The continental stress class is medium and ranges from three in the south to four in the north (see Glossary).

Rare or threatened species include:

- orchids (*Drakaea confluens*, *Caladenia bryceana* subsp. *bryceana*),
- birds (Muir's corella, western whipbird, western bristlebird, noisy scrub-bird),
- mammals (Gilbert's potoroo, southern brown bandicoot, chuditch, red-tailed phascogale, brush-tailed phascogale, quokka, numbat, woylie, tammar and the western ring-tailed possum),
- frogs (critically endangered white-bellied frog, yellow-bellied frog and sunset frog) and
- the *Baumea* reed beds of freshwater wetland in forest areas.

The region is a centre of endemism for plants (e.g. *Eucalyptus marginata*), has a locally patchy biota despite the geological and geomorphic uniformity of the lateritic plateau, and provides refugia for many threatened species of flora and fauna.

Remnant populations of several critical weight range mammals are now centered in this region. Wandoo and wandoo/powder bark woodland communities persist in eastern parts of the region.

### Overall condition and trend

Jarrah forest wetlands, riparian zones and terrestrial communities are mostly (about two-thirds) in good condition, although many are fair. Most are declining although many are static. There is a great variety of threatened ecosystems and species.

### Conservation priorities

There are threatened ecosystems and populations of threatened species in reserves. There needs to be a focus on protecting remaining as well as translocated populations of threatened species, both on and off reserves. Reserves and other ecosystem remnants low in the landscape need to be protected from salinity and excessive inundation. Controls need to be established for weeds, fire, pathogens, feral herbivores and predators on and off-reserves, especially in remnants of near-cleared vegetation associations. Clearing existing vegetation remnants needs to stop.

## Nationally important wetlands

The nine nationally important wetlands include swamps, lagoons, lakes, and a harbour. Most are ranked fair or good, but some range considerably along their length, with significant intervention being required for recovery.

The Mount Soho Swamps complex is in good to pristine condition. Other wetlands are either declining or declining rapidly and the rest are static. Threatening processes include:

- salinity,
- erosion,
- siltation,
- pollution (eutrophication from fertilisers and herbicides),
- feral animals (foxes, pigs, deer, horses, cats, rabbits, cattle and exotic fish),
- exotic weeds (watsonia, east coast wattles, exotic grasses, blue gums, various clovers and their allies),
- changed fire regimes, and
- pathogens (particularly *Phytophthora* dieback in forests and heaths).

The changed hydrology has reduced the seasonal fluctuations in water level, with wetlands becoming permanent water bodies and forests and heaths becoming wetlands. Many are also subject to illegal ti-tree cutting for bean sticks, cray pots and brush fencing.

Lake Muir is used illegally by motor vehicles and horse riders and is adjacent to a peat mining area.

## Wetlands of regional significance

The 15 wetlands of regional importance are all in the Southern Jarrah Forest region. They include rivers, streams, floodplains, lakes, pools, swamps and marshes. Permanent and seasonal or intermittent examples, as well as brackish, saline and fresh water examples of all types, are present. Peatlands and springs are also present. They range in condition from near pristine to fair-to-degraded.

Drainage systems such as the Denmark/Hay River are generally near pristine in their upper reaches, but fair in their middle and lower sections. Margaret River Swamps, St John's Conservation Park, Milyeannup Brook-Red Gully Floodplain System and Perup Swamps System are all static. Powlalup Nature Reserve, Tone River Floodplains-Talvewelup Wetland System, Frankland River and Kent River Wetland System, Frankland/Gordon Rivers Wetland System and Upper Kent River Wetland System are all declining. Arthur River is declining rapidly. Their threatening processes are:

- feral animals (foxes, pigs),
- changed fire regimes,
- pathogens (particularly *Phytophthora cinnamomi*),
- exotic weeds (bridal creeper, blackberry, *Pinus radiata*, gorse, pasture species),
- changed hydrology (salinity and altered flow regimes),
- pollution (fertilisers, pesticides),
- broadscale vegetation clearing,
- increasing fragmentation and
- firewood collection.

## Riparian zone

The main streams are the Avon, Murray, Collie, Blackwood, Kent, Denmark and Frankland. They each belong to a catchment of the same name. Within the region, all these systems have dams and/or reservoirs to provide an urban water supply, and water for irrigation, horticulture and agriculture.

Of the 39 riparian zones recognised in the region, about two-thirds have vegetation that is in pristine or good condition (recovery would occur in the short term with minimum intervention) and the rest are fair (requiring significant management intervention for recovery). Most are declining, with 12 continuing as static. The main threatening processes are altered flow patterns (caused by damming) and increasing salinity. Vegetation clearing and fragmentation, feral animals (particularly pigs) and grazing pressure are also widespread problems.

## Ecosystems at risk

Five Threatened Ecological Communities are listed under WA State legislation.

- Two are critically endangered - *Eucalyptus calophylla*-*Xanthorrhoea preissii* woodlands and shrublands and shrublands on southern Swan Coastal Plain Ironstones.
- One is endangered - *Banksia attenuata* and/or *Eucalyptus marginata* woodlands.
- Two are vulnerable - *Eucalyptus calophylla* - *Eucalyptus marginata* woodlands on sandy clay soils and *Calothamnus graniticus* heaths on south west coastal granites.

All are located in the western edge of the bioregion on the interface with the Swan Coastal Plain. Threatening processes include:

- weeds (kikuyu, watsonia and pasture grasses),
- salinity,
- ecosystem fragmentation,
- changed fire regimes,

- pathogens (particularly *Phytophthora cinnamoni*),
- feral animals (pigs and horses),
- recreational use of vehicles,
- damming of rivers,
- grazing pressure and
- urban development.

The condition or TECs is fair to good, but declining.

A further 22 other ecosystems are considered to be at risk in the bioregion, with most being in fair or good condition. However, the wheatbelt lowland mallet communities are in poor condition. Four ecosystems are at risk, all on the region's eastern border (with the wheatbelt). They are declining rapidly due to salinity and changed hydrology. Most other ecosystems at risk are declining or unknown in trend.

A wide range of threatening processes affect ecosystems at risk. These include weeds, changed fire regimes, pathogens, feral animals (particularly pigs in wetland areas), clearing, grazing, fragmentation, human recreational activities, salinity and changed hydrology.

## Species at risk

More than 10 per cent of the Jarrah Forest Bioregion's original mammal fauna is now regionally extinct.

Under State legislation, 17 plant species have been declared as critically endangered, 30 as endangered and 25 as vulnerable. One mammal and one amphibian are critically endangered. One mammal, two birds and two native bees are endangered. Four mammals, nine birds, and two amphibians are listed as vulnerable.

Existing populations of mammals are in fair or good condition and the trend for some of them is to improve.

Plant populations vary in condition and considerably. Some are poor (five critically endangered species) but most are fair or good. Survey work has found that some are improving. The condition and trend data for invertebrates is unknown. Threatening processes for plants are:

- vegetation clearing,
- fragmentation of vegetation,
- grazing pressure,
- feral animals,
- exotic weeds (particularly pasture grass),
- changed fire regimes,
- pathogens,
- altered flow regimes and water table,
- dissection due to roads,
- mining,

- illegal harvesting of some species,
- recreational vehicle users and
- small numbers of individuals and populations.

Native animals are adversely affected by:

- feral animals (fox, cats, rabbits, pigs and rats),
- changed fire regimes,
- habitat fragmentation and
- salinity.

Some species (particularly birds) are threatened by illegal culling and destruction of nesting sites in dead trees (logging).

## Management responses

### Reserve system

The jarrah bioregion has 149 nature reserves, 13 national parks and nine conservation parks. There are government proposals for an additional 35 national parks, which are in the early stages of implementation (March 2002), but information on these parks has not been included here.

The reserve system includes examples of most vegetation in the bioregion, and is dominated by jarrah and wandoo communities, granite outcrops and, on the south coast, by coastal shrublands and heaths.

The management standard for most nature reserves and conservation parks is fair while the standard for most national parks is good. Most nature reserves and conservation parks are small (less than 500 hectares), and are scattered across the bioregion with no resident staff and management visitation averaging once a year. Only one has a management plan.

Some of the national parks have resident staff, most have a management plan and service day-recreation for visitors. Even so, targeted ecological monitoring programs on the national parks are either absent or inadequate.

The small size and remnant vegetation function of most reserves has led to significant weed invasion, especially by pasture grasses. Reserves which have drainage lines and water courses are increasingly affected by salinity or rising water tables. Feral animals (foxes, rabbits and increasingly in the western sections, pigs) in all but the largest reserves are not controlled.

In the southern parts of the region, *Phytophthora* disease is degrading vegetation. This is compounded by the rising water tables. In the east, the understorey species composition on reserves has often lost many species found in similar habitats elsewhere, because of grass weed invasion, grazing, salinity and/or extended fire



frequencies. Fire regimes based on biodiversity outcomes are absent; deliberately lit wildfires can and do occur frequently depending on the proximity of the reserve to urbanisation.

There are two vegetation associations that are not reserved anywhere in the Northern Jarrah Forest. Four in the Southern Jarrah Forest are of high priority to include in the reserve system. Nine other vegetation associations have less than 10 per cent of their total area held in reserve and are also considered of high reservation priority in the Southern Jarrah Forest. All are woodland or low forests containing species of marri, wandoo, jarrah, banksia, yate, paperbark, mallet and/or river gum. Most are low in the landscape and threatened in some way.

The Regional Forest Agreement (RFA) reserve recommendations are already in the process of being implemented, a process that overlaps and may supersede the above reserve consolidation priorities. Nevertheless, large areas of the bioregion have already been cleared for agriculture, and remaining areas of certain ecosystems already fall below CAR thresholds.

Major parts of the landscape are also covered by mines, mining tenements or exploration leases. In particular, the central-eastern and northern portions of the bioregion (below the 600-700mm annual rainfall levels) are poorly represented in conservation reserves. This is the woolbelt and wheatbelt portion of the region which has had extensive clearing for agriculture.

The 500-800mm rainfall zone is showing rapid rises in ground water levels - up to one metre per year - which is affecting riparian vegetation and contributing to accelerated *Phytophthora* disease impacts. If IUCN I-IV reserves are used to calculate the priority for reservation rank, it is three (5.8 per cent reserved and 56.4 per cent of region's vegetation cover remains uncleared). However if IUCN V-VI are included in the calculations, it is class six (36.4 per cent). Both subregions have equal priority for reserve consolidation.

## Off-reserve conservation for species and ecosystem recovery

Priority groups for off-reserve conservation include:

- threatened flora on farmland in the eastern and northern zone of the subregion (Interim Recovery Plans are in place for critically endangered species, but limited work has been undertaken on other species),
- riparian vegetation in eastern parts of the region (rising water tables and /or salinity - State Salinity Strategy is being implemented), and

- understorey vegetation complexes in small woolbelt and wheatbelt remnant vegetation patches (threatening processes are weeds, grazing by sheep, rabbits and kangaroos, and absence of fire or overly extended fire regimes that impede the regeneration of certain plant species).

Off-reserve species recovery in the eastern area of the Jarrah Forest Bioregion is dependant on substantial and significant change in land use, supported by large scale revegetation programs to lower ground water levels.

Recovery and interim recovery plans have been written for all three declared frogs, most critical weight range mammals, some birds, some critically endangered plants and one threatened ecological community.

Some vertebrates, invertebrates and lesser priority plants are not covered by recovery plans. Both subregions require a large off-reserve effort, as resource constraints have limited the community's capacity to deal with salinity and rising water levels, habitat loss and habitat fragmentation.

## Integrated natural resource management (NRM)

Current natural resource management activities are:

- institutional reform of the hardwood timber industry (via the RFA process) that has resulted in gains for biodiversity conservation,
- threat abatement planning (State Salinity Strategy),
- feral animal control programs (for example, CALM's Western Shield program) with cooperative participation by landholders that has allowed populations of several threatened mammals to increase,
- industry codes of practice for blue gum plantations and
- limited integration with property management planning.

Opportunities for NRM include:

- institutional reform (rural reconstruction, industry reconstruction, new tenure and management arrangements in the woolbelt and wheatbelt),
- planning (local government planning and the National Action Plan for Water Quality and Salinity) and
- integration with property management planning (catchment planning).

However, there are constraints on NRM activities. These are:

- limited agency funding and staffing resources,
- limited community understanding of biodiversity and processes of integrating conservation practices into other forms of land management, and
- the extent of clearing and degradation that has occurred in the past.

## Major data gaps and research priorities

John Beard's vegetation mapping is available at a resolution of 1:100,000 or 1:250,000, while other mapping is available at a resolution of 1:50,000 and published at 1:250,000.

Community identification based on floristics has been done for most of the bioregion but the complexity of pattern on the landscape (hence cost of mapping) has prevented vegetation and ecosystem mapping based on community types, although localised areas have been mapped at finer scale.

Invertebrate plots are confined to SAP survey and noisy scrub bird sites in the southern sections of the Northern Jarrah Forest. Data on Southern Jarrah Forest invertebrates is confined to SAP survey quadrats, some wetlands and to selected taxa.

Vertebrate fauna data is sparse and patchy, being limited to SAP survey quadrats, Operation Foxglove quadrats and roadside cage trap transects associated with Western Shield monitoring. No systematic fauna surveys (vertebrate or invertebrate) have been conducted across the Jarrah Forest Bioregion.

Most reserves don't have long-term survey data on species' presence or absence, even for vertebrates.

A regional survey of flora has been completed, based on patchy sampling quadrats positioned on widespread surface-types as well as some of the localised substrates of particular interest. Non-vascular flora appears to be poor compared to equivalent community types in Tasmania, Victoria and New South Wales. Fungi surveys of the region have not been completed.

Rare flora surveys and monitoring are ongoing, but the work is limited by resources and the status of many living organisms (taxa) remains in doubt.

There is some data on population ecology and biology of persisting critical weight range mammals but less is available for all other vertebrates, particularly the uncommon ones. No data is available to provide a regional context on life-history (including population-trend) of most species, including predators (foxes, cats), invertebrates and reptiles.

There are data gaps in many other areas:

- There is no consistent regolith mapping available at better than 1:250,000 scale.
- There is no quantitative data on the affect of exotic predators, weed colonisation, fragmentation and farm clean-up, mineral-extraction on heavy metals, etc.
- Fire effect/response data is limited to few communities and taxa.
- An understanding of the effect of salinity/inundation on species and communities (including saline wetlands) is limited or lacking.
- Detailed *Phytophthora* mapping is lacking for most of the region. Detailed data on its impacts on individual species and communities is limited.
- There is no map showing the location of peat communities.

# Little Sandy Desert



Low shrubs and hummock grasses on red dune with Carnarvon Ranges in background in the Little Sandy Desert Bioregion, W.A.  
Photo: N.L. McKenzie

## Description

### Bioregional description and biodiversity values

The Little Sandy Desert Bioregion comprises red Quaternary dune fields with abrupt Proterozoic sandstone ranges of Bangemall Basin. It includes the headwaters and course of Rudall River.

A shrub steppe of acacias, *Aluta maisonneuvei* and grevilleas over *Triodia schinzii* hummock grassland occurs on the red sandy surfaces that dominate the desert. There is a shrub-steppe over *Triodia basedowii* on stony hills, with river gum communities and bunch grasslands on alluvial deposits in and associated with ranges.

The climate is arid, with summer rainfall. There are two subregions – Rudall and Trainor.

The region includes Savory Creek and the headwaters of Rudall River, two desert rivers with near permanent wetlands along their courses. Small permanent rockhole wetlands associated with ranges and uplands are locally significant water sources and have high biological and cultural significance. Small artificial wells have been constructed as water sources along the Canning Stock Route.

Land uses, in descending order of extent are unallocated Crown land, conservation and grazing of native pastures.

### Overall condition and trend

The bioregion has a continental stress class of six (near pristine), although a high proportion of the original mammal fauna is now extinct or declining, vegetation cover has been reduced as a result of fires and grazing by feral animals such as camels. Weeds such as buffel grass are spreading and feral predators (cats and foxes) are ubiquitous.

### Conservation priorities

Feral animal and weed control programs need to be implemented. The status of many species and ecosystems needs to be documented. Major reserves need to be acquired. There is a the need enter into co-management arrangements with local Aboriginal groups.

### Nationally important wetlands

There are three nationally listed wetlands. They are in a fair to good condition with two declining in condition (Lake Disappointment and Lake Dora-Rudall River) and a third (Pools of the Durba Hills) static. Threatening processes include grazing pressure (from feral camels, donkeys and rabbits) and exotic weed invasion (buffel grass and date palm). Human disturbance and vandalism of cultural features is also occurring.

### Wetlands of regional significance

There are five wetlands of subregional significance. They are of four types – freshwater springs, oases and rock pools, seasonal rivers and streams, and intermittent saline lakes. They are important as the only fresh water for large distances, contain rare and recently described taxa, are significant for the maintenance of ecological processes and have significant historical and cultural values. The condition and trend for four of the wetlands is unknown; the fifth is in fair condition but rapidly declining as a result of feral animals (camels).

### Riparian zone

Riparian zone vegetation in the subregion is in fair condition but declining. Buffel grass is common along Savory Creek and Rudall River, and permanent and semi-permanent pools are badly affected by camels. Threatening processes are feral animals (camel, cattle, donkeys and rabbits), weeds (buffel grass) and changed fire regimes.

### Ecosystems at risk

No Threatened Ecological Communities are listed for the region under WA State legislation, although six ecosystems are at risk. These ecosystems are:

- semi-permanent pools along rivers and creeks (Rudall catchment),
- rockholes,
- permanent pools (Durba Hills),
- riparian zones (Savory Creek),
- samphire communities (Lake Disappointment) and
- saline lakes.

Most are declining with two considered static in condition. The main threatening processes are feral animals and the associated grazing pressure (rabbit, camel, donkey) and exotic weeds (buffel grass and date palms).

## Summary of Species at Risk

Forty per cent of the Little Sandy Desert's original mammal fauna is now regionally extinct.

Under WA State legislation, one critically endangered bird (the night parrot) and three mammals (including both species of marsupial mole) have been declared as endangered. Three mammals, one bird and two reptiles have been declared as vulnerable. Rock-wallaby populations are continuing to decline despite a fox baiting program. The overall condition for vertebrates is fair with a trend declining, although very little is known about the current status of most species.

The threatening processes identified for most of the fauna are feral animals (fox, cat) and changes to the fire regime.

There are no DRF declared in the bioregion.

## Management responses

### Reserve system

The 558,448 hectares in conservation estate comprise 4.6 per cent of the bioregion and encompass seven of its 32 vegetation associations. The reserve system comprises part of one large national park (Rudall River), and is confined to the Rudall subregion. Its management standard is ranked as poor as it has no management plan and is rarely visited by staff despite having high tourist visitation. Two Aboriginal communities live in the park (Parnngurr and Punmu, with between 200-500 people), two mining communities are relatively close to the park (Nifty and Telfer), and despite having ongoing feral animal problems with camels and occasionally donkeys, no reserve management is undertaken. Formal fire management is absent, although Aboriginal people provide a regular burning regime along the roads.

Twenty vegetation associations are not represented in conservation lands, and have a high priority for acquisition. The level of reservation of the ecosystems at risk is unknown. A further six vegetation associations, while reserved to some small extent, have a high priority for further acquisition. The associations include hummock grasslands, shrublands, woodlands, and samphires.

Constraints on acquiring reserves include competing land uses (such as Aboriginal interests, where reserve acquisition can only proceed under a cooperative management model), mining interests, and limited knowledge of biodiversity values. Reservation of the Carnarvon Ranges was proposed to Government nearly 30 years ago.

## Off-reserve conservation for species and ecosystem recovery

It is generally recognised that further work is required to document the status and condition of both individual species and ecosystems in the Little Sandy Desert bioregion. For mammals the main recovery actions are feral animal control and fire management, and translocation programs are relevant.

Habitat protection and retention on lands under both private and State jurisdiction is needed, especially for ecosystems at risk and for threatened bird, reptile and plant species. As a related issue, recreational users of the Canning Stock Route are causing localised degradation of camping areas and tracks.

## Integrated natural resource management (NRM)

Almost no natural resource management actions are being undertaken. Threat abatement planning for vegetation and pest management is very limited, while mining industry codes of practice have been useful in requiring some localised biological survey work.

An opportunity for better threat abatement may emerge from co-operative management with desert Aboriginal communities. However, mineral tenements, the Land Administration Act in relation to pastoral lands, and low awareness of biodiversity benefits (environmental services and tourism) among the community at large impose constraints.

## Major data gaps and research priorities

Field work is needed to fill data gaps:

- There is no region-wide vegetation, environmental geology or soil mapping at better than 1:250,000 scale for conservation planning.
- The flora and fauna have only been examined in detail in small areas, so there is little data on ecological requirements and life histories of virtually all invertebrate species, plants, persisting critical weight range mammals, uncommon vertebrate and plant species, and ecologically dominant plant species (for example, hummock grasses).
- There is little data to provide a regional context on population trends for ecologically significant species such as native rodents, dasyurids, spinifex reptile communities, termites, ants, camels, foxes and weeds such as buffel grass.
- No data exists on the fauna and flora of small permanent rockhole wetlands or on aquatic environments of the Rudall River and Savory Creek.

- There is no quantitative data on the impact of camels, donkeys and rabbits on aquatic systems or other communities, especially effects on invertebrate and non-vascular plant communities.
- Changes to fire regimes in hummock grasslands and soil organic layers are likely to be having an effect particularly upon vertebrate communities, invertebrate communities, and non-vascular plants but there is no quantitative data on this.

# Mallee



*Eucalyptus hypochlamydea*  
mallee over *Melaleuca* low  
shrub-land in Bending Nature  
Reserve, Mallee Bioregion W.A.  
Photo: G.J. Keighery

## Description

### Bioregional description and biodiversity values

The south-eastern part of Yilgarn Craton is gently undulating, with partially occluded drainage. The climate is Mediterranean to semi-arid, with winter rainfall of between 250 and 500mm. There are two subregions – the Eastern Mallee and the Western Mallee.

The Eastern Mallee region contains calcareous clays and loams as duplex soils that often contain sheet and modular kankar, outcrops of metamorphosed sandstone, white and yellow sandplains, and loamy plains with numerous salt pans (pan fields). The vegetation is a mosaic: mallee grows on sandplains, samphire is common around small salt lakes, mallee and patches of woodland are found on clay, scrub-heath is present on sandstone, while mallee with boree (*Melaleuca pauperiflora*) grow on calcareous clay and loam.

The Western Mallee has more relief than its eastern counterpart. Its main surface-types comprise clays and silts underlain by kankar, exposed granite, sandplains, isolated uplands of laterite pavements and salt lake systems (on a granite basement). Mallee communities can be found on a variety of surfaces and *Eucalyptus* woodlands occur mainly on fine-textured soils, with scrub-heath on sands and laterite.

Land use is mainly grazing of improved pasture and dryland agriculture, with lesser areas of conservation, unallocated Crown land and Crown reserves, roads and other easements, and forestry plantation.

Rare features include:

- Granite outcrops. Four reptile species, uncommon terrestrial and aquatic invertebrates, and hundreds of plant species are restricted to granite outcrops. Individual outcrops have up to 200 species, including many endemics, making them the most diverse in the south west of Western Australia. These also provide seasonal resources and temporary refuge for fauna of surrounding habitats such as the black-flanked rock wallaby.
- Gypsum dunes such as Lake Tay are rich in rare and endemic plants (*Anigozanthos bicolor* subsp. *minor*, *Eremophila lactea*, *Myoporum turbinatum*, *Ricinocarpos trichophorus*, etc).

- The mixed thicket complex peculiar to the Russell Range includes dominants *Eucalyptus doratoxylon*, *Adenanthos oreophilus*, *Dampiera parvilolia*, *Monaotoca oligarrhenoides*, declared rare flora *Kennedia beckiana*, and priority taxa *Leucopogon apiculatus* and *Chorizema nervosum*.
- There are numerous endemic plant species belonging to the genera *Grevillea*, *Hakea*, *Eucalyptus*, *Acacia*, *Dryandra* and *Asteraceae*.
- Rare vertebrates including the western whipbird, western ground parrot, malleefowl, Cape Barren goose, slender-billed thornbill and chuditch.
- Freshwater wetlands are important refugia. Examples, such as Lake Bryde, East Lake Bryde and Lake Cronin, are becoming increasingly important as surrounding areas are salinised.
- Salt lake systems, the Russell Ranges and the region's eucalypt woodlands have high species- and ecosystem-diversity.

### Overall condition and trend

Salinity, vegetation fragmentation, weeds, fire, feral herbivores and predators have had a profound affect on the bioregion. Many ecosystems and species populations are in poor condition. Overall condition is fair to poor, and the trend is declining. Except for the presence of several large reserves, the Western Mallee resembles the Avon Wheatbelt which has a continental stress class of one (awful). A continental stress value of two is appropriate.

### Conservation priorities

Reserve threatened ecosystems and populations of threatened species. Focus on protecting remaining populations of threatened species, both on and off reserves. Protect reserves and other ecosystem remnants low in the landscape from salinity and excessive inundation. Control weeds, fire, pathogens, feral herbivores and predators on reserves and other vegetation remnants. Halt clearing.

### Nationally important wetlands

There are two wetlands of national significance, the Lake Grace System and Lake Bryde/East Lake Bryde. Their condition is fair; recovery is considered achievable but needing significant management intervention. Unfortunately, both are declining. The threatening processes include changes in hydrology (particularly increased salinity levels resulting from



input of saline surface water), disturbance of lake edges by recreational use of vehicles, and mining (gypsum and exploration permits).

## Wetlands of regional significance

Nineteen wetlands have regional importance. Their overall condition is good to near pristine, although the trend is for decline or unknown. Key threatening processes are changing hydrology (increasing salinity), vegetation clearing, grazing pressure, pollution (agricultural chemicals), exotic weed species and gypsum mining.

## Riparian zone

Three catchments extend into the region: Albany Coast, Esperance Coast and south-eastern periphery of Avon River Catchment. Their river systems are either in fair condition (Lort and Fitzgerald Rivers) or degraded (Young and Pallinup Rivers), and all are forecast to decline. Key threatening processes are the same as for other wetlands although pathogens are an additional problem.

## Ecosystems at risk

Three ecosystems are listed as threatened under State legislation: Lake Bryde wetland area (critically endangered), mixed thicket in the Russell Range and herblands (vulnerable) and bunch grasses on gypsum dunes (vulnerable). Changed fire regimes and pathogens are threatening the Russell Range mixed thicket, while changes to hydrology (salinity as well as flow regimes) are affecting the Lake Bryde wetland area. The gypsum dune communities are threatened by mining.

In addition, there are 13 other ecosystems at risk in the bioregion, all in fair or good condition where condition is known. The trends are for decline or rapid decline and again, many ecosystems are unknown. Relevant threatening processes include:

- changed hydrology (particularly salinity),
- clearing,
- pathogens (*Phytophthora* sp.) and
- mining.

The Western Mallee region is part of the wheatbelt and as such a general risk statement applies to its vegetation associations. More than 75 per cent has been cleared for agriculture (comprising about one third of the total number of vegetation associations in the subregion). The remaining areas of all valley floor woodlands are subject to secondary salinity. Therefore, a further 20 to 30 vegetation associations in the Western Mallee should be treated as being at risk.

## Species at risk

More than 35 per cent of the Mallee bioeconomy's original mammal fauna is now regionally extinct.

Under State legislation:

- eleven plant species have been declared as critically endangered,
- twenty one plants, two mammals and one bird are endangered, and
- fifteen plants, three mammals and four birds are listed as vulnerable.

Their trend ranges from static to declining rapidly. One bird, the slender-billed thornbill, is thought to be extinct, but one mammal, the Chuditch, is increasing in numbers under a fox baiting program. Most other species at risk are declining. Large numbers of ground-dwelling invertebrates are locally endemic and might face extinction from salinity.

Threatening processes affecting animals include land clearing, grazing pressure (mainly sheep and rabbits), changed fire regimes, feral predators (cats and foxes), and changed hydrology. Plants are threatened by clearing, vegetation fragmentation, weeds, changed fire regimes, salinity, changed hydrology, roadworks and small populations or restricted distributions.

## Management responses

### Reserve system

The conservation estate comprises 40 reserves, 38 nature reserves and two national parks.

It is biased towards ecosystems found high in the landscape (for example, at Dragon Rocks and Bending Nature Reserves), and those on poor soils around salt lake systems at the bottom (Lake Grace-Chinocup), although the Lake Magenta Nature Reserve includes an entire landscape profile. The reserve system in the Western Mallee is biased and fragmented.

Eighteen ecosystems are not reserved and have high priority for acquisition. They are:

- woodlands of wandoo, salmon gum, corel gum, morrel, yate and York gum on fine textured soils,
- jam-sheoak woodland,
- fresh water lakes,
- sedgeland,
- myall-greybush and salmon gum-saltbush on calcareous plains,
- woodland and samphire communities around saltlakes, and
- a scrub-heath.

Unreserved Threatened Ecological Communities include greenstone communities associated with the Bremer Range, shrublands on floors of freshwater lakes such as Lake Bryde and herblands and bunch grasslands of gypsum lunettes.

Reserve management across the bioregion is fair to good. Fire breaks and fire access tracks are installed and maintained. Some feral predator control occurs in larger reserves such as Lake Magenta, Dragon Rocks, Bending, Row and North Kalgarin Nature Reserves, although feral herbivores such as rabbits are not controlled.

Many nature reserves are threatened by saline groundwater, especially in the Western Mallee, but are mitigated (by pumping) on only a few reserves such as Lake Toolibin.

Competing land-uses are the main constraint to completing a comprehensive, adequate and representative (CAR) reserve system – agriculture, grazing and mining. Most ecosystems have been cleared well below CAR thresholds, so virtually all remnants are important for biodiversity conservation. Those with lowland communities (tall woodlands, mallee and melaleuca shrublands, freshwater and naturally saline wetlands) are under threat from rising watertables, and most of these communities will be lost.

Some opportunities exist to add to the conservation estate through the vesting of unallocated Crown land and the re-vesting of other Crown reserves, but there is some competition with other government agencies and local government for these areas. The process is also lengthy and somewhat ad hoc, and at present there are insufficient resources to acquire and manage an increased conservation estate.

The region has been assessed as IBRA Reservation Class five because more than 15 per cent of its area is reserved in CALM tenure. However, both the Eastern and Western Mallee subregions should be upgraded in priority to class three because of bias in coverage by their reserve systems.

Many surfaces are virtually all cleared, low-level landscape units are threatened, and while 33 per cent of native vegetation cover remains in the Western Mallee, only 17.3 per cent of native vegetation cover remains in its western and central parts.

## Off-reserve conservation for species and ecosystem recovery

Priority species and ecosystems include:

- critical weight range mammals and threatened birds,
- biota of granite outcrops, and

- flora with Interim Recovery Plans, of roadsides and of lowland communities, and the plant communities of banded ironstone ranges, Bremer Range, gypsum lunettes and Lake Bryde.

Recovery actions for all species and ecosystems include:

- habitat retention through reserves, private lands and other state lands,
- weed control,
- feral animal control,
- fencing,
- fire management,
- survey and mapping work,
- incentives for landholders to conserve communities,
- control of mining activities,
- pumping to control water tables (especially lowland areas),
- translocation,
- revegetation,
- germplasm storage and
- capacity building with local government authorities and landholders.

However, there are constraints on some of the above actions because:

- many species are locally extinct, making it is hard to obtain sufficient numbers for translocation (particularly mammals),
- habitat patches of large enough areas no longer exist in western parts of the bioregion,
- there are a variety of competing land uses (crop-farming, grazing, mining),
- predators are expensive to control,
- there is no viable technology to control salinity which affects 30 per cent of the cleared landscape,
- there is a lack of survey data and knowledge on habitat requirements, and
- there is a lack of staff resources.

The Eastern Mallee has an off-reserve conservation priority of four (some limited off-reserve measures are required) because significant areas of unallocated Crown land remain. In contrast, the Western Mallee is priority one (major constraints to achieve conservation outcomes).

## Integrated natural resource management (NRM)

The most significant contributions to biodiversity conservation in the Mallee region are the on-ground activities of the Department of Conservation and Land Management.

Natural resource management initiatives affecting biodiversity include incentives for re-vegetation, protecting vegetation remnants (by fencing and earthworks) and abating threats such as dieback, feral animals, fire, salinity and weeds.

To this end, industry codes of practice for extractive industries, mining, timber plantations and roadside construction and maintenance exist, there are integrated regional management plans, and rural land-use plans and environmental management systems are being prepared.

Government agencies are interacting with non-government organisations such as the Avon Catchment Network, Greening Australia, the World Wildlife Fund's Woodland Watch, the Threatened Species Network and the Malleefowl Preservation Society to build capacity among landholders and to implement strategic plans, including new industries based on native biota, particularly deep rooted perennial plants. Environment and natural resources policies under the Town Planning and Development Act 1928 will guide and coordinate many State agencies and local governments on the use and development of land.

The main constraints on successful natural resource management include:

- the lack of resources (human and infrastructure) for implementation,
- lack of rigour in the natural resource management area,
- the generally very poor understanding of the relevant socio-political processes,
- the lack of technical solutions that are economically viable,
- the need for more controls on land clearing and drainage and
- the need to integrate property management planning, catchment planning and Landcare.

While various Acts protect wildlife and soils, there is no duty of care legislation.

The Eastern Mallee was assessed as having a natural resource management rank of three to four. The capacity for ensuring that conservation is integrated into natural resource management to achieve significant biodiversity outcomes has been recognised. Natural resource management instruments are in place with some achieved biodiversity outcomes.

The Western Mallee has a natural resource management rank of one, and has major constraints to implementing effective natural resource management actions to achieve biodiversity outcomes. An overall rank of two seems appropriate.

## Major data gaps and research priorities

- A field survey of biodiversity in relation to physical landscape attributes is required in vegetation remnants. This commenced in 1999.
- Robust biodiversity surrogates need to be identified, as does population viability in the context of the region's fragmented landscape and fire.
- There is no data to provide a regional context on life-history (including population-trend) of most species, including foxes.
- Quantitative data on the effect of fire, exotic predators, weeds, landscape fragmentation and farm clean-up, mining, and a rising water table on communities is also required.
- A standardised database and GIS application is also essential for data querying and management.

# Murchison



Mulga over spinifex shrublands  
and flowering herbfield on  
red sandplain of the Murchison  
Bioregion, W.A.  
Photo: N.L McKenzie

## Description

### Bioregional description and biodiversity values

The northern part of the Yilgarn Craton has an arid climate, with mainly winter rainfall (200mm).

There are two regions – the Eastern and Western Murchison.

The Eastern Murchison comprises the northern parts of the craton's 'Southern Cross' and 'Eastern Goldfields' Terrains, and is characterised by internal drainage and extensive areas of elevated red desert sandplains with minimal dune development. Salt lake systems are associated with the occluded paleodrainage system. Broad plains of red-brown soils and breakaway complexes as well as red sandplains are widespread. Vegetation is dominated by mulga woodlands and is often rich in ephemerals, hummock grasslands, saltbush shrublands and *Halosarcia* shrublands.

The Western Murchison is the 'Murchison' Terrains part of the Craton, and contains the headwaters of the Murchison and Wooramel Rivers, which drain the subregion westwards to the coast. The region is made up of mulga low woodlands (usually with bunch grasses and often rich in ephemerals) on outcrop, and fine-textured Quaternary alluvial and eluvial surfaces (extensive hardpan washplains that dominate and characterise the subregion) mantling granitic and greenstone strata. Surfaces associated with the occluded drainage occur throughout, with hummock grasslands on Quaternary sandplains, saltbush shrublands on calcareous soils and halosarcia low shrublands on saline alluvia.

Grazing of native pastures accounts for most land use, although unoccupied Crown land, conservation reserves and mining are also significant land uses.

Special values include calcrete aquifers with endemic faunas of aquatic invertebrates (for example, the Lake Way system, Jundee, Lorna Glen, Cunyu, Austin Downs and Killara Stations).

There are 41 vegetation associations (hummock grasslands, succulent steppe or low woodlands) that have at least 85 per cent of their total area in the bioregion. The bioregion is rich and diverse in both its flora and fauna but most species are wide ranging and usually occur in adjoining regions. A snake (*Pseudechis butleri*) is the only regionally endemic species of known vertebrate.

Refugia include:

- Lake Barlee (an intermittent salt lake that fills for approximately one year in 10 and provides breeding sites for banded stilts and other water birds),
- Wooleen Lake (a floodplain lake and associated marshes which is also an important breeding habitat for waterbirds including gull-billed terns) and
- Anneen Lake (a large saline brackish lake and marsh with numerous islands and peninsulas which is a significant breeding area for gull-billed terns and whiskered terns and other waterbirds).

### Overall condition and trend

Both regions in the Murchison have a continental stress class of three but the regional ecologists argue that it should be two or even one because of the high level of environmental degradation and the small area of land reserved for nature conservation.

Wetlands are in fair or good condition and the riparian systems are poor to fair. The trend for both wetland and riparian systems is to remain static or decline. Ecosystems and species at risk are subject to a large number of threatening processes, and the trend is not known in many cases.

### Conservation priorities

Management of reserves and parks in the bioregion is generally fair or good, though some issues such as control of feral animals and fires need to be addressed as quickly as possible, as does the need for further survey work.

Pastoral leases are currently being acquired and added to the conservation estate (and it is a priority for this process to continue), but these areas often face similar management issues at existing reserves and parks.

### Nationally important wetlands

There are six wetlands of national importance in the bioregion, all of which are lakes: Ballard, Barlee, Marmion, Wooleen, Breberle and Anneen.

The current condition of all the lakes is fair to good with recovery possible provided some intervention occurs. The trend for all lakes is to remain static although not enough is known about some lake systems to provide a reliable prediction.

The key threatening processes that affect wetlands in the bioregion are grazing pressure, feral animals (goats, foxes, cats and rabbits) and some impact from nearby mining operations on Anneen Lake.

### Wetlands of regional significance

The only wetland of regional significance is in the Western Murchison, Mungawolagudgi Claypan on Muggon Station. It is an intermittent freshwater lake and contains significant *Melaleuca uncinata* shrublands and vegetation associations associated with dunes. Both the condition and trend are static. Goats are a key threatening process, as is changed hydrology (increased inflow of sediments due to erosion of catchment).

### Riparian zone

The principal streams in the Murchison bioregion are Wooramel and Murchison Rivers and their catchments of the same names. Riparian condition is poor to fair and the trend is declining. Threatening processes affecting riparian systems are grazing (particularly sheep), feral animals (goats, rabbits and foxes), weeds (buffel grass, saffron thistle, thorn apple, mexican poppy), changed hydrology and changed fire regimes.

### Ecosystems at risk

No ecosystems are listed as threatened under WA State legislation but 52 communities and vegetation associations are thought to be at risk for a variety of reasons.

Subterranean fauna is generally in good condition and is not changing (except in Depot Springs where this information is not known) but is threatened by salinity, pollution and water drawdown.

Woodlands and shrublands (acacia, chenopod, melaleuca, casuarina and eucalyptus) and grasslands are generally in fair or good condition and are either declining or show a static trend. All of these communities are threatened by grazing (stock, goats and rabbits) and changed fire regimes.

Several communities are threatened by clearing, impacts of mining, erosion and sedimentation that is causing hydrological change.

Wetland and aquatic communities are in fair condition but trends are unknown. Threatening processes include grazing in catchment areas, feral fish (Tilapia) and changed hydrology.

### Species at risk

Under State legislation:

- one reptile is listed as endangered, and
- three mammals, three birds and one reptile are listed as vulnerable.

More than 40 per cent of the Murchison's original mammal fauna is now regionally extinct.

Most other fauna are in fair or degraded condition, and the listed fauna species are declining or declining rapidly. Feral predators (cats and foxes), changed fire regimes and vegetation loss are the threatening processes that affect vertebrate animals.

Three plant species are currently listed as Declared Rare Flora (two of which are vulnerable) with one additional species listed under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999. The condition of both *Conospermum toddii* and *Eucalyptus articulata* is good but are experiencing some decline. All other DRF and priority species have not been studied in sufficient detail to ascertain their condition and trend. Threatening processes that affect plants include changed fire regimes, grazing pressure, feral animals (especially goats), weeds and vegetation clearing.

## Management responses

### Reserve system

Six nature reserves, one national park, one timber reserve and five areas of unallocated Crown land form the Department of Conservation and Land Management's conservation estate.

The management rank for all types of reserves is fair to good: there are no feral predator programs in place, wildfire management facilities are limited by resources, mining exploration is supervised (except for old exploration drill holes which often remain open), and feral herbivore grazing activities still pose a conservation risk in some areas.

Existing conservation lands cover a wide array of surfaces at all levels in the landscape. There are 60 ecosystems or vegetation associations that are high priority to reserve but are not currently represented in the Department's estate (of any kind).

Constraints on reserve acquisition include:

- competing land uses (pastoralism and mining),
- the cost of land and subsequent management,
- difficulties in identifying biodiversity values (lack of detailed biodiversity pattern data) and
- significant degradation due to pastoral practices and feral herbivores.

The Murchison is reservation class two, but with only 1.39 per cent of the area in IUCN I-IV reserve, it should be ranked as class one, the highest priority for reserve acquisition. The most important issue relating to reserve management is control of feral animals.

### Off-reserve conservation for species and ecosystem recovery

There are no recovery plans for *Falco peregrinus*, *Polytelis alexandrae*, *Minuria tridens*, *Conospermum toddii*, *Eucalyptus articulata* or any stygofauna species.

There are a number of recovery plans which are applicable within the bioregion, including:

- Recovery Plan for the Greater Bilby,
- 1996 Action Plan for Australian Marsupials and Monotremes,
- Recovery Plan for Mallee Fowl,
- The Action plan for Australian Birds 2000, and
- Recovery Plan for the Great Desert Skink 2001–2011 and
- The Action Plan for Australian reptiles.

The recovery actions recommended for fauna species include habitat retention through reserves, State or private lands as well as control of feral predators (cats and foxes), and reducing grazing (feral herbivores).

Recovery actions for flora species and ecosystems differ slightly as control of weeds, suitable fire regimes and a better understanding of life history requirements for all rare flora are required in addition to actions taken for fauna species above.

The Murchison bioregion has a priority of two (significant off-reserve effort required). However, there are resource constraints and limited community capacity.

### Integrated natural resource management (NRM)

The natural resource management initiatives currently being undertaken include:

- threat abatement planning (e.g. vegetation management plans, pest management),
- industry codes of practice (in relation to mining and exploration activities),
- environmental management systems,
- ecologically sustainable product marketing,
- institutional reform (through the Gascoyne Murchison Strategy and purchase of leases for conservation estate),
- integration with property management planning and catchment planning, and

- Landcare through Land Conservation District Committees in the region.

Opportunities for natural resource management actions include:

- duty-of-care legislation for leasehold and other lands,
- rural and industry reconstruction,
- new tenure and management arrangements,
- planning with local governments and National Action Plan for Water Quality and Salinity, and
- ecologically sustainable product marketing (e.g. AgWA's EMU process).

The Murchison bioregion is in the highest rank for natural resource management priority because there are major constraints to implement effective natural resource management actions that will achieve biodiversity outcomes.

Much of the native vegetation is severely degraded through past agricultural practices (primarily sheep grazing) and feral herbivores. The Pastoral Lands Act leases still require the landholder to maintain certain stock levels that do not necessarily fit with conservation values.

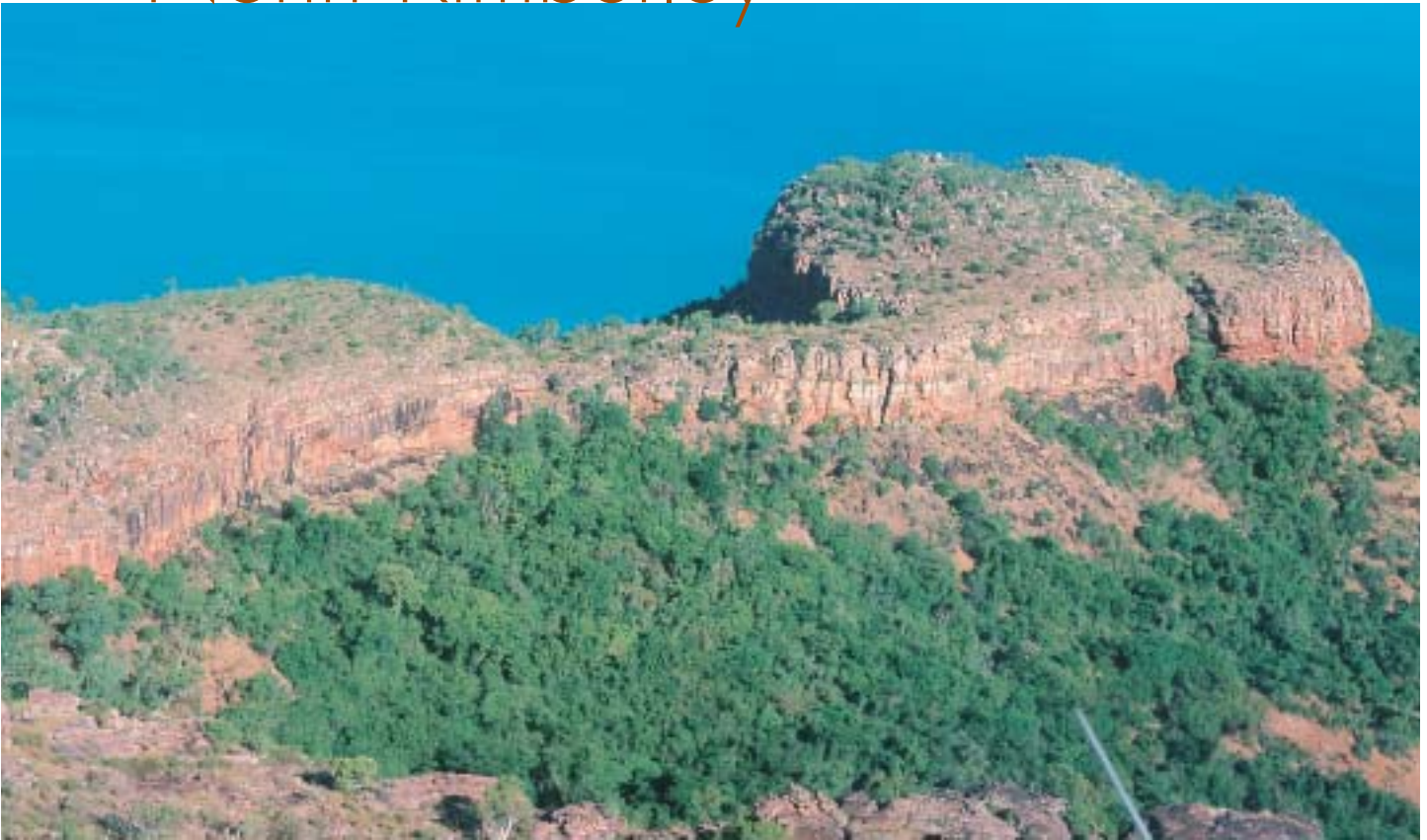
Pastoral industry reform is essential to achieve desired conservation outcomes. Awareness of conservation values through education of various industry (mining, pastoral) and members of the public needs to be increased and limited financial resources are also a major constraint.

### Major data gaps and research priorities

The highest priority data gaps in the bioregion are:

- data on distributions, population sizes and habitat requirements for many organisms, and
- quantitative information on the effects of feral animals, weeds, changes to fire regimes and mineral extraction on communities of greenstone surfaces.

# North Kimberley



Open savanna woodland on rugged sandstone and vine thickets on scree slopes under escarpments in the Prince Frederick Harbour, North Kimberley Bioregion, WA.  
Photo: N.I. McKenzie



## Description

### Bioregional description and biodiversity values

The North Kimberly bioregion is a dissected plateau of the Kimberley Basin. It features a savannah woodland of woollybutt and Darwin stringy bark over high sorghum grasses and *Triodia schinzii* hummock grasses on shallow sandy soils across outcropping Proterozoic siliceous sandstone strata.

Savannah woodlands of *Eucalyptus tectifica* and *Eucalyptus grandifolia* alliance over high sorghum grasses occur on the red and yellow earths mantling basic Proterozoic volcanics.

Riparian closed forests of paperbark trees and *Pandanus* occur along the drainage lines. Extensive mangals occur in estuaries and sheltered bays. Numerous small patches of monsoon rainforest are scattered through the district.

The climate is dry, hot, tropical and sub-humid with summer rainfall.

The bioregion is divided into two subregions – Mitchell in the west and Berkeley in the east.

The Mitchell subregion has a diverse array of exposed basement strata dissected by rivers, and a rugged sunken coastline, deeply embayed. Skeletal sandy soils incompletely mantle sandstone boulder country, significant areas of volcanic and dolerite surfaces, lateritised upland, and alluvial floors along major river valleys.

The Berkeley subregion is less dissected than the Mitchell, and is dominated by an upland of mainly Pentecost sandstones more continuously mantled by (sandy) soils supporting an open savanna woodland with a few vine thickets.

Special values of the bioregion include a sunken coastline with extensive coastal archipelagos (Buccaneer and Bonaparte) and island groups (Osborne, Eclipse and Sir Graham Moore Islands). The islands form a microcosm of the Mitchell region and present an opportunity to protect intact ecosystems. There is tropical laterite flora with a palm-dominated landscape (*Livistona eastonii*) unique in Western Australia.

The Cape Bougainville rainforest on laterite and volcanics has no hoofed feral animals and is the largest single patch of rainforest in the Kimberley.

The flora and fauna of the Mitchell's north-western margin is still intact, including threatened and/or

endemic species such as the golden bandicoot (*Isodon auratus*), scaly-tailed possum (*Wyulda squamicaudata*), monjon (*Petrogale burbidgei*), nabarlek (*Peradorcas concinna*), golden-backed tree-rat (*Mesembriomys macrurus*), Kimberley rock-rat (*Zyzomys woodwardi*), rough-scaled python (*Morelia carinata*) and black grasswren (*Amytornis housei*). The region is fox and rabbit free and essentially uninhabited. There is a wide range of other endemic vertebrate and land snail species. The declared rare flora species *Eucalyptus ceracea* is endemic.

The main land uses are grazing of native pastures, Aboriginal reserves, unallocated Crown land and Crown reserves, and conservation.

### Overall condition and trend

The Continental Stress Class is six (near pristine). This should be reviewed in the light of the threatening processes that are operating at the landscape scale (fire and grazing).

The condition and trend of nearly all flora and fauna species at risk are unknown but indications are that there is a continuing general deterioration in the condition of the bioregion mainly due to fire and grazing.

### Conservation priorities

Current fire management practices, pastoral practices and feral animal control need to be improved. An investigation of the current status of individual species and ecosystems is urgent, along with research to build a better understanding of the impact of threatening processes. A range of vegetation associations and ecosystems at risk needs to be reserved.

CALM, Aboriginal communities and the Western Australian Tourism Commission need to collaborate on protecting the natural values of the Mitchell's coastline and islands.

### Nationally important wetlands

Four nationally important wetlands are present in the North Kimberly Bioregion, of which three are river systems and one a series of wetlands. Two of these are in good condition and two are considered to be near pristine. Two are declining in condition but the trend for the two that are near pristine is unknown. The primary threatening processes for all these wetlands are changed fire regimes and grazing pressure.

## Wetlands of regional significance

Three wetlands in the Mitchell subregion have been identified as being of regional significance. Further work is required to identify wetlands of regional significance in the Berkeley subregion. The wetlands include a riverine floodplain, a freshwater swamp forest and a permanent freshwater lake. The threatening process for one is unknown and grazing pressure is the main threat for the other two.

## Riparian zone

The condition of vegetation in riparian zones is generally good but is declining. Threatening processes include changed fire regimes, grazing pressure from feral herbivores and changed hydrology.

## Ecosystems at risk

One Threatened Ecological Community (the Black Spring organic mound spring community) is declared Endangered under State legislation, and four are declared Vulnerable (Walcott Inlet, Roe River Rainforest Swamps, Theda Soak Rainforest and Organic mound springs of the southern North Kimberley).

Eleven other ecosystems have been identified as being at risk. They include tropical and sub-tropical rainforest, tropical forests and woodlands, paperbark forests and woodlands and hermland, sedgeland and rushland. A number are unclassified at the National Vegetation Inventory System (NVIS) scale of resolution. Most are in fair condition, and declining or static. The main threatening processes are grazing pressure and changed fire regimes.

There is very little data on threatened ecosystems in the Berkeley; its rainforests, for example, are thought to be subject to the same pressures as their counterparts in the Mitchell.

## Species at risk

Under State legislation, two birds and two reptiles (both turtles) are declared as endangered (gouldian finch, crested shrike-tit, and logger head and olive turtles), and a further three mammals, three birds and four turtle species are vulnerable including the golden bandicoot, golden-backed tree rat, Butler's dunnart, red goshawk, purple-crowned fairy wren and partridge pigeon.

*Eucalyptus ceracea* is the only Declared Rare Flora (Vulnerable) species. The threatening processes for most plants and terrestrial vertebrate are primarily changed fire regimes operating at the landscape scale. To a lesser extent grazing pressure and predation have been identified for vertebrates. The threats for most other groups have not been identified.

## Management responses

### Reserve system

Regional conservation lands include one large biosphere reserve (Prince Regent River Nature Reserve), one large national park (Drysdale River), two smaller national parks (Mitchell River and Lawley River) and two small conservation parks (Laterite and Camp Creek).

These reserves comprise 13.2 per cent of the bioregion. Their management standard is poor to fair. Apart from a donkey control program, no feral animal control programs exist. There is limited strategic aerial prescribed burning and some opportunistic hand burns, the latter being confined to very small areas of the Mitchell subregion. The effect of threatening processes (fire, weeds, ferals) is not yet determined. Due to uncontrolled stock access, vegetation changes are overt in the region's reserves, particularly in valley systems.

Of the 31 vegetation associations mapped in the region, 16 are unreserved and, along with nine unreserved ecosystems at risk, have a high priority for acquisition. A further eight vegetation associations have a high priority for further acquisition, even though small areas are reserved. Acquisition priorities include grasslands with associated woodland, hummock grasslands with associated woodland, pindan shrublands, tropical woodlands and tropical forests including rainforests, mangroves and mudflats. The level of reservation of three of the ecosystems at risk is unknown.

Constraints on reserve acquisition include competing land uses (such as pastoral production), the cost of purchasing pastoral lands and the lack of data on biodiversity patterns across the region's landscape. We cannot accurately define all acquisition priorities on the ground.

### Off-reserve conservation for species and ecosystem recovery

Recovery actions for mammal, bird, turtle and plant species at risk require data on status, population trends and mechanisms of threatening processes, as well as locations of remaining populations. For ecosystems at risk:

- frequent, broad scale, hot, late dry-season burning in savanna needs to be avoided,
- feral stock needs to be removed from conservation estate,
- stock on other lands need close-order management, and
- donkeys and pigs need to be eradicated.

Savanna fire regimes and grazing are the main causes of decline in biodiversity values throughout the region, including its rainforests and riparian zones. To address this issue, coordination between Government agencies, the pastoral grazing industry, traditional owners and the broader community will need to be improved. Limited off-reserve effort would result in significant biodiversity gains.

## Integrated natural resource management (NRM)

Existing NRM actions include:

- legislation for pastoral lease condition inspections by the Department of Agriculture. Pastoralists are notified of any problems and, ultimately, the Commissioner for Soil Conservation can resume the lease. In practice, this process does not appear to be very effective,
- threat abatement planning as part of NRM,
- coordinated efforts by the Department of Agriculture to control donkeys, and
- establishing Land Conservation District Committees that provide a venue for discussing conservation matters and integrating property and catchment planning.

There are several opportunities for NRM.

- The duty-of-care for biodiversity on pastoral lands needs to be tightened.
- Environmental management systems for controlling weeds, fire and feral animals should be coordinated across a variety of land tenures through Land Conservation District Committees, supported by research into the mechanism and impacts of these threatening processes and cost effective solutions.
- Shire planning should incorporate biodiversity objectives, acknowledge the worth of the natural environment to tourism and the cost of managing biodiversity and making national parks accessible.
- Catchment and regional plans should be developed collaboratively by all stakeholders.

Constraints include financial resources, the small number of people available to implement strategies and people able to recognise biodiversity benefits.

## Major data gaps and research priorities

- There are no region-wide vegetation, soil and environmental geology maps at better than 1:250,000 scale for planning.
- There has been no quadrat-based fauna and flora survey of the region to assess species and ecosystem status, condition, trend and the effects of threatening processes such as cats, cattle, donkeys, pigs, fire and weeds.

# Nullarbor



Low bluebush shrubland  
with samphire on the  
Nullarbor Plain Bioregion.  
Photo: Peter Canty

## Description

### Bioregional description and biodiversity values

The Nullarbor bioregion extends over most of the onshore part of the Eucla Basin – an epeirogenic basin of Cretaceous and Tertiary sediments on an irregular basement predominantly of Precambrian granite and metamorphic rocks. It has an arid, non-seasonal climate with average rainfall of between 150 and 200mm.

There are two subregions within the bioregion – a northern band known as Carlisle and the central band known as the Nullarbor Plain.

Carlisle is dominated by the Carlisle Plain, the northern periphery of the Bunda Plateau. Soil profiles are well developed, with a high proportion of red quartz-rich sand mixed with loams and calcareous clays which is partly calcreted over calcareous sandstone. Sandplains with extensive seif dunes supporting a tree steppe of *Eucalyptus gongylocarpa*, mulga and *E. youngiana* over hummock grassland occupy northern parts of the subregion, but occasional breakaways and quartzite hills provide minor relief. Salt lakes supporting samphire communities and major valley floors with lake derived dunes are also present, part of an inactive paleodrainage system that flows into the Nullarbor karst. Low woodlands of *Acacia papyrocarpa* (western myall) over *Maireana sedifolia* (bluebush) dominate its central and southern parts.

The Nullarbor Plain is a tertiary limestone plain with subdued, arid karst features. It is a vast and remarkably flat treeless plain wholly contained within the much larger Bunda Plateau and has shallow calcareous soils, thinly mantling massive limestone. It supports a bluebush-saltbush steppe, although low woodlands of western myall over bluebush are present in peripheral areas, including *Myoporum platycarpum* and *E. oleosa* in the east and west.

The Nullarbor is the world's largest karst system. Significant features include the shallow surface depressions (the donga, ridge and corridor terrain), collapse dolines, blowholes, drip pits, rillenkarren, rundkarren, pavements, solution pans and rockholes.

Endemic reptiles, birds, plants and vegetation associations are also present, including *Cinlosoma cinnamomeum* and *Pogona nullarbor*. The Nullarbor caves provide refuge for many evolutionarily relictual invertebrates and two vertebrates. Caves often contain sub-fossil remains that have been very useful in reconstructing lists of the original vertebrate fauna assemblages.

Dominant land uses include unallocated Crown land, grazing leases and conservation reserves. The current continental stress class is six for both the Carlisle and Nullarbor Plain subregions but the Nullarbor is clearly in poor condition warranting a higher stress class of three or even two.

A high proportion of the Nullarbor's original mammal fauna is extinct, vegetation cover has been stripped from large areas and replaced with the invasive weed *Carrichtera annua* (Ward's weed), foxes and cats are ubiquitous, and until recently rabbits were so common that a rabbit skin and meat industry flourished in the region.

### Overall condition and trend

Overall condition is only fair because weeds, fire and feral predators and herbivores have substantially modified habitats over extensive areas of the Carlisle and Nullarbor Plain subregions and caused numerous extinctions in indigenous mammals. The trend is declining as weeds continue to spread, displacing indigenous vegetation. The reserve system is strongly biased, with a third of vegetation associations not represented, and large areas of existing reserves severely degraded.

### Conservation priorities

Weed and feral animal control present the greatest problems. Priorities are the re-establishment of healthy succulent communities, the completion of the reserve system and the reconstruction of original fauna. Protection of cave faunas and fire control are also important.

### Nationally important wetlands

There are no wetlands of national significance in the Nullarbor Bioregion.

### Wetlands of regional significance

Nine wetlands of regional significance are recognised. One, Plumridge Lakes, is a seasonally intermittent saline lake in good condition with a static trend. Another (Hampton Scarp Rockholes) comprises freshwater pools, degraded in condition and static in trend.

Three others are intermittent freshwater lakes and floodplains in degraded condition and declining (Lake Boonderoo, Duck Pond in Arubiddy Station and paleodrainage channel on Gunnadorah Station). The

other four are inland subterranean Karst wetlands in good condition with unknown trends (Cocklebidly, Murra El Elevyn, Tommy Graham's and Mulla Mullang).

Threatening process for the surface wetlands includes feral herbivores, stock and feral predators; for subterranean wetlands they are public visitation, earth works and feral predators.

## Riparian zone

There are no true riparian zones or riparian zone vegetation in the bioregion.

## Ecosystems at risk

No threatened ecological communities have been declared in the Nullarbor region under WA State legislation. However, wetlands of the Nullarbor region are considered to be at risk, as specified above.

## Species at risk

Under State legislation:

- three cave-dwelling spiders are listed as vulnerable, each being restricted to only one cave system, and
- three mammals and three birds are listed as vulnerable.

Twenty five species of indigenous mammal and one bird have become extinct in the region, although many persist elsewhere in WA.

The invertebrates are threatened by human use of the caves, but their population trends are unknown. The vertebrates are thought to have been affected by habitat changes caused by introduced herbivores and changed fire regimes in combination with introduced predators. No Declared Rare Flora species are found in the Carlisle or Nullarbor Plain subregions.

# Management responses

## Reserve system

The conservation estate comprises parts of three large nature reserves and, in South Australia, a large national park and part of a large conservation park.

Fourteen of the 27 vegetation associations recognised from the WA part of the region are not represented in reserves, including four that are considered of high priority. All vegetation associations that are under particular threat and are therefore high priority to reserve are succulent steppe communities involving saltbush, bluebush and/or grassland, although some have salmon gum, gimlet, myall or myoporum upper strata. Overall, 16 per cent of the Nullarbor bioregion

is reserved in IUCN I-IV reserves (including 36 per cent of the Carlisle subregion and 4.7 per cent of the Nullarbor Plain). The bioregion has an IBRA Reservation Class of five. The reserve system is incomplete and biased in terms of CAR criteria. The Nullarbor Plain region is considered to be of higher priority (Class three) because significant threatening processes such as grazing, feral animals and changed fire regimes exist.

Constraints are primarily resource related in terms of management and research, although competition for grazing land in the western and eastern ends of the region is a factor. The Aboriginal Land Agreement (Spinifex) is likely to work in favor of biodiversity conservation.

Reserve management is fair to good across all reserves because biodiversity values and or management issues are often poorly identified. Weeds are widespread, considerable degradation has occurred in vegetation and components of the fauna (especially in the Great Victoria Desert Nature Reserve), resource degradation is occurring elsewhere (though retrievable), wildfire management is non-existent, and the ongoing impact of feral herbivores is unknown.

## Off reserve conservation for species and ecosystem recovery

- Control mechanisms for Ward's weed need to be developed and implemented.
- Cave faunas on privately managed lands especially require habitat protection and further research into species' ecological requirements.
- Critical weight range mammals and regionally extinct bird populations need to be reintroduced, protected from feral predators and their habitats managed for fire and introduced herbivores.
- Wetland communities need to be protected by reservation and feral mammal control.
- Main recovery actions include habitat retention through reserves, implementation of management plan recommendations, capacity building with landholders and industry concerning pastoral operations, and fire management to reduce the impact of large intense, summer wildfires on habitat and fauna populations.
- Further research is required to determine species status, distribution and gain increased knowledge of region's biodiversity, and cost-efficient methods for feral animal and weed control to allow reintroductions and extant populations of critical weight range species to recover.

The main constraint is lack of resources to implement management activities and the remoteness from population centres. Weed, feral and fire control are region-wide priorities and significant conservation effort is required in both subregions, cave fauna management is a priority in the Nullarbor Plain region.

### Integrated natural resource management (NRM)

Existing natural resource management actions include industry codes of practice particularly in relation to pastoral lease management, and integration environmental management systems with property management planning and Landcare. Declaration of reserves has been the most effective natural resource management activity so far.

Opportunities for natural resource management include legislation for duty-of-care covering leasehold and other lands (threat abatement planning for vegetation, threatened species, pests and fire). Capacity building in community, landholders, industry and institutions will be required to implement these actions, and programs to increase the awareness of conservation values through education of local industries and communities are needed.

Major constraints include the need to modify the Land Administration Act, to complete negotiations related to the Spinifex Land Agreement and to overcome limited financial resources.

### Major data gaps and research priorities

Before the bioregional survey in 1984, no comprehensive biological study of the Eucla Basin had ever been undertaken. Other Nullarbor work had been largely opportunistic or focused on individual species or taxonomic groups.

The main gaps are:

- there is no vegetation and regolith mapping at better than a 1:250,000 scale,
- a regional survey of flora and vertebrate fauna is based on very sparse sampling (83 sites across the entire region),
- there is little data on the habitat requirements of virtually all invertebrate species, most ephemeral plants, persisting critical weight range mammals and uncommon vertebrate and plant species,
- there is no data to provide a regional context on life history (including population trend) for any species apart from rabbits,
- there is no quantitative data on the effect of exotic predators, weed colonization and fire, and
- there is only limited data on the impact of grazing on vegetation systems of pastoral leases.

# Pilbara



Shot Pool Pyramid,  
Photo: Peter Kendrick



## Description

### Bioregional description and biodiversity values

The Pilbara Craton Bioregion has a semi-desert-tropical climate, with active drainage in the Fortescue, De Grey and Ashburton river systems.

There are four subregions – Chichester, Fortescue Plains, Hamersley and Roebourne.

The Chichester subregion has undulating Archaean granite and basalt plains including significant areas of basaltic ranges. Plains support a shrub steppe characterised by *Acacia pyrifolia* over *Triodia pungens* hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on the ranges.

The Fortescue Plains subregion is alluvial and has river frontages, with extensive salt marsh, mulga-bunch grass, and short grass communities on the plains in the east. River gum woodlands fringe the drainage lines. An extensive calcrete aquifer (originating within a palaeo-drainage valley) feeds numerous permanent springs in the central part of the Fortescue region, supporting large permanent wetlands with extensive stands of river gum and cajuput.

The Hamersley subregion is a mountainous area of Proterozoic sedimentary ranges and plateaux, dissected by basalt, shale and dolerite gorges. The valley floors have low mulga woodland over bunch grasses on fine textured soils, while the ranges have *Eucalyptus leucophloia* over *Triodia brizoides* on skeletal soils.

The Roebourne subregion comprises Quaternary alluvial and older colluvial coastal and sub-coastal plains, with a grass savanna of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia translucens* or *A. pyrifolia* and *A. inequilatera*. Resistant linear ranges of basalts occur across the coastal plains. These uplands are dominated by *Triodia* hummock grasslands. Ephemeral drainage lines support *Eucalyptus* woodlands. Samphire, *Sporobolus* grasslands and mangal occur on the marine alluvial flats and river deltas. The islands are Quaternary sand accumulations, basalt and/or limestone.

This bioregion has many special values including:

- the geological complexity of the Marble Bar-Nullagine mineral province,

- persisting populations of threatened and endangered species (mulgara, spectacled hare-wallaby, bilby, orange leaf-nosed bat and princess parrot),
- arid zone populations of northern brushtail possums, ghost bats and north-western long-eared bats,
- physical features, endemic species and species-rich ecosystems associated with the Fortescue River, especially the Millstream wetlands, Millstream aquifer, Fortescue Marsh and Chichester gorges, which are also refugia for various fire-sensitive plants,
- species-rich, refugial ecosystems associated with gorges, waterfalls and mountain-tops of the Hamersley Range with undescribed land snail, lizard and plant species,
- endemic stygofaunal radiations in calcrete aquifers,
- coastal islands act as refugia for vulnerable species now rare or extinct on the adjacent mainland (for example the western chestnut mouse and *Ctenotus angusticeps*), and breeding sites for turtles and seabirds,
- many Aboriginal culturally significant sites and
- rock piles of the Burrup Peninsula which act as fire refuges.

Bioregional endemics include *Ningauia timealeyi*, an undescribed *Planigale*, *Dasykaluta rosamondae*, *Pseudomys chapmani*, *Pseudantechinus roryi*, *Diplodactylus savagei*, *Diplodactylus wombeyi*, *Delma elegans*, *Delma pax*, *Ctenotus rubicundus*, *Egernia pilbarensis*, *Lerista zietzi*, *Lerista flammicauda*, *Lerista neander*, two or three undescribed taxa within *Lerista muelleri*, *Notoscincus butleri*, *Varanus pilbarensis*, *Acanthophis wellsi*, *Demansia rufescens*, *Ramphotyphlops pilbarensis*, *Ramphotyphlops ganei*, and stygofauna of the calcrete aquifers.

### Overall condition and trend

The continental stress class across the Pilbara bioregion ranges from three to six (see Glossary), but a combination of weed invasions, hot frequent bushfires, feral predators and grazing by exotic herbivores is causing a loss of soil fertility and vegetation cover, and consequent loss of native species such as critical weight range mammals. Erosion from increased runoff velocities is occluding drainage lines.

## Conservation priorities

There is a need to improve the conservation reserve system's CAR, and to control weeds and manage fire regimes both on and off reserves.

## Nationally important wetlands

Six wetlands of national importance are listed, including river courses, aquifer-fed springs, an inland salt marsh, natural springs and an artificial salt marsh. They act as refuges, support populations of endemic species, and are species-rich ecosystems. On average, their condition is fair (improvement requires significant management intervention) while the trend is declining or static. Threatening processes include grazing pressure, weed colonisation, changes to hydrology and water extraction for development.

## Wetlands of regional significance

Twelve wetlands of regional significance have been identified, including riverine gorges, aquifer-fed springs, ephemeral swamps and lakes, claypans, river sections with permanent pools, and mangrove communities.

Some are extensive and species-rich ecosystems, acting as refuges and supporting populations of endemic species. On average, their condition is fair (improvement requires significant management intervention) while the trend is declining or static. Threatening processes include grazing pressure, weed colonisation, changes to hydrology and water extraction for development.

## Riparian zone

The main river systems include the De Grey, Oakover, Turner, Fortescue, Robe, Cane and Ashburton rivers. All arise in the region's uplands and are active systems. Their riparian zones are generally degraded to fair (significant management intervention is required for recovery). They are declining because of:

- trampling and grazing pressure from cattle and feral herbivores,
- colonisation by a variety of weeds such as buffel grass, mesquite and Parkinsonia, and
- fire.

## Ecosystems at risk

Two Threatened Ecological Communities (TECs) have been declared vulnerable under State legislation – the Ethel Gorge aquifer stygobiont community and the *Themeda* grasslands of the Pilbara region. The condition of TECs is fair or good but declining. Threats are

groundwater drawdown, grazing, stock animals, weeds, changed fire regimes and changed hydrology.

A further 35 community-types are considered to be at risk, though they are not declared threatened under WA legislation. These ecosystems include:

- freshwater wetlands,
- mulga and snakewood communities,
- scree-slope and hilltop communities,
- mangroves,
- stygofaunal communities near mines,
- grasslands and salt marshes,
- cracking clay communities and
- islands.

Most appear to be vulnerable, but many have unknown status and one mulga community is probably endangered.

Their condition varies from degraded (lower slope mulga and Munjina Claypan) to fair or good. The trend in the condition of these ecosystems is declining although lower slope mulga, fresh water swamps, mangrove and island communities are often rapidly declining.

All except the islands are threatened by cattle, feral herbivores and fires. Feral mammals are ubiquitous on the Pilbara mainland, and also present on some islands. Wetlands and islands are being colonised by invasive weeds such as buffel grass and kapok bush. Hydrological changes are also degrading mulga, mangrove and stygofauna communities.

## Species at risk

More than 15 per cent of the Pilbara's original mammal fauna is now extinct in the region.

Under State legislation one reptile species is declared as endangered, and four mammals, six reptiles and two plants are vulnerable.

Under the Commonwealth EPBC Act:

- six mammals are vulnerable (the listing for the *Rhinionictis aurantius* only applies to its Pilbara population),
- one reptile is endangered,
- five reptiles are vulnerable (four marine turtles and a python),
- one bird is vulnerable (the Alexander parrot) and
- two plants are vulnerable.

The vertebrates generally display a declining or static trend, while the plants are improving. The condition of extant fauna ranges from degraded in the case of the bilby and rock wallabies to good-near pristine for the Pilbara olive python. The conditions of most other species is unknown. The condition of the two declared rare flora (DRF) plants in the Pilbara is good.

The Pilbara olive python is not thought to be threatened. The plants listed are thought to be disturbance specialists.

Threatening processes for fauna species at risk include habitat changes associated with land use (direct recreation and hunting for turtles), feral predators and grazing. Various other plant, mammal, reptile and bird species are listed as priority and have similar threatening processes with the addition of mining, changed hydrology, weeds and changed fire regimes.

## Management responses

### Reserve system

There are two major National Parks: Karijini (in the Hamersley subregion) and Millstream-Chichester (in the Chichester and Fortescue subregions). The Mungaroo Ranges (Chichester) and many coastal islands (Roebourne) are nature reserves. Meentheena (Chichester) and Cane River-Mount Minnie (Hamersley) are conservation parks.

Conservation lands are dominated by uplands and ranges country with hummock grass communities on skeletal soils on scree-slopes. Upper-slope and mulga communities are also present. Networks of gorges, ephemeral watercourses with riparian woodland communities, freshwater springs and riverine communities are prominent features. A total of 1.7 million hectares (with examples of 42 of the region's 88 vegetation associations) is in this conservation estate, which is 8.7 per cent of the region's area.

Forty-five vegetation associations are listed as having a high priority for reservation. They comprise:

- various snakewood, cassia, acacia and eremophila shrublands,
- desert bloodwood or mallee/hummock grass,
- mulga/tussock grass,
- acacia and eucalyptus woodland,
- teatree,
- mangrove,
- grass plain,
- sedgeland,
- river gum,
- coolibah,
- samphire and
- pindan communities.

Various fresh-water swamps, claypans, inland salt marshes, mangrove stands and valley floor mulga woodlands specifically identified among the 35 'at risk' communities are also unreserved.

Overall, riverine systems and wetlands have the highest priority for reservation, as do some of the most productive parts of pastoral leases, and coastal and island sites important for industrial development or prospective for minerals. Aboriginal lands may not be available for reservation.

Bioregional priority for reserve acquisition is Class three. The Fortescue Plains region has the highest priority for further reservation because only 0.8 per cent is reserved in CALM estate. The next highest priority is the Chichester region, which has 3.9 per cent in reserves with a further 2.7 per cent of its area recently being purchased by CALM. Reserve systems in Chichester, Fortescue Plains and Roebourne are highly biased. Invasive weeds, wildfires and eradication of feral mammals are issues on all reserves, even those with resident staff; some reserves are seldom visited by management staff, and access to Mungaroo Nature Reserve is difficult.

### Off-reserve conservation for species and ecosystem recovery

Recovery actions are identified for ecosystems and species at risk found off CALM estate.

- Habitat protection is required for five species of marine turtle (especially nesting locations), dugong, *Ctenopus angusticeps* (a skink), estuarine crocodile, *Lagorhcheses conspicillatus*, *Macrotis lagotis* and the tree *Terminalia supranitifolia*. Better fire control is needed for the land-dwelling species, and fox management for the mammals.
- The two bats (*Macroderma gigas* & *Rhinonicteris aurantius*) need protection with the maintenance of old mine workings, a mining industry code of practice, the removal of barbed-wire fences (for ghost bats), and the completion of surveys for natural roosts.
- *Petrogale lateralis* and *Petrogale rothschildi* need to be translocated to Pilbara islands, followed by fox control.
- Broad-scale surveys to clarify the distribution and status of stygofaunas are required, followed by habitat protection as required in regions where research shows that mine dewatering may affect their persistence.
- Weed (buffel grass) control is urgently needed on coastal islands. Its interaction with indigenous fauna is unknown, but it eliminates native flora.
- Wetlands of the lower De Grey River require protection from weeds, stock and feral herbivores, including pigs. Fencing is required if lands remain under cattle production.

- Surveys to clarify distributions, status and threatening processes are needed for *Falco peregrinus*, *Sminthopsis longicaudata*, *Ramphotyphlops gaini* and 38 plant species (including herbs, shrubs, grasses, trees and sedges).

Significant off-reserve conservation activities are needed in Fortescue Plains subregion particularly habitat protection through agreements. Significant biodiversity gains can be made from translocations in the Roebourne subregion, and from fire control, habitat protection and feral mammal control (mangroves, lower riparian fencing and fox eradication) in the Hamersley and Roebourne subregions. Weed control is urgent, especially on the islands.

## Integrated Natural Resource Management (NRM)

Existing actions:

- There are threat abatement plans on pastoral lands for vegetation (including fire), for fox and feral herbivore control, and for de-commissioning and revegetating mine-sites.
- Industry codes of practice have been set up, with capacity building through Land Conservation District Committees and Chamber of Minerals and Energy in liaison with landholders.
- Environmental management systems and ecological sustainable product marketing have been set up.

Opportunities:

- Legislated 'duty of care' needs to be enacted for pastoral leases, Aboriginal lands and mining areas.
- There needs to be joint or compatible management of pastoral lands owned by mining companies.
- Institutional reform (for example, rural reconstruction, industry reconstruction, new joint management arrangements and excision of high quality conservation lands when leases/tenements are renewed) needs to occur.
- There should be State and local government planning for the CAR reserve system, and planning for the National Action Plan for Water Quality and Salinity.

Constraints:

- There is a lack of funding to acquire high value lands held under pastoral lease when they are offered for sale, and to adequately manage existing estate for control of fire, weeds and feral herbivores, even in major national parks.
- The Pastoral Lands Board needs to co-operate in restructuring leases after reserve areas are excised.
- There needs to be an increased awareness of conservation values by educating the mining and pastoral industries, and the general public.
- 'Conservation Through Reserves' is limited by the extensiveness of mining leases, tenements and associated infrastructure, resulting in unnecessary alienation of high quality conservation areas (for example, Legendre Island).

The priority across the bioregion is to integrate conservation into pastoral production and development systems.

## Major data gaps and research priorities

- The coverage by environmental geology/regolith mapping at better than 1:250,000 scale is incomplete.
- There is no quantitative (quadrat-based) regional survey of flora or fauna, so regional flora and fauna is poorly known. Only small, local areas have been examined in detail by biologists, usually for industrial development.
- There is little detailed data on the ecological requirements and life histories of virtually all invertebrate species, plants, persisting critical weight range mammals, uncommon vertebrate and plant species, and ecologically dominant plant species (e.g. hummock grasses).
- There is little data to provide a regional context on population-trends for even ecologically significant species such as native rodents, dasyurids, spinifex reptile communities, termites, ants, weeds such as buffel grass, kapok bush and ruby dock.
- There is no quantitative data on the impact of weed colonisation, fire in hummock grasslands, exotic herbivores on aquatic and terrestrial communities, or the long term effect of mining on stygofaunas.

# Swan Coastal Plain



*Banksia attenuata* woodland on sandplains of the northern Swan Coastal Plain Bioregion, W.A.  
Photo: G.J. Keighery.

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## Description

### Bioregional description and biodiversity values

The Swan Coastal Plain Bioregion comprises the Dandaragan Plateau and the Perth Coastal Plain.

Its climate is classified as warm Mediterranean and rainfall ranges between 1000 and 600mm annually. It includes urban developments associated with the city of Perth, and is dominated by woodlands of *Banksia* and tuart on sandy soils, sheoak on outwash plains, and paperbark in swampy areas.

The colluvial and aeolian sand areas represent three phases of Quaternary marine sand dune development (which provide relief), and include a complex series of seasonal fresh water wetlands, alluvial river flats, coastal limestones and several offshore islands.

Younger sandy areas and limestones are dominated by heath and/or tuart woodlands, while *Banksia* and jarrah-*Banksia* woodlands are found on the older dune systems. Fine-textured outwash plains at the foot of the Darling Escarpment are extensive only in the south, and were once dominated by *Casuarina.obesa*-marri woodlands and *Melaleuca* shrublands. In the north-east, the plain rises to duricrusted Mesozoic sediments dominated by jarrah woodland. The Dandaragan Plateau is the region's north-eastern corner, and is composed of cretaceous marine sediments mantled by sands and laterites. The plateau is characterised by *Banksia* low woodland, jarrah-marri woodland, marri woodland, and by scrub-heaths on laterite pavement and gravelly sandplains. A variety of plants, including tuart are endemic to the region.

### Overall condition and trend

The Swan Coastal Plain has been subjected to almost every type of environmental disturbance. The Dandaragan Plateau region has a Continental Stress Class value of two, while the very much larger Swan Coastal Plain region was mistakenly assessed at three (see Glossary). The Swan Coastal Plain's stress class value should be between one and two. The overall condition of dryland (and wetland) areas in the region is classed as degraded, a trend which is likely to continue.

## Conservation priorities

The 25 Threatened Ecological Communities in the Swan Coastal Plain are associated with fertile soils of localised extent and occurrence, especially in the southern parts of the region (wetlands, clays and other alluvials and colluvials). An additional 27 other ecosystems are at risk. Of the 53 vegetation associations that occurred in the Swan Coastal Plain region in pre-European times, 18 are centered in the Swan Coastal Plain and have less than 10 per cent of their original area in conservation lands. Eight high and medium priority ecosystems in the Dandaragan Plateau are not represented in conservation lands.

The reserve management standard throughout the Swan Coastal Plain ranges between poor and good. Most of the larger reserves, national parks or conservation parks tend to be relatively well managed and most now have specific management plans. Smaller reserved areas are usually associated with protection of coastal plain wetlands or are small vegetated remnants surrounded by urban and semi-rural land uses.

Processes that threaten the ecological health of CALM-managed lands in this bioregion include:

- increased soil salinity (particularly in the northern part of the bioregion),
- bushfire control,
- feral animal control,
- disturbance by urban development,
- agricultural activities,
- root-fungus (*Phytophthora*),
- weed invasions,
- limited diversity of vegetation communities within reserves and parks,
- a lack of formalised biodiversity monitoring programs, and the costs associated with acquiring land for new reserves and ongoing management.

The Dandaragan Plateau and Perth subregions are both listed as belonging to reservation class four (10 to 15 per cent of the subregions is reserved for conservation, any tenure). However the system is strongly biased and threats are numerous and pervasive.

### Nationally important wetlands

The bioregion has 26 nationally significant listed wetlands, with only one on the Dandaragan Plateau. They are in fair to good condition, requiring minimum to significant management for recovery.

Their condition is static, with a declining trend forecast for one wetland. Many threatening processes affect these wetlands, all relating to urbanisation.

Matters which need to be addressed include:

- eutrophication (a high level of nutrient runoff), invasion of weed species (particularly grasses from urban gardens),
- increased or decreased flow to the wetlands,
- construction of canals,
- the presence of feral animals,
- shoreline development and
- recreational activities.

## Wetlands of regional significance

More than a quarter of the Perth subregion's land area (from Wedge Island to Dunsborough) is wetland. About 4700 basin and flat wetlands are listed, most of which would warrant inclusion as wetlands of regional significance. Because of the impracticality of including them all here, refer to Hill *et al.* 1996a.

## Riparian zone

The Moore/Gingin, Hill, Swan, Serpentine, Murray, Harvey, Collie, Preston, Capel and Wellesley rivers flow through the Swan Coastal Plain. Most have their catchment areas in bioregions to the east. Vegetations associated with these rivers and catchments are in poor to fair condition, with further decline in vegetation quality expected. Threatening processes affecting riparian vegetation include:

- broadscale vegetation clearing,
- increasing fragmentation,
- changes in hydrology caused by salinity and altered flow regimes,
- grazing pressure,
- exotic weeds and
- feral animals.

## Ecosystems at risk

The bioregion has 25 Threatened Ecological Communities listed under WA legislation. Eleven have been declared as being critically endangered, five as endangered and nine as vulnerable.

An additional 27 ecosystems (seven of which are 'Beard' vegetation associations) are also at risk. A total of 48 ecosystems (vegetation units) have a substantially reduced area on the Swan Coastal Plain. Ecosystems at risk include eucalypt woodlands with shrubby understoreys and other shrublands which includes wetlands.

The wetland environments on the Swan Coastal Plain are under particular threat from altered surface flow regimes and groundwater levels as well as invasion of weed species, disturbance by people, vehicles, and feral animals.

Eucalypt woodlands have been adversely affected by vegetation clearing and fragmentation, weed invasion, feral animals and changed fire regimes. *Banksia* woodlands appear to be under the same pressures as eucalypt woodlands, and several are listed as threatened.

Only two of the 48 ecosystems are showing signs of improvement. Their status is that four are declining rapidly, 27 are declining, 18 are static and one is unknown. Most ecosystems at risk are in fair or good condition, but two – critical weight range mammals and a *Casuarina obesa* association (between Thomas Rd and the Serpentine River) – are currently in a degraded condition.

Forty-one of the Beard vegetation associations in the Swan Coastal Plain region each covered more than 0.1 per cent (1334 hectares) of the region in pre-European times. Seven have less than 10 per cent (the average is 3.5 per cent) of their original area remaining and could be considered at risk. Few are adequately represented in reserves. At best, less than 3.4 per cent of the original area is reserved. Eighteen vegetation associations have between 10 and 30 per cent of the original area remaining and of these, only four have more than 10 per cent of the region's pre-European area in CALM reserves.

Thirty-one vegetation associations are not represented in reserves or are poorly reserved in the region, and are a high priority to include.

## Species at risk

Twenty five per cent of the Swan's original mammal fauna is now extinct in the region.

State legislation has listed 15 plants, one reptile (the western swamp tortoise) and one crustacean (the Crystal Cave crangonyctoid) as being critically endangered in the region. Nineteen plants and one bird (the Carnaby's cockatoo) are listed as endangered.

Vulnerable species include 18 plants, four mammals, one bird, and two reptiles. One species *Dasyornis broadbenti litoralis* (rufous bristlebird – western subspecies) is extinct in the region. Fauna is in a poor or degraded condition with the exception of invertebrates, the status of which is often unknown.

There is no clear trend for fauna although only two mammals – the chuditch and the quokka – are improving. The rest are either static or declining and once again, the invertebrate trend is unknown.

Declared rare flora is in fair or good condition but trends vary widely. Targeted survey work has resulted in the discovery of more populations, and thus an improving trend. However the ongoing effects of various threatening processes can lead to declining or rapidly declining trends. Threats to all species at risk include:

- broadscale vegetation clearing,
- increased fragmentation,
- grazing pressure,
- feral herbivores (rabbits),
- feral predators (foxes and cats),
- exotic weeds,
- changed fire regimes,
- pathogens,
- changed hydrology (due to both salinity and altered flow regimes), and
- the recreational use of areas by people.

## Management responses

### Reserve system

In the Swan Coastal Plain subregion there are 65 nature reserves, eight national parks and two conservation parks. Two reserves at the northern and southern ends of the Dandaragan Plateau make up the vast proportion of the conservation estate in that subregion.

Approximately half the nature reserves in the Swan Coastal Plain subregion are small (less than 100 hectares), with 10 reserves being less than 10 hectares and only eight exceeding 1,000 hectares. In the southern and central zones of the subregion, the areas highly disturbed by urban development and intensive agricultural activities include nature reserves which are frequently associated with the protection of coastal plain wetlands or small vegetated remnants surrounded by urban and semi rural land uses.

The largest reserves are found in the northern part of the Swan Coastal Plain. Only two are less than 700 hectares. These reserves contain coastal and northern sand plain communities grading to low eucalypt woodlands, which are used by commercial apiarists in season.

There are no resident staff on nature reserves. Management visits vary greatly; urban wetland reserves are often frequently visited while others are restricted to a minimum of once a year. Only a small number of reserves have formally approved management plans or interim management guidelines.

In the southern and central parts of the region, because of their small size and position low in the landscape,

most reserves have significant weed invasion (especially watsonia, arum, bridle creeper, kikuyu and other annual and perennial grasses). Feral animals (foxes, rabbits and pigs increasingly in the south) in all but the largest reserves are not controlled. Significant problems impede the Department of Conservation and Land Management's ability to undertake control programs in urban and semi urban environments.

Across all areas of the bioregion, *Phytophthora* (dieback) disease is changing the species composition of reserves. In many of the smaller reserves, understorey species composition is poor and in a degraded state resulting from:

- grass and other weed invasion (but some small reserves, including those on the heavy soils of the eastern coastal plain, are able to retain the majority of the original species),
- grazing impacts (including from kangaroos) and
- too frequent fires.

Fire regimes aimed at biodiversity conservation outcomes are generally absent, deliberately lit wildfires can and do occur frequently depending on the proximity of the reserve to urbanization, and formal biodiversity monitoring programs are absent.

Five of the eight national parks have management plans which are being implemented, although targeted ecological monitoring programs are either absent or inadequate. Park areas range from 1,059 to 26,965 hectares, with two of the eight parks primarily servicing the recreation and day visitor requirements of the Perth metropolitan area. Three parks have resident staff. All but two (Lesueur and Moore River national parks) are on or near the coast so the diversity of vegetation communities in these parks is limited.

Feral animal control (fox, rabbit) is carried out in national parks but is hampered by the animals' proximity to urban areas.

Salinity issues are not evident on the western side of the region but the extensive use of ground and surface water resources may affect the health of the vegetation in a number of these parks.

The fungal disease dieback (*Phytophthora* sp, *Armillaria* sp.) is present in all parks. Tuart decline caused by borer (*Phorocantha* spp.) is significantly affecting much of Yalgorup National Park, as well as having an impact on Neerabup and Yanchep national parks. The southern and central Swan Coastal Plain parks often have high weed loads especially arum, bridle creeper and pasture grass species, often associated with riparian and moisture gaining sites.

Fire regimes are often dominated by a requirement to protect adjoining land values.



In most parks formal biodiversity monitoring programs are absent. Neither of the conservation parks have resident staff, although a management plan is available for Leschenault Peninsula. The size ranges from 27 hectares to approximately 1,000 hectares.

Weed invasion along riparian habitats and pasture grass invasion along the boundaries is of concern. Fox and rabbit control is undertaken. Fire regimes currently set at exclusion are yet to be optimised for biodiversity outcomes. Formalised biodiversity monitoring programs are absent but vegetation assessment plots were established during the Swan Coastal Plain Vegetation project and could form the basis of permanent monitoring program.

The bioregion has been assigned a reservation class of four, however the threatening processes are significant enough in the region to warrant a higher priority. However, there are a number of factors which constrain CALM's ability to acquire reserves. The priority issue is that the bioregion has many competing land uses (such as agriculture, mining, urban area and grazing), and the cost of purchasing land close to urban areas is very high.

### Off-reserve conservation for species and ecosystem recovery

The major threat to biodiversity of the Swan Coastal Plain bioregion is clearing, often for urban development, and the landscape is highly fragmented. The priorities for off-reserve conservation in the bioregion include a large number of Declared Rare Flora that have populations outside reserves, threatened invertebrates (only found on non-reserved land), diatomite lakes of the Dandaragan Plateau, plant assemblages of the Wannamal Lake system, the assemblage of critical weight range mammals (many of which are now subregionally extinct), remnant vegetation complexes on the Abba Plains, *Agonis* and/or tuart woodlands along coastal wetlands, and a range of Threatened Ecological Communities (such as upland vegetation, wetlands, stromatolites, caves and sedgeland). The most important recovery action for these communities and assemblages is habitat retention and protection through reserves, on other State lands and on private land. Most critically endangered flora and one bird have recovery or interim recovery plans, as do a couple of endangered plants. Only critically endangered TECs have interim recovery plans (drafts in some stages) and no other TECs or ecosystems at risk have recovery documentation.

In addition to habitat retention and protection, other common recovery actions include weed control, feral animal control, revegetation, fencing of remnant vegetation, capacity building with friends groups and Green Corps, reinstatement of hydrology, fire

management and research. Aquatic root mat communities require emergency artificial watering during dry seasons as an additional recovery action. There are significant constraints to the application of some necessary recovery actions. The high cost of land associated with urban and semi-rural property reduces CALM's ability to acquire further conservation estate. Remnant vegetation and reserves are generally very small and sometimes highly modified from their original composition. The proximity to cities and urban areas constrain the agency's ability to undertake effective feral animal and weed control as well as fire management. However, the proximity to urban landscapes encourages community involvement, public education and concern regarding conservation issues.

The Swan Coastal Plain requires significant off-reserve effort to prevent the further degradation of ecosystems and species within the bioregion.

### Integrated natural resource management (NRM)

Natural Resource Management actions such as soil conservation, land clearing legislation, Bushcare, strategies for local government, and local conservation have been largely ineffective in the Swan Coastal Plain bioregion. Consequently, there are many opportunities for NRM activities to operate more effectively and suggestions include the following:

- Incentives for conservation on private property, such as rate rebates, or additional subdivision rights.
- Legislation – including duty of care for leasehold and other lands – requires more rigorous control and needs to be concentrated on high disturbance areas such as rail and road reserves.
- Institutional reform such as rural reconstruction, industry reconstruction, new tenure and management arrangements.
- Tradable rights: carbon credits would provide impetus to new revegetation efforts.
- Other planning opportunities including local government planning and National Action Plan for Water Quality and Salinity.
- Integration with property management planning, catchment planning and Landcare. Increasing the role of NRM in all agricultural activities.
- Coordinated threat abatement planning.
- Improved local government planning.
- Increased/improved integration with property and catchment management planning.

A number of impediments exist. The current role of Government Departments in NRM and policing of activities such as land clearing is fragmented and unclear. Departments that have responsibility for resource exploitation may also have resource protection roles. Penalties for undertaking activities such as land clearing are comparatively minor and do not have the support of the greater rural community. There is a need to increase awareness of conservation values through education of various industries (mining, agricultural) and the public in general. There is also a high level of property speculation for assumed future urban or rural subdivision at inflated land prices, and a large part of this speculation is on bush blocks. Limited financial resources are also a major constraint. Both subregions are ranked as having major constraint problems to implement effective NRM actions due to the extent of past degradation, competing land uses, high property values, and urbanisation pressures.

### Major data gaps and research priorities

As yet there has been no regolith mapping in the Swan Coastal Plain and vegetation mapping is 1:250,000 at best (though some areas have higher resolution but this is not available throughout the bioregion). Most reserves do not have long term survey data for vertebrates and many of the invertebrate specimens have been yet to be sorted, identified or analysed, even though existing data suggests there may be significant species or groups of species within the bioregion. There is relatively little data available on the habitat requirements for virtually all invertebrates, persisting critical weight range mammals and uncommon vertebrate and plant species.

There is no data to provide a regional context (including population trends) for most species, including introduced or pest species. Detailed floristic surveys have been carried out in the southern part of the Swan Coastal Plain which has provided valuable information, especially about Threatened Ecological Communities, however more survey work is required in the northern part of the region. At present there is no quantitative data on the effects of exotic predators, weed colonisation, fragmentation and farm clean up, fire or mineral extraction (on gypsum). To date there has been no systematic monitoring of the effect of salinity on species composition of communities, although 10 bench-mark quadrats have now been established.

### References

Hill, A.L., Semeniuk, C.A., Semeniuk, V. and Del Marco, A. (1996a). *Wetlands of the Swan Coastal Plain. Volume 1: Wetland Mapping, Classification and Evaluation - Main Report*. Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Perth, Western Australia.

# Warren



Karri forest and granite hills of  
the Warren Bioregion, W.A.  
Photo: G.J. Keighery

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## Description

### Bioregional description and biodiversity values

The region is dissected undulating country forming part of land forms known as the Leeuwin Complex, the Southern Perth Basin (Blackwood Plateau), the Yilgarn Craton and western parts of the Albany Orogen.

A combination of hills, plateaux and plains, the bioregion features four main soil types:

- loamy soils supporting karri forest;
- red laterites supporting jarrah-marri forests,
- leached sandy soils in depressions and as plains supporting low jarrah woodlands and paperbark/sedge swamps, and
- Holocene marine dunes supporting *Agonis flexuosa* thickets, *Banksia* woodlands and heaths.

The climate is moderate Mediterranean. High rainfall coupled with low evaporation allows the growth of high forests and wetlands at a scale unique in Western Australia.

Many of the region's plants and animals are endemic, especially in plant groups such as Myrtaceae, Rutaceae, Proteaceae, Papilionaceae, Restionaceae, Styliaceae and Sterculiaceae. The bioregion is a biodiversity hot spot, with hundreds of taxa of vascular plants per square kilometre.

Warren is a refuge for relict species from wetter and milder climatic conditions. This is evidenced by groups and species of vascular and cryptic flora and invertebrates normally associated with rainforests or Nothofagus forests of South Eastern Australia, and now extinct elsewhere in the State.

Tingle forest provides a haven for relictual invertebrates, while peat or organic wetlands support relictual populations of aquatic invertebrates.

Barren limestone areas with underground drainage systems (karst regions) support an endemic invertebrate fauna.

The Warren Region is also the State's richest area for mosses and liverworts normally associated with rainforests. Notable values include the tall forests (karri, jarrah and the tingles), the limestone systems with their cave faunas, and the mound-forming microbial associations in the west of the region.

Gondwanan invertebrate fauna includes the Tingle *Moggridgea* trapdoor spider and Torndirrup's *Austrarchaea mainae* spider, *Dardarus* sp. millipede, *Cynotelopus*

*notabilis* and velvet worms. A number of notable critical weight range mammals also persist in the region, including the southern brown bandicoot, the chuditch and the brush-tailed phascogale. Rare birds include the western whipbird and several cockatoos and parrots.

The dominant land uses are grazing, irrigated horticulture and conservation, with significant lesser areas of forestry.

### Overall condition and trend

Although the Warren bioregion was assessed as having a Continental Stress Class of five, the original data used to obtain this ranking was flawed. The region should have a greater stress class (three).

The wetlands and river systems are generally in fair or good condition, though the trend is for these areas to decline. High numbers of ecosystems and species are at risk from a variety of threatening processes. The trends at both the ecosystem and species levels are either to remain static or to be declining.

### Conservation priorities

The bioregion contains a high number of relatively small reserves and parks, but there is little opportunity to expand existing CALM estate as nearly all of the unreserved land has been cleared. Reserve management is generally good, with biodiversity issues being addressed although a large number of constraints still exist. Natural resource management policies are being implemented and achieving some biodiversity outcomes.

### Nationally important wetlands

There are eight wetlands of national significance. These are the lower reaches of the Blackwood River, Cape Leeuwin System, Dogerup Creek System, Gingilup – Jasper Wetland System, Broke Inlet System, Maringup Lake System, Mt Soho Swamps and the Owingup Swamp System.

The condition of wetlands ranges from fair to near pristine, with most ranked as good and near pristine. The trend ranges from declining rapidly to static. Threatening processes include:

- wide vegetation clearing (now controlled but the impacts are still becoming apparent),
- feral animals (foxes, pigs, deer, horses, cats and rabbits),

- exotic weeds (Watsonia, east coast wattles, exotic grasses, blue gums, clovers and allies),
- changed fire regimes,
- pathogens (*Phytophthora* dieback in adjacent forests and heaths),
- changed hydrology (salinity and water levels),
- pollution from herbicides and fertilisers (agricultural and plantation),
- plantation harvesting (and the subsequent return to traditional agriculture on several significant holdings),
- illegal tea tree cutting (bean sticks, cray pots and brush fencing) and
- mining (which could affect a lake and groundwater).

### Wetlands of regional significance

Nine more wetland areas are regionally significant. Conditions vary widely from degraded (Scott River Wetland System) to intermediate, between good and near pristine (Bolghinup Lake Swamp, Black Point and Lake Charley-Donnelly Estuary Wetland System). Others, such as the Kordabup River/Parry Inlet Wetland System, change in condition from near-pristine at their source, becoming progressively worse until they are degraded at the mouth or in agricultural areas.

Trends for all the wetlands are static except for the Scott River Wetland System, which is declining. The threatening processes that affect wetlands of regional significance are the same as those affecting the wetlands of national significance.

### Riparian zone vegetation

There are 13 riparian systems in the Warren bioregion. However, only six (Scott, Gardner/Canterbury, Shannon, Inlet, Deep/Weld, and Walpole) have their main catchments in the bioregion. Seven (Margaret, Blackwood, Donnelley/Barlee/Beedalup, Warren, Frankland, Bow and Kent/Styx) have only their lower reaches in the bioregion.

Most riparian systems are in a degraded or fair condition but the Shannon, Inlet and Deep/Weld rivers are in a good to near pristine condition. The trend for all river systems is declining or static. Threatening processes that affect riparian systems include:

- wide vegetation clearing in agricultural zones,
- increasing remnant vegetation fragmentation,
- exotic weeds (blackberry, arum lily, Victorian tea tree, pasture species),
- changed fire regimes,
- changed water levels,
- salinity,

- pollution,
- water damming and diversion,
- eutrophication (rivers or lakes with a high rate of algae growth resulting from fertiliser runoff),
- mining,
- feral animals (pigs, horses, deer), and
- recreational use.

### Ecosystems at risk

Eight ecological communities have been declared threatened, critically endangered or vulnerable.

Four aquatic root mat communities of the caves of the Leeuwin Naturaliste Ridge have been declared critically endangered under Western Australian legislation. Three communities – the extant marine shoreline stromatolitic community, Scott River ironstone heaths and the Mount Lindesay vegetation complex – are listed as endangered, while one – the *Calothamnus graniticus* heath on south west coastal granites at Meelup – is listed as vulnerable.

A further 14 ecosystems are at risk. The condition of ecosystems at risk varies from near pristine for the aquatic root mat communities to degraded for the sphagnum communities of the tingle forest. Most are currently in fair or good condition.

All ecosystems at risk are either declining or static with the shoreline stromatolitic community declining rapidly. Threatening processes include:

- changed fire regimes,
- salinity,
- ground water nutrient loads,
- weeds (arum, kikuyu, pasture grass),
- vegetation clearing and fragmentation,
- pathogens,
- roadside disturbance,
- mining activities,
- climate change,
- urban development,
- feral animals (pigs),
- human recreation and tourism, and
- pollution from agricultural activities.

## Species at risk

Twenty per cent of Warren's original mammal fauna is now extinct in the region.

Two plant species and the white-bellied frog have been declared as critically endangered under State legislation. Thirteen plants and one mammal (dibbler) are endangered while 10 plants, three mammals (chuditch, western ring-tailed possum and quokka), six birds (malleefowl, Australasian bittern, Baudin's cockatoo, Muir's corella, western bristlebird and western whipbird), one amphibian (sunset frog) and two invertebrates (*Austroassimineia lethia* and *Austrarchaea mainae*) are classed as vulnerable.

Most species are currently in fair or good condition, though there are a significant number of degraded populations. The trend is for species to remain static or to decline. Two birds (noisy scrub-bird and western ground parrot) were formerly found in the bioregion and have the potential to be translocated back into the area.

A wide variety of threatening processes affect species at risk. These are:

- small population sizes,
- restricted distribution,
- changed fire regimes,
- pathogens,
- vegetation clearing and fragmentation,
- feral animals (rabbits, pigs, foxes, cats),
- weeds (pasture grass, watsonia, marrum grass),
- roadside disturbance and roadworks,
- grazing pressure,
- salinity,
- timber harvesting (and poor logging practices),
- altered water levels,
- recreation activities,
- urban development,
- climate change, and
- lack of recruitment.

## Management responses

### Reserve system

There are 25 nature reserves and four national parks in the Warren bioregion. Nature Reserves range in size from 12 to 4300 hectares, with the management standards rank being fair. Although biodiversity values and/or management issues are poorly identified, they show resource degradation is occurring, although it is retrievable.

Most reserves (20) are less than 100 hectares in size. There is a noticeable absence of nature reserves in the central part of the bioregion.

No staff are resident on reserves and management visitation is generally limited to a minimum of once a year. Few reserves have formal approved management plans or interim management guidelines. Most reserves have significant weed invasion (e.g. pasture grasses and clovers) and feral animal (fox, rabbit and pig) problems.

*Phytophthora* is infecting native vegetation communities in all parts of the region and this is compounded by seasonal inundation. Very small reserves often have a poor composition of understorey species and are in a degraded state because of grazing impacts, extended fire frequencies and grass invasion from surrounding farmlands.

Warren contains 11 national parks and a major portion of three others. The parks range in size from 50 to approximately 117,000 hectares. Management plans exist for Leeuwin Naturaliste, Shannon, D'Entrecasteaux and Walpole-Nornalup national parks.

Staff reside at four parks (Leeuwin Naturaliste, Walpole Nornalup, Torndirrup and William Bay) and other parks are serviced as needed from the nearest CALM office. The management standards rank is good for all parks except Scott, which is classed as fair because of *Phytophthora* and feral pig impacts.

Factors that have an impact on conservation values are:

- the linear design of Sir James Mitchell, Leeuwin Naturaliste and William Bay national parks;
- semi rural land developments and an intensification of agricultural practices on adjoining lands impacting surface water; and
- routine feral animal (fox, some limited rabbit) control undertaken in all of the national parks.

Weeds are subject to annual control programs in the most accessible areas but the spread of some weeds (the African thistle) is being exacerbated by high recreational visitor numbers.

Fire regimes are strongly influenced by high numbers of visitors and the protection of adjoining land uses in parks close to urban and semi rural developments. The development and implementation of fire regimes consistent with biodiversity goals is absent from all these parks.

Fifty of the bioregion's 54 vegetation associations are well represented in conservation estate. However, two vegetation associations (jarrah-marri medium forest and low jarrah forest mosaic and jarrah-marri low forest) that only have small areas of their distributions in reserve remain a high priority.

The overall reservation priority class is five because most of the bioregion's vegetation associations are reserved to the maximum extent, and only minor additions to the system are feasible.

Constraints to the acquisition of new reserves include irreplaceability, limited opportunity to meet the comprehensive, adequate reserve (CAR) system requirements, economic constraints (the price of land) and competing land uses such as mining and agricultural land.

### Off-reserve conservation for species and ecosystem recovery

Most vertebrates in the bioregion are within reserves but some are also found outside reserves. A large number of priority species of plants are found on freehold land and non-conservation reserves, and general recovery actions are appropriate for the whole group.

Off-reserve recovery actions required for all species at risk are:

- the restoration of hydrological systems (including adjacent bioregions);
- data gathering on individual plant life histories and development of fire regimes (frequency, timing, intensity) designed to maintain taxa and ecosystems;
- the mapping of peat communities;
- maintaining and expanding existing baiting/control programs for foxes and developing better control techniques for cats, rabbits, and other feral animals;
- the continuing development of disease management systems (particularly in relation to *Phytophthora*),
- identifying assessment systems for ecosystems and taxa at risk, and developing remedies;
- working with the community and others to reverse the impacts of agricultural fertilisers and pesticides and herbicides on aquatic systems; and
- finding resources for environmental weed control programs both on and off reserves.

## Integrated natural resource management (NRM)

Existing NRM actions include:

- threat abatement (the Salinity Action Plan, Western Shield, and Weed Action Groups),
- industry codes of practice (timber industry regulation),
- environmental management systems,
- planning with local governments and
- integration with property management planning, catchment planning and Landcare for land clearing controls.

Feasible opportunities include:

- institutional reform (e.g. finalise reservation actions for the Salinity Action Plan that have been pending for many years),
- environmental management systems (greater inclusion of tertiary institutions in research with student funding assistance), and
- further control over the process to prevent further land clearing.

The main constraints are limited financial resources, and a lack of staff trained in conservation biology. Warren has an NRM rank of four, indicating that NRM instruments are in place and achieving some biodiversity outcomes.

### Major data gaps and research priorities

The primary gaps are environmental mapping and biodiversity survey work. In particular there needs to be more consistent vegetation mapping, longer term fauna, invertebrate and rare flora surveys, detailed studies of the habitat requirements of uncommon species and quantitative data on threatening processes, especially detailed *Phytophthora* mapping.

# Yalgoo



Gimlet, *Callitris* and Mulga woodlands over herbfields of 'everlastings' on red earth plains east of Lake Moore in the Yalgoo Bioregion, WA.  
Photo: N.L. McKenzie



## Description

### Bioregional description and biodiversity values

Yalgoo extends west to the boundary of the South-west Botanical Province and includes the Toolonga Plateau of the southern Carnarvon Basin.

This region is an interzone between south-western bioregions and the Murchison. It is characterised by callitris-*E. salubris*, mulga, and bowgada open woodlands and scrubs on earth to sandy-earth plains in the western Yilgarn Craton and the southern Carnarvon Basin. The latter has a basement of Phanerozoic sediments and is rich in ephemerals. The climate is Mediterranean, semi-arid to arid and warm.

The dominant land use in the region is grazing, with smaller areas of conservation estate, unoccupied Crown land/Crown reserves and mining.

Special values include the Tallering Peak ironstone and jaspilite range (unique landform and vegetation complexes), banded ironstone in the Mt Gibson Ranges (containing a significant number of endangered flora), Warradagga Rock (a granite outcrop with endangered flora and invertebrates in ephemeral ponds) and the Mt Singleton Ranges (where there is a number of endangered flora with some unusual vegetation associations). A number of rare vertebrate animals (*Egernia stokesii badia*, *Calyptorhynchus latirostris* and *Acanthiza iredalei iredalei*), plants (*Acacia vassalii*, *Darwinia masonii* and *Eucalyptus crucis* subsp. *praecipua*) and ecosystems (particularly shrublands and succulent steppe) exist within the region.

Yalgoo is also rich and diverse in flora and fauna although most species are wide ranging and usually occur in at least one of the adjoining regions. Freshwater pools are refugia for species requiring mesic conditions.

### Overall condition and trend

The Continental Stress Class for Yalgoo is four, even though much of Yalgoo is visibly degraded by past agricultural practices (primarily sheep grazing) and feral herbivores. Stress class calculations have been distorted by the large Toolonga Nature Reserve located on the region's northern periphery. The stress class should actually be three.

The condition of wetlands and riparian systems in the bioregion is fair to good but often declining. The trend for some wetlands is unknown. Many ecosystems and species are considered to be under threat from vegetation clearing and fragmentation, grazing pressure, feral animals, changed fire regimes, weeds, salinity and mining.

### Conservation priorities

Reserves system is biased both in its geographical dispersal and coverage of vegetations. Access and management is limited on most reserves. Feral herbivores, feral predators, weeds need to be controlled throughout the region. There are considerable constraints on off-reserve conservation in the region. Its NRM priority is high.

### Nationally important wetlands

Two wetlands of national significance are present, Thundelarra Lignum Swamp (currently in good condition) and Wagga Wagga Salt Lake (currently in fair condition). Their trend is unknown. Threatening processes that affect wetlands are:

- grazing and
- feral animals (goats, foxes, cats and rabbits).

### Wetlands of regional significance

Lake Moore and Lake Monger are both significant for maintenance of ecological processes at a regional scale. Both are currently in good condition but the trend is unknown. Threatening processes include:

- grazing (goats and sheep) and
- hydrological changes due to degradation of surrounding vegetation associations, increasing runoff and siltation.

### Riparian zone

The principal streams are the Murchison and the Greenough rivers. The Yalgoo region incorporates the Murchison/Gascoyne, Yarra Yarra and Ninghan Catchment areas. The river systems are only in fair condition and are forecast to decline. Threatening processes are:

- grazing pressure and
- feral animals (goats, foxes and rabbits).

## Ecosystems at risk

There are no WA State legislated Threatened Ecological Communities in Yalgoo but 13 ecosystems are considered to be at risk. These are communities that are associated with water, chenopod or acacia shrublands, plant communities of unusually high diversity, an outcrop community and critical weight range mammal assemblages. Most ecosystems at risk are threatened by:

- grazing,
- feral herbivores (goats and rabbits) and
- changed fire regimes.

Tallering Peak is threatened by mining, critical weight range mammals by feral predators and granite rockpools by siltation. All ecosystems at risk are in fair to poor condition and are declining, with the exceptions of Tallering Peak vegetation complexes (static) and mammals in the critical weight range, which are declining rapidly.

## Species at risk

Fifty per cent of Yalgoo's original mammal fauna is now extinct in the region.

One plant species (*Eremophila viscida*) has been declared as critically endangered. Four plants, one bird and one reptile are endangered under State legislation. Two birds are listed as being vulnerable. Threatening processes to plants are:

- feral herbivores (particularity goats),
- grazing,
- changed fire regimes,
- clearing,
- fragmentation and
- mining.

The conditions and trends for all plants are unknown.

Threats affecting fauna (birds and reptiles) are:

- vegetation fragmentation,
- feral predators,
- grazing and
- poaching (in the case of Major Mitchell's and Carnaby's Cockatoos, nests are subject to poaching of eggs and young).

Endangered and vulnerable fauna are all in poor condition and declining.

## Management responses

### Reserve system

Toolonga Nature Reserve is a large reserve in the north and accounts for more than 80 per cent of CALM estate in the region.

Management actions are limited and access is extremely limited to most reserves. No fire breaks or fire access tracks are installed, and no feral animal control programs are in place. Management action is also limited at Kadji Kadji Timber Reserve. Again no fire breaks or fire access tracks have been installed, no feral animal control programs are in place (there is no knowledge of the extent of the problem) and a grazing lease is held over part of area.

All other areas under CALM jurisdiction are recently purchased pastoral lands (held as pastoral leases or unallocated Crown land) and management actions vary widely. Fire control measures have usually been put in place and numbers of feral herbivores and stock have been reduced. No feral predator control programs are in place.

There are 72 Beard vegetation associations in Yalgoo, 42 of which are not reserved or are poorly reserved. It is a high priority to reserve them, as well as the 10 ecosystems at risk. Even so, Yalgoo is rated as having a reservation class of four, resulting from the sheer size of Toolinna Nature Reserve. Clearly, the region's current reserve system is highly biased in terms of CAR criteria, even in terms of comprehensiveness, and should be no more than reservation class three.

Constraints on consolidating the reserve system are primarily competing land uses: pastoralism occupies more than 76 per cent of the region and there are considerable mining interests. Challenges to further reservation include:

- the cost of land,
- subsequent land management, and
- the difficulty in locating biodiversity values in most areas given the level of land degradation.

## Off-reserve conservation for species and ecosystem recovery

The priority groups for off-reserve conservation include:

- birds (*Leipoa ocellata*, *Cacatua leadbeateri mollis*, *Calyptorhynchus latirostris*, and *Acanthiza iredalei iredalei*),
- reptiles (*Egernia stokesii badia*) and
- plants (*Acacia cerastes*, *A. unguicula*, *A. vassalii*, *Darwinia masonii*, *Hyalosperma stoveae*, *Lepidium merrallii*, *Melaleuca oldfieldii*, *Micromyrtus* sp. *Ninghan* (MG Corrick 9332), *Persoonia pentasticha*, *Sauropus* sp. *Woolgorong* (M Officer s.n. 10/8/94), *Stenanthemum poicilum*, and *Eucalyptus crucis* subsp. *praecipua*).

Recovery plans have been written for these birds and reptiles, but not for any plants in the bioregion.

A number of actions need to be taken to prevent further decline of species and ecosystems, including:

- landscape-wide habitat retention,
- fox and cat control,
- reduced grazing pressure (fencing of sensitive areas, especially where there are large goat populations),
- further research on habitat requirements for many species,
- weed control,
- investigation of optimal fire regimes and
- the reintroduction of some species to previous areas of habitat.

Significant off-reserve effort is required, despite resource constraints and limited community capacity.

## Integrated natural resource management (NRM)

Existing initiatives are:

- institutional reform through the Gascoyne-Murchison Strategy (the purchase of leases for the conservation estate),
- threat abatement planning (vegetation management plans, pest management),
- industry codes of practice relating to pastoral, mining and exploration activities,
- environmental management systems and ecological sustainable product marketing,
- integration with property management planning,
- catchment planning and
- Landcare through Land Conservation District Committees.

Opportunities for NRM include:

- duty of care legislation for leasehold and other lands,
- institutional reform (rural reconstruction, industry reconstruction, new tenure and management arrangements),
- planning opportunities with local government,
- a National Action Plan for water quality and salinity, and
- supporting pastoralists as they identify and implement ecologically sustainable practices.

Constraints are substantial (rank = 1). Under land administration legislation, pastoral leases can be required to maintain stocking levels that may degrade conservation values. Gazetting of new reserves is limited by mining leases and tenements.

## Major data gaps and research priorities

The highest priority data gaps in the bioregion are:

- the lack of environmental maps at better than 1:250,000 scale,
- survey data on the region's flora and fauna distributions and population sizes,
- information on the habitat requirements for many organisms, and
- quantitative data on the effects of feral animals and weeds, hydrological changes and current fire regimes, particularly on wetland systems and other ecosystems low in the landscape.

## Glossary and Acronyms

|                                   |  |
|-----------------------------------|--|
| aeolian                           | Relating to, caused by, or carried by the wind.  |
| AgWA                              | Department of Agriculture of Western Australia.  |
| alluvial                          | Relating to the deposits made by flowing water.  |
| ANCA                              | Australian Nature Conservation Agency (now known as Environment Australia).  |
| Archaean                          | Of or belonging to the earlier of the two divisions of Precambrian time, from approximately 3.8 to 2.5 billion years ago, marked by an atmosphere with little free oxygen, the formation of the first rocks and oceans, and the development of unicellular life.   |
| Beard vegetation association      | Mapping unit of vegetation based on dominant species at 1:250,000 scale, used and developed in Western Australia by John Beard.  |
| bentonite                         | An absorbent aluminum silicate clay formed from volcanic ash.  |
| breakaway                         | Geomorphological feature which includes a hard-capped rock top layer and an easily eroded slope.   |
| bryophyte                         | A division of photosynthetic, chiefly terrestrial, nonvascular plants, including the mosses, liverworts, and hornworts.  |
| CALM                              | Department of Conservation and Land Management   |
| CAR                               | <b>Comprehensiveness</b> - includes the full range of communities recognised by an agreed national scientific classification at appropriate hierarchical levels. <b>Adequacy</b> - the maintenance of ecological viability and integrity of populations, species and communities. <b>Representativeness</b> - those sample areas of the vegetation association that are selected for inclusion in reserves should reasonably reflect the biotic diversity of the communities   |
| chenopod                          | Member of the plant family Chenopodiaceae, normally associated with saline sites.  |
| colluvial<br>of a cliff or slope. | A loose deposit of rock debris accumulated through the action of gravity at the base   |
| Condition rank                    | Categories are: (i) Degraded (Recovery unlikely in medium term); (ii) Fair (Recovery requires significant management intervention); (iii) Good (Recovery would occur in short term with minimum intervention) and (iv) Near pristine.  |
| Continental Stress Class          | A measure of the average stress on natural landscapes within a subregion, relative to other subregions in Australia. It is based on a number of surrogates that reflect the major threatening processes on natural ecosystems, and on biodiversity in particular. These surrogates include the extent of native vegetation, continuity in native vegetation, intensity of land use in native vegetation, number of threatened ecosystems, weed density, salinity risk/hazard in native vegetation, feral vertebrate density and number of threatened species. Values range from 1 (highest stress) to 6 (lowest stress). The decision rules used are outlined in Morgan, G. (2001). <i>Landscape health in Australia. A rapid assessment of the relative condition of Australia's bioregions and subregions</i> . Environment Australia and National Land and Water Resources Audit. |
| CTR                               | Conservation Through Reserves  |
| CWR                               | Critical Weight Range (used to refer to mammals approximately 35g to 5.5kg mean adult body weight that have experienced modern decline)  |
| DIWA                              | Directory of Important Wetlands in Australia   |
| Dominant land use                 | Categories are: (i) Urban (includes industrial, airfields); (ii) (a) Rural residential, (b) Mining; (iii) Cultivation (irrigated horticulture, agriculture, plantations and intensive production); (iv) Cultivation (dry land agriculture); (v) Forestry (plantations); (vi) Forestry (native forests, state forests, timber reserves) (vii) Grazing (improved pastures, dryland); (viii) Grazing (native pastures);   |

|                        |   |
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|                        | (ix) Traditional Indigenous (uses includes Aboriginal reserves); (x) UCL and Crown reserves; (xi) Native forest outside of public lands (essentially ungrazed by domestic stock); (xii) Defense lands and reserves; (xiii) Conservation; (xiv) Reservoirs and (xv) Other (description provided).  |
| DRF                    | Declared Rare Flora   |
| EA                     | Environment Australia   |
| EMS                    | Environmental Management System   |
| EMU                    | Ecosystem Management Unit   |
| endemic                | Restricted or peculiar to a locality or region.   |
| EPBC                   | Environmental Protection and Biodiversity Conservation (used in reference to the Act of Federal Parliament 1999).   |
| epeirogenic            | Uplift or depression of the earth's crust, affecting large areas of land or ocean bottom.   |
| ephemeral              | Plants - Short-lived species.   |
| Watercourses           | A stream that flows briefly and only in direct response to local precipitation, and whose channel is always above the water table.  |
| eutrophication         | Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.  |
| germplasm              | The hereditary material of the reproductive cells   |
| GMS                    | Gascoyne Murchison Strategy   |
| gnamma hole            | Small hole in sheet granite outcrop.  |
| gneiss                 | A banded or foliated metamorphic rock, usually of the same composition as granite.  |
| granite                | Plutonic igneous rock having visibly crystalline texture.   |
| greenstone             | Any of various altered basic igneous rocks colored green by chlorite, hornblende or epidote.  |
| gypsum                 | A common white or colorless mineral (hydrated calcium sulphate), used especially as a soil amendment and in making plaster of paris.  |
| herbaceous             | Relating to or characteristic of an herb as distinguished from a woody plant.   |
| horst                  | A mass of the earth's crust that lies between two faults and is higher than the surrounding land.   |
| hummock grassland      | Grassland dominated by <i>Triodia</i> spp., which forms small mounds.   |
| IBRA                   | Interim Biogeographic Regionalisation for Australia (version 5.1 is used for this document)   |
| ironstone              | Rock containing enough iron to permit commercial extraction.  |
| IRP                    | Interim Recovery Plan   |
| isohyet                | Line on a map connecting points of equal precipitation.   |
| IUCN categories I-IV   | Areas of land formally protected for nature conservation values, including strict nature reserve/wilderness (managed for science or wilderness), national park (managed for ecosystem conservation and recreation), natural monuments (managed for conservation of specific natural features) and habitat/species management areas (managed mainly for conservation through management intervention). |
| IUCN categories V & VI | Areas of land formally protected for nature conservation values, including protected landscapes/seascapes (managed mainly for landscape or seascape conservation and recreation) and managed resource protected areas (managed mainly for the sustainable use of natural ecosystems).   |

|                 |   |
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| jaspilite       | A compact siliceous rock resembling jasper.   |
| Jurassic        | Of, or belonging to the geologic time, rock series, or sedimentary deposits of the second period of the Mesozoic Era, in which dinosaurs continued to be the dominant land fauna and the earliest birds appeared.   |
| kankar          | Calcareous material layer that is deposited in the soil.  |
| karst           | An area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns.   |
| laterite        | A red residual soil in humid tropical and subtropical regions that is leached of soluble minerals, aluminum hydroxides and silica but still contains concentrations of iron oxides and iron hydroxides.   |
| LCDC            | Land Conservation District Committee  |
| mallee          | Plant which is multi-stemmed from the base.   |
| mallet          | Small or medium sized tree, with numerous erect branches.   |
| mangal          | Mangrove  |
| Mesozoic        | Of, belonging to, or designating the era of geologic time that includes the Triassic, Jurassic, and Cretaceous periods and is characterized by the development of flying reptiles, birds, and flowering plants and by the appearance and extinction of dinosaurs.   |
| morrell         | Tree which has a long straight trunk and rough bark.  |
| NHT             | Natural Heritage Trust  |
| NLWRA           | National Land and Water Resources Audit   |
| non-volant      | Non-flying  |
| NRM             | Natural Resource Management   |
| NRM actions     | Categories are: (i) Incentives; (ii) Legislation including duty of care for leasehold and other lands; (iii) Institutional reform (e.g. rural reconstruction, industry reconstruction, new tenure and management arrangements); (iv) Valuing ecosystem services, tradable rights; (v) Threat abatement planning as part of NRM (e.g. vegetation management plans, pest management); (vi) Industry codes of practice; (vii) Environmental management systems, ecological sustainable product marketing; (viii) Capacity building required with community, landholders, industry and institutions; (ix) Other planning opportunities including local government planning and National Action Plan for Water Quality and Salinity; (x) Integration with property management planning, catchment planning and Landcare and (xi) Other (description provided). |
| NRM rank        | Categories are: (i) Major constraints to implement effective NRM actions to achieve biodiversity outcomes e.g. structural reform needed owing to extent of past degradation, land capability, property size, social and economic disruption; (ii) Significant constraints to integrate conservation as part of production/development system; (iii) Identified capacity for conservation to be integrated into NRM to achieve significant biodiversity outcomes; (iv) NRM instruments in place with some achieved biodiversity outcomes and (v) Conservation outcomes well integrated into production/development systems   |
| NRS             | National Reserve System   |
| NRS constraints | Categories are: (i) Irreplacibility (i.e. very few options remain to conserve ecosystem/landscape); (ii) Limited opportunity remains to meet CAR criteria in terms of comprehensiveness and representativeness; (iii) Economic constraints (e.g. land prices); (iv) Competing land uses and (v) Other (description provided).   |
| NVIS            | National Vegetation Inventory System  |

|                               |   |
|-------------------------------|---|
| NVIS descriptions             | Categories are: (1) Cool Temperate Rainforest; (2) Tropical and sub-tropical rainforest + dry rainforest; (3) Eucalyptus tall open forest and Eucalyptus forests with a dense broad leaved understorey (wet sclerophyll); (4) Eucalyptus forests with a shrubby understorey; (5) Eucalyptus forests with a grassy understorey; (6) Eucalyptus forests with a heath understorey; (7) Tropical eucalypt forest and woodlands with a annual grassy understorey; (8) Eucalyptus woodlands with a shrubby understorey; (9) Eucalyptus woodlands with a grassy understorey; (10) Low tropical eucalyptus forests and woodlands; (11) Tropical mixed spp forests and woodlands; (12) Callitris forests and woodlands; (13) Brigalow ( <i>Acacia harpophylla</i> ) forests and woodlands; (14) Other <i>Acacia</i> forests and woodlands; (15) <i>Melaleuca</i> forests and woodlands; (16) Other forests and woodlands; (17) Alpine and sub-alpine woodlands, shrublands, sedgeland and herbfields; (18) Arid eucalyptus low open woodlands with hummock grass; (19) Arid eucalyptus low open woodlands with tussock grass; (20) Mulga ( <i>Acacia aneura</i> ) woodland and low open woodland; (21) Mixed species arid acacia woodlands and shrublands; (22) Arid acacia low open woodlands and shrublands with chenopods; (23) Arid acacia low open woodlands and shrublands with hummock grass; (24) Arid acacia low open woodlands and shrublands with tussock grass; (25) Other low open woodlands and shrublands with tussock grass; (26) <i>Casuarina</i> and <i>Allocasuarina</i> forests and woodlands; (27) Mallee eucalyptus low open woodlands; (28) Tall shrublands; (29) Mallee heath and shrublands; (30) Heath + <i>Banksia</i> woodlands and shrublands; (31) <i>Chenopod</i> shrublands; (32) Other shrublands; (33) <i>Spinifex</i> Hummock Grasslands; (34) Mitchell Grass ( <i>Astrebla</i> ) tussock grasslands; (35) Blue Grass ( <i>Dicanthium</i> ) and Tall Bunch Grass ( <i>Chrysopogon</i> ) tussock grasslands; (36) Other tussock grasslands; (37) Other Grasslands; (38) Herbland, Sedgeland and Rushland; (39) Mixed <i>Chenopod</i> , <i>Samphire</i> and <i>Forblands</i> ; (40) Mangroves, tidal mudflat and coastal samphire; (41) Bare areas, rock, sand, claypan, salt lakes and lagoons; (42) Freshwater lakes; (43) Unclassified native vegetation and (44) Not natural. |
| Off-reserve conservation rank | Categories are: (i) Major constraints to achieve conservation outcomes (e.g. due to level of habitat loss, landscape condition); (ii) Significant off park effort needed, resource constraints, limited community capacity; (iii) Relatively limited off park measures will result in significant biodiversity gains; (iv) Range of off reserve measures required, capacity exists and some achieved biodiversity outcomes and (v) Off reserve measures significantly in place. perched clay wetlands Wetland that is bound by a layer of clay which separates the wetland from soil or water table below the clay.   |
| perennial                     | Continuing more than two years.   |
| Phanerozoic                   | Of, or relating to the geologic time period from approximately 570 million years ago to the present, comprising the Paleozoic, Mesozoic, and Cenozoic eras, and marked by an abundance of fossil evidence of life, especially higher forms, in the corresponding rocks.   |
| Pindan                        | <i>Acacia</i> woodland characteristic of Dampierland.   |
| playa                         | A nearly level area at the bottom of an undrained basin, sometimes temporarily covered with water.  |
| Proterozoic                   | Of, or relating to the later of the two divisions of Precambrian time, from approximately 2.5 billion to 570 million years ago, marked by the buildup of oxygen and the appearance of the first multicellular eukaryotic life forms.  |
| Quarternary                   | An ice age that began approximately 1.6 million years ago and continues to the present time.  |
| refugia                       | An area that has escaped ecological changes occurring elsewhere and so provides a suitable habitat for relict species.  |
| regime                        | A regulated system.   |
| regolith                      | The layer of loose rock resting on bedrock, constituting the surface of most land.  |

|  |   |
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| Reserve management standards rank      | Categories are: (i) Poor (e.g. high visitor impact and/or other threatening processes that are not managed and are leading to permanent resource degradation in a number of parks); (ii) Fair (e.g. Biodiversity values and or management issues are poorly identified; resource degradation is occurring though retrievable);<br><br>(iii) Good (e.g. major biodiversity issues effectively managed and) and (iv) Very good (e.g. high proportion of parks have park management plans, ecological monitoring programs in place and key biodiversity issues are being addressed). |
| riparian zones                         | The area between a stream or other body of water and the adjacent upland identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.   |
| RP                                     | Recovery Plan   |
| samphire                               | Succulent stemmed member of plant family Chenopiaceae.  |
| SAP                                    | Salinity Action Plan  |
| seif dunes                             | Type of sand dune which consists of a long sharp ridge lying parallel to the direction of the prevailing wind.  |
| sinkhole                               | A natural depression in a land surface communicating with a subterranean passage, generally occurring in limestone regions and formed by solution or by collapse of a cavern roof.  |
| Species and Ecosystem Recovery Actions | Categories are: (i) Habitat retention through reserves; (ii) Habitat protection on private lands; (iii) Habitat protection on other state lands; iv) Regrowth retention; (v) Fencing; (vi) Weed control; (vii) Feral animal control; (viii) Revegetation; (ix) Fire management; (x) Translocation; (xi) Reinstatement of hydrology; (xii) Research; (xiii) Capacity 1 building required with community, landholders, industry and institutions and (xiv) Other (description provided).  |
| stygofauna                             | Subterranean aquatic free-living fauna.   |
| succulent steppe                       | Semiarid plain, with vegetation having thick, fleshy, water-storing leaves or stems.  |
| taxa                                   | A group or category, at any level, in a system for classifying plants or animals.   |
| TEC                                    | Threatened Ecological Community   |
| TFRT                                   | Threatened Flora Recovery Team  |
| Threatening processes                  | Categories are: (i) Broad scale vegetation clearing; (ii) Increasing fragmentation, loss of remnants and lack of recruitment; (iii) Firewood collection; (iv) Grazing pressure; (v) Feral animals; (vi) Exotic weeds; (vii) Changed fire regimes; (viii) Pathogens; (ix) Changed hydrology (salinity); (x) Changed hydrology (other, e.g. altered flow regimes affecting riparian vegetation); (xi) Pollution; (xii) Other (description provided).  |
| Trend in status or condition           | Categories are: (i) Extinction (e.g. targeted research has not observed species in recent times or no record in last 20 years); (ii) Rapidly declining (e.g. < 10 year time frame); (iii) Declining; (iv) Static; (v) Improving and (vi) Unknown  |
| troglobite                             | Any organism living in caves only.  |
| UCL                                    | Unoccupied Crown Land   |
| VCL                                    | Vacant Crown Land (now known as UCL)  |



