A Conservation Case Study of Western Australia's Rejuvenated Drainage Subregion (Avon Wheatbelt 2) in 2003

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

GOVERNMENT OF WESTERN AUSTRALIA

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

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By Brett C. Beecham

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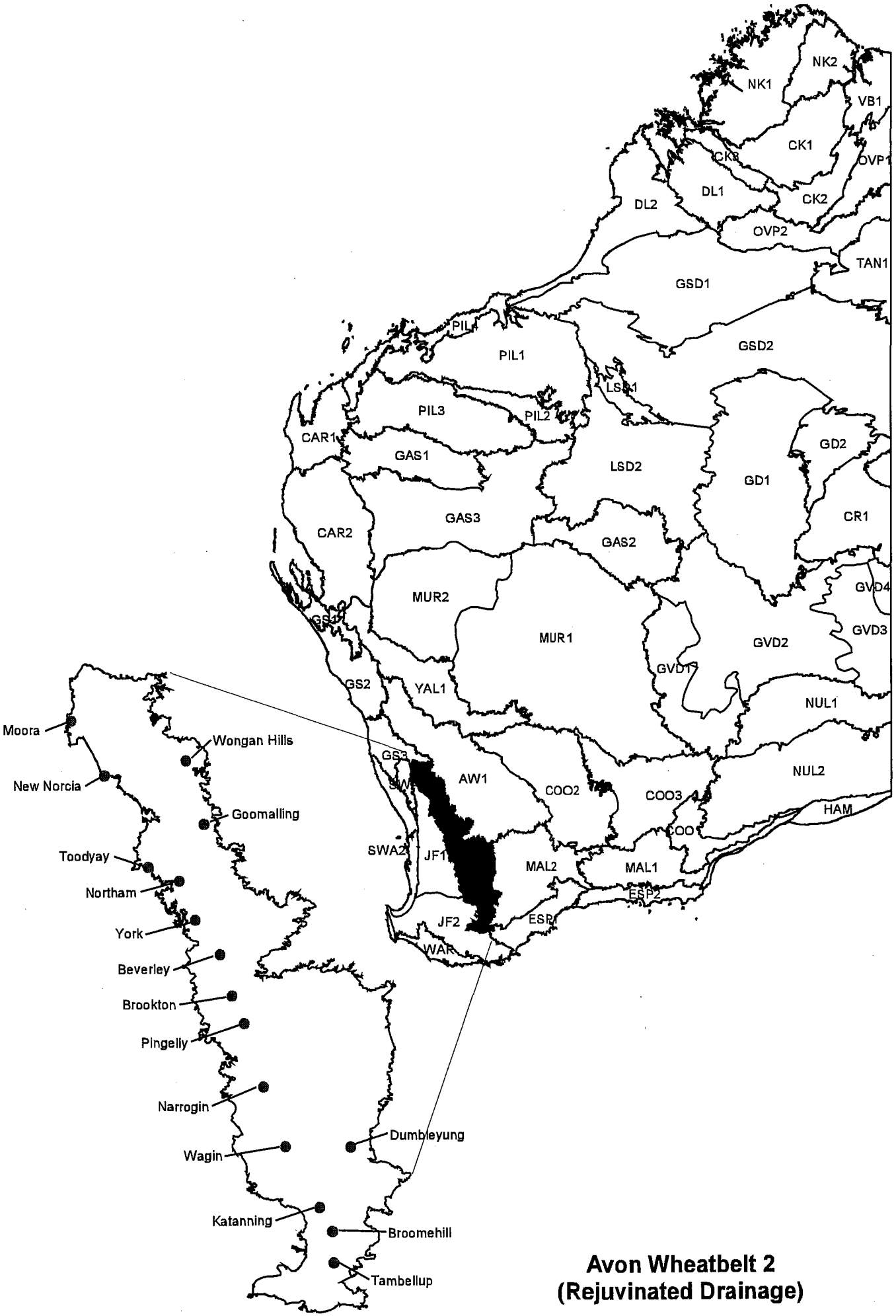
Front cover photography
Black-flanked rock-wallabies persist on some of the region's granite outcrops. Photo by Babs and Bert Wells/CALM.

Back cover photography
Wandoo woodlands are a feature of unsalinised valley floors throughout the sub-region. Photo by Avril Baxter.



Avon Wheatbelt 2
(Rejuvinated Drainage)

Foreword

This booklet is an environmental case study of the western subregion of Western Australia's Avon Wheatbelt bioregion (AW2) and a follow-up to WA's first published biodiversity conservation snapshot – the Biodiversity Audit of WA's 53 Biogeographical Subregions 2002 (May and McKenzie 2003).

Research has shown that the subregion is experiencing a decline in environmental health caused by past extensive clearing of native vegetation. Remnant vegetation, wetlands, riparian systems, and species populations are in poor condition. About 25 per cent of WA's declared rare flora occurs in eucalypt woodlands in this subregion.

The subregion is part of an internationally recognised biodiversity hotspot because of its rich biodiversity, high levels of endemism and landscape stress. Less than 30 per cent of the subregion remains as uncleared remnants of natural vegetation, and more than 10 per cent of its total land surface is already affected by salinity.

All watercourses and remaining valley floor woodlands are degraded and the trend is for further rapid decline.

There are four nationally significant wetlands: the Coyrecup, Dumbleyung and Toolibin lakes, and the Yealering lakes system. Their condition is fair but all are continuing to decline because of water diversion, damage by off-road vehicles to vegetation mats, water pollution, invasion of the bridal creeper weed, salinity and excessive inundation. Siltation and agricultural fertilizers are affecting the remaining live trees, leading to algal booms and the disappearance of surrounding vegetation.

This publication offers specific management recommendations for the subregion in the wake of its threatening processes – land clearing, exotic weed invasion, salinity, altered water flows and feral animals. Given the ubiquitous and pervasive nature of these threatening processes, including global warming, continuing general decline in the subregion's biodiversity values is inevitable unless action is taken to reduce and reverse the threats.

To minimise environmental deterioration in this subregion, natural resource management initiatives include incentives for revegetation, fencing remnant vegetation and the abatement of threats such as dieback, feral animals, altered fire regimes, salinity and weeds.

The Government is supporting the design and implementation of recovery actions for a wide variety of species, including two species of critically endangered trapdoor spiders, the red-tailed phascogale (listed as endangered) and the western quoll, numbat and black-footed rock wallaby (listed as vulnerable).

Opportunities for natural resource management are being supported by the State Government, which will continue to address the environmental threats posed to regions in WA.

Judy Edwards

Dr Judy Edwards MLA
Minister for the Environment

Keiran McNamara

Keiran McNamara
Executive Director
Department of Conservation
and Land Management

July 2004

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Introduction and acknowledgments

This case study was originally compiled as part of Western Australia's contribution to an audit of nature conservation issues Australia-wide. The broader Australia-wide project was defined, carried out and published under the auspices of the Natural Heritage Trust's National Land and Water Resources Audit (Australian Terrestrial Biodiversity Audit 2002). This project follows on from the publication of the Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002 (May and McKenzie 2003) and the Bioregional Summary of the 2002 Biodiversity Audit for Western Australia (McKenzie *et al* 2003).

This case study reviews the nature conservation issues that are faced by one subregion in Western Australia, Avon Wheatbelt 2 (Re-juvenated Drainage). It provides a more thorough appraisal of the subregion's conservation requirements and includes two maps relevant to these issues. It is a companion volume to a case study written about the North Kimberley's Mitchell subregion (NKI) as a part of Western Australia's Biodiversity Audit. Refer to Appendix A for an explanation of each subheading, terms of reference and directions provided to the author. Appendices B and C are the lists of keys and rankings that were provided by the Australian Terrestrial Biodiversity Audit (National Land and Water Resources Audit 2002). Maps can be found in the fold out section at the back of this document.

The data and interpretations presented are based on first-hand experience, being compiled by the Department of Conservation and Land Management's regional nature conservation staff between July 2001 and January 2002, with some updates in late 2003.

By providing an overview of the status of the species and ecosystems in the Rejuvenated Drainage subregion's lands and waterways in terms of a consistent set of criteria, this report provides a detailed, systematic basis for assessing conservation priorities and allowing comparisons to other parts of Western Australia. It also indicates the likely consequences for biodiversity if no action is taken. Further information is provided than in the subregional synopses contained in the Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002 (May and McKenzie 2003), but some topics are common to both documents.

In many instances, the reader will become aware that a subregion or area is under ecological threat from forces ranging from grazing, to salinity, or weeds. Some of these problems are challenging, and in some places they are not being well managed. Where feasible, potential solutions have been outlined. These solutions need to become part of the day-to-day management of our lands and waters if the environment is to improve.

The Australia-wide Terrestrial Biodiversity Audit project was managed by Paul Sattler, Colin Creighton, Rochelle Lawson and Jim Tate (NLWRA), with general direction from an Audit Biodiversity Assessment Advisory Committee comprising Keiran McNamara (Chair, CALM), Gus McGown (Agforce), Ray Nias (WWF), Hugh Possingham (BDAC), Denis Saunders (CSIRO), Christine Schweizer (EA), Geoff Barrett (Birds Australia), Cynthia Maher (NFF), Stephen Hunter (Audit Advisory Council) and Phil Pritchard (AFFA). The regional boundaries are modified from the phytogeographical regionalisation devised by John Beard for Western Australia. This case study follows a standardised structure that was supplied by the NLWRA.

Western Australia signed contracts to complete the Statewide biodiversity audit after meeting with representatives from State, Territory and Commonwealth environmental agencies in April 2001 (refer to May and McKenzie 2003). The Western Australian component of the Biodiversity Audit was funded by NLWRA and CALM, and was managed by Norm McKenzie. For contributing data and providing helpful assessments of the drafts, the author thanks the Western Australian Museum, Perth Herbarium, Western Australian Threatened Species and Communities Unit (WATSCU), Nathan Eaton, Richard Hobbs, Greg Keighery, Sue McKenna and many others.

This case study was implemented and managed with the assistance of Jelena May (scientific editor and page layup), Robyn Wilson (GIS), and Angas Hopkins and Damian Shepherd (vegetation layer).

It is anticipated that there are a range of gaps and omissions in this initial edition. Information will become more extensive as data continues to be gathered and nature conservation work in Western Australia progresses. Author Brett Beecham invites all interested people to make use of the information. Robust discussion on its usages is encouraged, and candid recommendations are invited for its improvement. Hopefully it will provide a framework for the State biodiversity strategy, and for setting priorities among nature conservation activities 'on the ground'.

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

Description, biodiversity values and conservation issues

Description and area

The Avon Wheatbelt bioregion is a dissected plateau of Tertiary laterite in the Yilgarn Craton. It's climate is semi-arid (dry) warm Mediterranean. There are two subregions, roughly divided to eastern (Avon Wheatbelt 1 – Ancient Drainage) and western (Avon Wheatbelt 2 – Re-juvenated Drainage) areas. This case study focuses on the western subregion, Avon Wheatbelt 2.

The Re-juvenated Drainage subregion comprises gently undulating rises to low hills with abrupt breakaways. Its drainage is re-juvenated 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 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. Subregional area is 3,012,977 ha.

Dominant land use

Dominant land uses in the subregion are cultivation - dry land agriculture (iv) and dryland grazing - improved pastures (viii), with smaller areas of conservation (xiii), Crown reserves (x), forestry - native forests, state forests and timber reserves (vi), forestry - plantations (v) and rural residential (ii). Appendix B, key b contains the full list of landuses defined by the National Land and Water Resources Audit (2002). Refer also to Map 1 – Landuses in Avon Wheatbelt 2 (Re-juvenated Drainage Subregion) in fold out section at the back of this document.

Continental Stress Class

The subregion's Continental Stress Class is 1. This indicates that this subregion, as well as the AW1 subregion) has the highest stress class in Western Australia and is subject to wide-ranging landscape level threatening processes.

Known special values

Critical Weight Range (CWR) mammals:
These are mammals weighing between 35g and seven kg threatened by fox predation. Two species are now totally extinct, the pig-footed bandicoot and the crescent nailtail wallaby. Several species are subregionally extinct, and some are still extant. Table 1 shows the State wide and AW2 subregional status of CWR mammals.

Table 1: Critical Weight Range Mammals in Avon Wheatbelt 2.

Species	Current conservation status (WA)	Status in AW2 Subregion
Mala (*Lagorchestes hirsutus*)	Threatened (Extinct in the wild)	Subregionally Extinct
Red-tailed phascogale (*Phascogale calura*)	Threatened (Endangered)	Threatened (Endangered)
Western barred bandicoot (*Perameles bougainville bougainville*)	Threatened (Endangered)	Subregionally Extinct
Chuditch (*Dasyurus geoffroii*)	Threatened (Vulnerable)	Threatened (Endangered)
Numbat (*Myrmecobius fasciatus*)	Threatened (Vulnerable)	Threatened (Vulnerable)
Bilby (*Macrotis lagotis*)	Threatened (Vulnerable)	Subregionally Extinct
Boodie (*Bettongia lesueur lesueur*)	Threatened (Vulnerable)	Subregionally Extinct
Banded hare-wallaby (*Lagostrophus fasciatus fasciatus*)	Threatened (Vulnerable)	Subregionally Extinct
Black-flanked rock-wallaby (*Petrogale lateralis lateralis*)	Threatened (Vulnerable)	Threatened (Vulnerable)
Greater stick-nest rat (*Leporillus conditor*)	Threatened (Vulnerable)	Subregionally Extinct
Western ringtail possum (*Pseudocheirus occidentalis*)	Threatened (Vulnerable)	Subregionally Extinct
Woylie (*Bettongia penicillata ogilbyi*)	Priority 4, Conservation Dependent	Conservation Dependent
Tammar wallaby (*Macropus eugenii derbianus*)	Priority 4, Conservation Dependent	Conservation Dependent
Quenda (*Isoodon obesulus fusciventer*)	Priority 4, Conservation Dependent	Conservation Dependent
Western brush wallaby (*Macropus irma*)	Priority 4, Conservation Dependent	Conservation Dependent
Brush-tailed phascogale (*Phascogale tapoatafa*)	Priority 4, Conservation Dependent	Conservation Dependent
Common brushtail possum (*Trichosurus vulpecula*)	No listing	Conservation Dependent

Toolibin Lake:

- This is the principal breeding area for colonial waterbirds in the inland drainage systems of south-western Australia.
- It is a major breeding area for the freckled duck (*Stictonetta naevosa*).
- It is an increasingly important breeding area for other waterbirds.
- The lake has been identified as a Critically Endangered Threatened Ecological Community.

Pingelly (Boyagin-Tutanning Reserves):

- There is a high density of rare and geographically restricted flora (Fig. 12.1, Hopper and Muir 1984).
- It supports populations of several CWR marsupials at risk from fox predation (numbat, Quenda, Woylie, tammar wallaby, red-tailed phascogale, brushtail possum) that had disappeared from most of the Australian or Western Australian mainland.

Dryandra Woodland:

- The woodland supports extant populations of several CWR marsupials at risk from fox predation (numbat, Woylie, tammar wallaby, red-tailed phascogale, brushtail possum) that had disappeared from most of the Australian or Western Australian mainland.
- Dryandra State Forest has a vascular flora of at least 850 species, more than Mt. Lesueur (a well recognised area of high species richness) (Keighery and Lyons 2001).

South West Botanical Province (includes AW2):

- This has high species richness and endemicity particularly for Proteaceae (632 spp, 99 per cent endemic; 16 genera, five endemic) (Cowling and Lamont 1998).
- Hopper and Gioia (2003, in prep) are currently undertaking an extensive analysis of patterns in floristic richness, endemism and "hotspots" across the South West Botanical Province.

Transitional Rainfall Zone:

Equivalent to the Mallee, Avon Wheatbelt and Geraldton Sandplains IBRA Regions. This zone contains the most species-rich areas, including the lateritic uplands of the western edge of the wheatbelt (Hopper 1992). Genera with their major concentration of species in the AW2 subregion include:

- *Acacia* and *Verticordia* (Hopper et al. 1996).
- *Lhotskya*, *Eriostemon*, *Wehlia*, *Baeckea*, *Melaleuca*, *Chamelaucium*, *Micromyrtus* and *Thryptomene* (Hopper 1979).

Eucalyptus woodlands:

- This has high floristic diversity (Table 4 in Yates *et al.* 2000). Twenty five per cent of the plants are Declared Rare Flora. (Yates *et al.* 2000; Hopper *et al.* 1990).

Mallee eucalypts and *Melaleuca* for oil production:

It is seen as vital to identify local *Eucalyptus* and *Melaleuca* species that can be introduced in commercial quantities to develop a plantation based oil mallee industry in the south west of Western Australia. The use of locally endemic species is seen as preferable, to minimise the risk of eastern Australian species hybridising with local species and becoming environmental weeds. The use of local species is also seen as providing some fauna habitat benefits as well. Populations of mallee *Eucalyptus* species (Spathulata group) contain individuals that produce higher than average quantities of cineole oil. Identifying these individuals with natural populations, and introducing their genetic material into breeding programs is critical to the success of this program. The subregion supports significant populations of many of these species.

Wongan Hills greenstone belt and associated laterite-capped mesas:

The Wongan Hills are a range of flat-topped hills situated 194km north-east of Perth in Western Australia's northern wheatbelt. Mt. Matilda (434m) and Mt. Rupert (419m) are the highest points in the hills. The area has terrain typical of the Wongan Hills which comprise a series of laterite capped mesas trending north-south, dissected by numerous steep gullies in which exposures of greenstone and granite can be seen. The Wongan Hills Area is underlain by the Archaean rock of the Darling Plateau, which is part of the Yilgarn Block, a stable nucleus composed mainly of granite and gneisses with some altered volcanics and sediments known as greenstone belts. The hills are formed on infolded beds of the altered volcanics and sediments that are more resistant to erosion than the country rock. The rocks have been eroded into low, rounded hills and became thickly crusted with laterite. Subsequently the laterite has been breached to form mesas bounded by breakaways and scarp slopes. The area is within the Avon botanical district of the South West Botanical Province. The Wongan Hills support a vegetation system that forms a small enclave within the Guangan Vegetation System.

The Wongan Hills Area is significant in maintaining ecological processes in the wheat belt region of south-western Australia. There is no other area of intact breakaway country of comparable size in the wheat belt region and the vegetated portion of Wongan Hills is the largest single area of natural vegetation remaining in the northern wheatbelt. The area is one of the few pockets of uncleared land that is large and varied enough to continue to provide a habitat for the remaining species of the wheatbelt. It therefore plays a critical role in the maintenance of the biodiversity in the wheat belt region. It is important for maintaining a large number of bird species that have undergone major population declines throughout the wheat belt region.

The Wongan Hills Area has remained a stable refuge for a number of bird species that are totally reliant on mallee and woodland habitats. This is of considerable importance as 53 per cent of the bird species using woodlands and 63 per cent of those in mallee habitats have declined since European settlement. The area is also important as a refuge for wheatbelt migrant and nomadic species. A number of plant species that are either Declared Rare or Priority Flora in Western Australia have been collected in the Wongan Hills. These include:

- *Acacia botrydion*
- *A. cochlocarpa* subsp. *velutinosa*
- *A. congesta* subsp. *wonganensis*
- *A. denticulosa*
- *A. pharangites*
- *A. pygmaea*
- *A. semicircinalis*
- *Calothamnus accedens*
- *Conostylis wonganensis*
- *Dampiera glabrescens*
- *Daviesia spiralis*
- *Dryandra comosa*
- *D. pulchella*
- *D. wonganensis*
- *Eremophila ternifolia*
- *Eucalyptus recta*
- *Gastrolobium glaucum*
- *Grevillea dryandroides* subsp. *dryandroides*
- *G. kenneallyi*
- *Hemigenia conferta*
- *Loxocarya albipes*
- *Lysiosepalum abollatum*
- *Melaleuca sciotostyla*
- *Microcorys eremophiloides*
- *Philotheca wonganensis*
- *Rhagodia acicularis*
- *Stylidium coroniforme*
- *Verticordia staminosa* subsp. *staminosa*
- *V. wonganensis*

With the exception of bats, the mammal fauna of the Wongan Hills is depauperate. The wheatbelt region of Western Australia has suffered a considerable loss of faunal diversity in a relatively short period. In the last 100 years the Wongan Hills have probably lost at least 10 mammal species. In recent times only nine species of native mammals have been collected in or near the Wongan Hills.

Unlike mammals, the bird fauna is rich. Ninety species have been recorded in the Wongan Hills including several rare, threatened and regionally uncommon fauna species such as the malleefowl (*Leipoa ocellata*), peregrine falcon (*Falco peregrinus*) and Carnaby's cockatoo (*Calyptorhynchus latirostris*). Four species of frog and 22 species of reptile have been collected in the Wongan Hills. Most reptile and frog records are within their known range. Fauna that are infrequently recorded in wheatbelt reserves include:

- *Diplodactylus pulcher*
- *Underwoodisaura milii*
- *Ctenophorus ornatus*
- *Demansia psammophis*

Wongan Hill also contains an interesting assemblage of spiders, including the shield-backed trapdoor spider and the endemic Wongan Hills wishbone spider (*Dekana wonganensis*). Forty species from 28 genera have been recorded in total, and includes both widely distributed species and species with a more restricted range.

The Hills include vegetation types that have become rare and uncommon in the wheatbelt of Western Australia. The salmon gum, York gum, gimlet and *Eucalyptus falcata* woodlands and *Acacia acuminata* low forest are rare woodland/forest types. Some 97 per cent of York gum/jam woodlands and 78 per cent of salmon gum/gimlet woodlands have been cleared in the South West Botanical Province.

The Wongan Hills Area is of biogeographical importance as it contains a high number of endemic, disjunct species of fauna and flora and a number of species at their limits of distribution. Plant species endemic to the Wongan Hills include:

- *Acacia botrydion,*
- *A. pharangites,*
- *A. pygmaea,*
- *Calytrix stowardii,*
- *Clematis aff. microphylla,*
- *Dryandra pulchella,*
- *Eremophila ternifolia,*
- *Eriostemon wonganensis*
- *Rhagodia acicularis*

Although the Wongan Hills do not constitute a natural barrier to birds, a number of species have distributional limits in or close to the hills. The area is therefore of biogeographical interest as it contains species of both the arid zone and south-west. Specifically, Wongan Hills is one of the few areas in the wheatbelt where the splendid fairy-wren and blue-breasted fairy-wren occur sympatically. The area maintains an assemblage of reptiles on laterite hill country that is not represented anywhere else in the central wheatbelt. It has a diverse bird fauna, with 90 species being recorded, compared with the average of about 75 species of birds recorded on most wheatbelt reserves and bush remnants.

The Wongan Hills area is considered to be an excellent and intact representation of the landforms and vegetation characteristic of the breakaway country in the northern/central wheatbelt. The Wongan Hills Area is important in contributing to a wider understanding of the ecology of the northern wheatbelt and is the type locality for two species of spider and a number of plant species. Data gathered here serves as a base line for monitoring the region's ongoing ecological change.

References for this section on Wongan Hills are Beard (1981), Beard and Sprenger (1984), Burbidge and

McKenzie (1989), Carter and Lipple (1982), Chinnock (1982), Coates (1988), Conservation Through Reserves Committee (1974), Curry (1994), Dell and Harold (1977), Hobbs (1991), Kenneally (1977a; 1977b; 1977c; 1977d; 1982), Main (1987), Morris and Dell (1977), de Rebeira and de Rebeira (1977), Saunders and de Rebeira (1991), Saunders and Ingram (1987), Saunders, *et al.* (1985), Saunders *et al.* (1982), Smith (1987) and Watkins (1993).

Granite outcrops:

- These are important as seasonal resources and temporary refuge for fauna of surrounding habitats.
- Four species of reptiles are restricted to granite outcrops.
- At least 1320, and possibly as many as 2000 plant species occur on Western Australian granite outcrops. The most diverse individual outcrops have up to 200 species, including many endemics (such as *Eucalyptus caesia* in Boyagin Nature Reserve).
- Yilliminning Rock has 36 recorded lichen species, including two restricted to this rock (*Paraparmelia sammyii, P. sargentii*).
- The mygalomorph genus *Teyl* shows extensive radiation in the southern half of WA (Harvey and Main undated), and is a Gondwanan relic of 'wet' habitats (Main 1996). These species occur in meadows on many granite outcrops (Main 2000) and are restricted to outcrops.
- The larvae chironomid fly *Archaeochlus* (Withers and Edward 1997) is restricted to granite outcrops.
- Recent surveys in the wheatbelt have identified at least 230 species of aquatic invertebrates from granite pools. These contribute significantly to endemism of aquatic fauna of the inland south-west and have particular conservation value for about 50 species restricted to them (Pinder *et al.* 2000).

Existing plans or systematic reviews of biodiversity and threats

There has been no comprehensive subregional or regional biodiversity planning process or systematic review of biodiversity or threats. Several publications have reviewed specific elements of biota at this scale, but not necessarily using IBRA boundaries:

- Beard's Vegetation Mapping at a scale of 1:250,000 – broad structural vegetation types covers all of the subregion (Beard 1979a, Beard 1979b, Beard 1979c, Beard 1979d, Beard 1980a, Beard 1980b, Beard 1980c).
- Conservation status of vegetation types throughout Western Australia. (Hopkins *et al.* 1996) – based on modified Beard vegetation mapping at 1:250,000.
- Birds of Southwestern Australia: An atlas of changes in distribution and abundance of the wheatbelt fauna (Saunders and Ingram 1995).
- SAP Biodiversity Survey of the Agricultural Zone (unpublished data; Frost *et al.* 2001) – a systematic, broadscale biogeographic survey of the biota (aquatic invertebrates, waterbirds, terrestrial vascular flora, ground-dwelling arachnids, scorpions, centipedes, small mammals, reptiles and frogs) occurring low in the landscape and under threat from salinity.
- Salinity Risk Mapping completed for the agricultural zone by the Land Monitor project showing both current and predicted extent (Frost *et al.* 2001).
- CALM's Wheatbelt Region is currently drafting a Regional Plan that includes a broad analysis of biodiversity values, threatening processes and management priorities (unpublished).

Several other surveys have reviewed elements of the biota and threatening processes at smaller scales within the subregion, or have reviewed the biota of a selection of reserves within the subregion (again not necessarily using IBRA boundaries). This list does not include the numerous surveys that have been completed for individual reserves or single species. Surveys and available information includes:

- Biological Survey of the Western Australian Wheatbelt Part 5 (Chapman *et al.* 1978), and Part 7 (Dell *et al.* 1979).
- Conservation values of small reserves in the wheatbelt of Western Australia (Safstrom 1995; Safstrom *et al.* 1996; Ecoscape 2000). This brief survey covers biological and human use values of numerous reserves using a standard methodology to assist with land use planning.
- Management of Granite Outcrops Symposium, Hyden, April 16-18, 1999 (Withers and Hopper 2000).
- Regional Assessment of the Wheatbelt of Western Australia: Central Wheatbelt (Wooller and Moore 2000) Part of AW2
- A review of grassy woodlands in the Western Australian Wheatbelt (Mattiske Consulting 1995) – literature review, survey of possible sites to document flora and a report detailing location and describing floristics.
- An overview of eucalypt woodlands in south-western Australia, including their composition, diversity, distribution, conservation status, and threats to their persistence (Yates *et al.* 2000).
- Production of habitat hollows by wheatbelt eucalypts (Rose 1993) – survey of tree diameter, age and hollow formation of wandoo and salmon gum from across the major east-west rainfall gradient.
- Some nature reserves of the Western Australian wheatbelt Part 1-28 (Muir 1978-1979) – brief surveys of various reserves providing a vegetation map and description, and list of fauna, human uses and other values.

- "Native Vegetation Handbook" series for various Shires in the Avon and Blackwood Basins (eg. Weaving 1995) – contain basic information on and lists of native vegetation, wetlands, fauna and flora, land resources and land management and land degradation issues.

Wetlands of national significance (DIWA listings)

Table 2: Name, category, condition, trend, reliability and threatening processes of DIWA listed wetlands.

Name and code	Description	Current condition	Trend in condition	Reliability	Threatening processes
Coyrecup Lake, WA001	Permanent saline/brackish lakes (B7), Seasonal saline marshes (B12)	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Salinity (ix), changed hydrology - salinisation from surface inflow and rising water table in addition to excessive inundation, are killing the remaining live trees in the lake (x), other - siltation (xiii), pollution - eutrophication from agricultural fertilisers (xi)
Dumbleyung Lake, WA002	Permanent saline/brackish lakes (B7)	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Pollution – eutrophication leading to algal blooms; increased siltation (xi), changed hydrology - increased salt loads due to drainage and groundwater pumping in catchment (ix), other - excessive human disturbance, e.g. water-skiing among moulting shelducks in spring-summer (xii)
Toolibin Lake, WA003	Freshwater swamp forest (B14)	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Salinity (ix), changed hydrology - salinisation has caused the loss of the eucalypt component of the overstorey; increased inundation due to drainage of agricultural land (by earthworks construction) in the catchment; remaining lake vegetation, predominantly *C. obesa* and *M. strobophylla*, is showing signs of salt stress; loss of fringing vegetation, particularly rushes, appears to have reduced the numbers of the secretive species Australasian bittern *Botaurus poiciloptilus* and purple swamphen *Porphyrio porphyrio*; numbers of freckled duck *Stictonetta naevosa* appear to be declining (x), pollution - eutrophication due to agricultural fertilisers (xi)
Ycalering Lakes System, WA004	Seasonal/interm ittent saline lakes (B8)	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Salinity (ix), changed hydrology - salinisation and excessive inundation (x), pollution - eutrophication (xi)

See Appendix B for description (key d) and threatening process (key e) and Appendix C for condition (rank 2), trend (rank 3) and reliability (rank 1).

Wetlands of subregional significance

Table 3: Name, location, category, special values, condition, trend, reliability and threatening processes affecting wetlands of subregional significance (in addition to DIWA listed wetlands in Table 2).

Name	Location	Description	Special values	Current condition	Trend in condition	Reliability	Threatening processes
Mortlock River System	477000E 6526000N Zone 50	Seasonal/intermi ttent saline lakes (B8). System appears to be less	Wetlands identified in state lists of	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Salinity (ix), changed hydrology (x)

Name	Location	Description	Special values	Current condition	Trend in condition	Reliability	Threatening processes
		driven by gypsophilous soils, hence a very different flora. Many rare and potentially rare flora species. Largely freehold land. Has lost some fresh components, but much of the edging woodlands of casuarina and York gum are still relatively intact.	important wetlands (i)				

See Appendix B for description (key d), special values (key c) and threatening process (key e) and Appendix C for condition (rank 2), trend (rank 3) and reliability (rank 1).

Riparian zone vegetation

All major watercourses within the AW2 subregion are categorised as "very poor – land cleared of virtually all natural vegetation." (Fig. 18, Wallis and Higham 1998).

Table 4: Name, condition, trend, reliability and threatening processes of riparian zone vegetation.

Name	Current condition	Trend in condition	Reliability	Threatening processes
All fringing vegetation of riparian zones	Degraded (i)	Rapidly declining (ii)	Quantitative and qualitative (iii)	Fragmentation (ii), grazing pressure (iv), exotic weeds (vi), salinity (ix), changed hydrology (x), broadscale clearing (i), feral animals (v), pollution (xi), firewood collection (iii)

See Appendix B for threatening process (key e) and Appendix C for condition (rank 2), trend (rank 3) and reliability (rank 1).

Threatened Ecological Communities

Table 5: Name, status, NVIS code, condition, trend, reliability and threatening processes of Threatened Ecological Communities (ie. those that have been approved by the Threatened Ecological Community Scientific Committee and signed off by the Western Australian Minister for Environment).

Community	WA status	NVIS	Current condition	Trend in condition	Reliability	Threatening processes
Perched wetlands of the Wheatbelt region with extensive stands of living swamp sheoak (*Casuarina obesa*) and paperbark (*Melaleuca strobophylla*) across the lake floor.	CR	Freshwater lakes (42)	Fair (ii)	Rapidly declining (ii)	Quantitative and qualitative (iii)	Feral animals (v), exotic weeds (vi), salinity (ix), changed hydrology (x), fragmentation (ii)
Heath dominated by one or more of *Regelia megacephala*, *Kunzea praestans* and *Allocasuarina campestris* on ridges and slopes of the chert hills of the Coomberdale floristic region.	E	Heath + banksia woodlands and shrublands (30)	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Broadscale clearing (i), grazing pressure (iv), exotic weeks (vi), changed fire regimes (vii), other - mining; recreation (xii), fragmentation (ii)

Community	WA status	NVIS	Current condition	Trend in condition	Reliability	Threatening processes
Herbaceous plant assemblages on bentonite lakes	E	Freshwater lakes (42)	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Grazing pressure (iv), feral animals (v), exotic weeds (vi), salinity (ix), changed hydrology (x), other - mining (xii)
Salt flats plant assemblages of the Mortlock River (East Branch)	E		Fair (ii)	Rapidly declining (ii)	Quantitative and qualitative (iii)	Broadscale clearing (i), grazing pressure (iv), feral animals (v), exotic weeds (vi), salinity (ix), changed hydrology (x)

See Appendix B for NVIS key f (NVIS Major Vegetation Sub-groups) and threatening processes (key e) and Appendix C for condition (rank 2), trend (rank 3) and reliability (rank 1). CR = Critically Endangered, E = Endangered.

Other ecosystems at risk*

Table 6: Name, status, NVIS code, condition, trend, reliability and threatening processes of other ecosystems at risk (that are not currently listed as TECs).

Ecosystem	WA status	NVIS	Current condition	Trend in condition	Reliability	Threatening process
Deep pools and natural braided sections of fresh to brackish rivers of the Avon Botanical District	Priority	N/A	Degraded (i)	Declining (iii)	Quantitative and qualitative (iii)	Grazing pressure (iv), exotic weeds (vi), salinity (ix), changed hydrology (x), other - siltation (xii), fragmentation (ii)
Wheatbelt Mottlecah (*Eucalyptus macrocarpa* subsp. *macrocarpa*) dominated heathland on deep white sands.	-	Mallee heath and shrublands (29)	Fair (ii)	Declining (iii)	Qualitative (ii)	Grazing pressure (iv), changed fire regimes (vii), fragmentation (ii)
Plant assemblages of the Wongan Hills System - mallee over *Petrophile shuttleworthiana/Allocasuarina campestris* thicket on shallow gravelly soils over ironstone on summit and slopes; shrub mallee on slopes of lateritic hills; mallee over *Allocasuarina campestris* thicket on the slopes of the laterite plateaus; mallee over melaleuca thicket on red brown loam over gravel on slopes below the plateau; mallee over *Melaleuca coronicarpa* heath on shallow red soil on scarp slopes; *A. campestris/ Calothamnus asper* thicket over red-brown clay/ ironstone/greenstone on scree slopes; and in lower areas: *Eucalyptus longicornis/E. salubris* woodland, *E. salmonophloia* and *E. loxophleba* woodlands;	Priority	Mallee heath and shrublands (29)	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), other - mining (xii), fragmentation (ii)

Ecosystem	WA status	NVIS	Current condition	Trend in condition	Reliability	Threatening process
Acacia acuminata low forest; *E. ebbanoensis* mallee over scrub; and open mallee of *E. drummondii.*						
Brown mallet communities exist in the western wheatbelt on brown or grey clays on low slopes and valleys. Near York and on the Arthur River, on grey clays, the understorey is dominated by *Melaleuca viminea* over sedges (*Gahnia trifida*) and bunch grasses. At Kojonup and near Tambellup, on brown clays, sparse shrubs and succulent shrubs (*Disphyma crassifolium*) dominate the understorey (G. Keighery, pers. comm.)	-	8	Fair (ii)	Declining (iii)	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), salinity (ix), changed hydrology (x), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii)
Red morrell woodland communities of the western wheatbelt. There appear to be at least three variants; the 'normal' on calcareous clays in the valleys, another on dune rises around saline lakes, and a rare variant on massive laterites (Dongolocking and Brookton) (G. Keighery, pers. comm.)	-	8	Fair (ii)	Declining (iii)	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), salinity (ix), changed hydrology (x), changed fire regimes (vii)
Banksia prionotes and *Xylomelum angustifolium* on low level sandplains	-		Near pristine (iv)	Static (iv)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), feral animals (v), exotic weeds (vi), changed fire regimes (vii), pathogens (viii)
Tamma-Dryandra-Eremaea shrubland on cream sands of the Ulva landform unit	-		Near pristine (iv)	Static (iv)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), feral animals (v), exotic weeds (vi), changed fire regimes (vii), pathogens (viii)

See Appendix B, for NVIS key f (NVIS Major Vegetation Sub-groups) and threatening processes (key e) and Appendix C for condition (rank 2), trend (rank 3) and reliability (rank 1).

*Specific communities are listed in the tables above, however vegetation types on dissection valley floors and lower slows are more than 90% cleared for agriculture and comprise about 1/3 of the total number of the vegetation types in the subregion. The remaining areas of valley floor woodlands are subject to secondary salinity. Therefore, a further 20 to 30 vegetation types in this subregion should be treated as "at risk".

Fauna species at risk

Table 7: Name, status, condition, trend, reliability and threatening processes of fauna species at risk.

Species	Status	Current condition	Trend in condition	Reliability	Threatening processes
Schedule 1; Rare/likely to become extinct, Division 1 (Mammals)					
Phascogale calura	E	Fair (ii)	Static (iv)	Quantitative and qualitative (iii)	Feral animals (v), broadscale clearing (i), fragmentation (ii)
Dasyurus geoffroii	V	Fair (ii)	Improving (v)	Quantitative and qualitative (iii)	Feral animals (v), broadscale clearing (i), fragmentation (ii)
Myrmecobius fasciatus	V	as above	Static (iv)	as above	as above
Petrogale lateralis lateralis	V	as above	Improving (v)	as above	as above
Schedule 1; Rare/likely to become extinct, Division 2 (Birds)					
Calyptorhynchus latirostris	E	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii), salinity (ix), changed hydrology (x), exotic weeds (vi)
Calyptorhynchus baudinii	V	as above	as above	as above	as above
Leipoa ocellata	V	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii), changed fire regimes (vii), exotic weeds (vi), grazing pressure (iv)
Schedule 1; Rare/likely to become extinct, Division 3 (Reptiles)					
Egernia stokesii badia	V	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), feral animals (v)
Schedule 4; Other specially protected fauna, Division 2 (Birds)					
Falco peregrinus	SP	Fair (ii)	Static (iv)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii)
Schedule 4; Other specially protected fauna, Division 3 (Reptiles)					
Aspidites ramsayi	P1	Degraded (i)	Declining rapidly (ii)	Quantitative and qualitative (iii)	Broadscale clearing (i), grazing pressure (iv), feral animals (v)
Morelia spilota imbricata	SP	Fair (ii)	Declining (iii)	as above	as above
Other Species at risk within the subregion					
Psophodes nigrogularis oberon	Near threatened	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii), changed fire regimes (vii)
Acanthiza iredalei iredalei		Fair (ii)	Static (iv)	Quantitative and qualitative (iii)	Grazing pressure (iv)
Platycercus icterotis xanthogenys	P2	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Broadscale clearing (i), grazing pressure (iv)
Lerista viduata	P1	Fair (ii)	Unknown (vi)	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), feral animals (v), changed fire regimes (vii)
Bothriembryon bradshawi	P1	Fair (ii)	Unknown (vi)	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii)
Parartemia contracta	P1	Fair (ii)	Unknown (vi)	Qualitative (ii)	Salinity (ix)
Daphnia jollyi	P1	Fair (ii)	Unknown (vi)	Qualitative (ii)	Salinity (ix), changed hydrology (x)
Limnocythere porphyretica	P1	Fair (ii)	Unknown (vi)	Qualitative (ii)	Unknown threatening processes

See Appendix C for condition (rank 2), trend (rank 3) and reliability (rank 1) and Appendix B for threatening processes (key e). Recent changes to the Wildlife Conservation (Specially Protected Fauna) 2003 are not included here, please refer to the Addendum at the end of this case study. E = Endangered, V = Vulnerable, SP = Special Protection, P1 = Priority 1, P2 = Priority 2.

Declared Rare and Priority Flora

Table 8: Name, status, condition, trend, reliability and threatening processes of flora species at risk.

Species	Status	Current condition	Trend in condition	Reliability	Threatening processes
Declared Rare Flora					
Acacia prismifolia	X	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Acacia aphylla	CR	as above	Rapidly declining (ii)	as above	as above
Acacia ataxiphylla subsp. *magna*	CR	as above	as above	as above	as above
Acacia insolita subsp. *recurva*	CR	as above	as above	as above	as above
Acacia pharangites	CR	as above	as above	as above	as above
Acacia subflexuosa subsp. *capillata*	CR	as above	as above	as above	as above
Acacia vassalii	CR	as above	as above	as above	as above
Adenanthos pungens subsp. *effusus*	CR	as above	as above	as above	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x), pathogens - *Phytopthora* sp. (viii)
Banksia cuneata	CR	as above	as above	as above	as above
Caladenia drakeoides	CR	as above	Declining (iii)	as above	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Conostylis scorsiflora subsp. *trichophylla*	CR	as above	Rapidly declining (ii)	as above	as above
Darwinia carnea	CR	as above	as above	as above	as above
Daviesia euphorbioides	CR	as above	as above	as above	as above
Eremophila pinnatifida	CR	as above	as above	as above	as above
Eremophila resinosa	CR	as above	as above	as above	as above
Eremophila scaberula	CR	as above	Declining (iii)	as above	as above
Eremophila veneta	CR	as above	Rapidly declining (ii)	as above	as above
Gastrolobium hamulosum	CR	as above	as above	as above	as above
Grevillea dryandroides subsp. *dryandroides*	CR	as above	as above	as above	as above
Grevillea pythara	CR	as above	as above	as above	as above
Grevillea scapigera	CR	as above	as above	as above	as above
Roycea pycnophylloides	CR	as above	as above	as above	as above
Synaphea quartzitica	CR	as above	Declining (iii)	as above	as above
Thomasia sp. Green Hill (S.Paust 1322)	CR	as above	as above	as above	as above
Verticordia fimbrilepis subsp. *fimbrilepis*	CR	as above	Rapidly declining (ii)	as above	as above
Verticordia staminosa subsp. *staminosa*	CR	as above	as above	as above	as above
Acacia aristulata	E	as above	Declining (iii)	as above	as above
Acacia brachypoda	E	as above	as above	as above	as above

Species	Status	Current condition	Trend in condition	Reliability	Threatening processes
Acacia lanuginophylla	E	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Acacia pygmaea	E	as above	as above	as above	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii)
Adenanthos pungens subsp. *pungens*	E	as above	as above	as above	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x), pathogens - *Phytopthora* sp. (viii)
Banksia oligantha	E	as above	as above	as above	as above
Boronia capitata subsp. *capitata*	E	as above	as above	as above	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Conostylis drummondii	E	as above	as above	as above	as above
Conostylis wonganensis	E	as above	as above	as above	as above
Daviesia dielsii	E	as above	as above	as above	as above
Eremophila ternifolia	E	as above	as above	as above	as above
Gastrolobium appressum	E	as above	as above	as above	as above
Gastrolobium glaucum	E	as above	as above	as above	as above
Grevillea christineae	E	as above	as above	as above	as above
Grevillea curviloba subsp. *incurva*	E	as above	as above	as above	as above
Grevillea dryandroides subsp. *hirsuta*	E	as above	as above	as above	as above
Grevillea involucrata	E	as above	as above	as above	as above
Hakea aculeata	E	as above	as above	as above	as above
Lasiopetalum rotundifolium	E	as above	as above	as above	as above
Lechenaultia pulvinaris	E	as above	as above	as above	as above
Melaleuca sciotostyla	E	as above	as above	as above	as above
Orthrosanthus muelleri	E	as above	as above	as above	as above
Philotheca wonganensis	E	as above	as above	as above	as above
Rhizanthella gardneri	E	as above	as above	as above	as above
Stylidium coroniforme	E	as above	as above	as above	as above
Acacia denticulosa	V	as above	as above	as above	as above
Acacia semicircinalis	V	as above	as above	as above	as above
Allocasuarina fibrosa	V	as above	as above	as above	as above
Asterolasia nivea	V	as above	as above	as above	as above
Calectasia pignattiana	V	as above	as above	as above	as above
Conostylis misera	V	as above	as above	as above	as above
Eucalyptus olivacea	V	as above	as above	as above	as above
Eucalyptus rhodantha var. *rhodantha*	V	as above	as above	as above	as above
Grevillea flexuosa	V	as above	as above	as above	as above
Microcorys eremophiloides	V	as above	as above	as above	as above
Pultenaea pauciflora	V	as above	as above	as above	as above
Rhagodia acicularis	V	as above	as above	as above	as above
Stylidium merrallii	V	as above	as above	as above	as above
Thomasia glabripetala	V	as above	as above	as above	as above
Verticordia carinata	V	as above	as above	as above	as above
Verticordia hughanii	V	as above	as above	as above	as above
Priority 1					
Acacia cochlocarpa subsp. *velutinosa*	P1	Fair (ii)	Unknown (vi)	Unknown	Unknown threatening processes
Acacia microneura	P1	Fair (ii)	Unknown (vi)	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)

Species	Status	Current condition	Trend in condition	Reliability	Threatening processes
Acacia sclerophylla var. *teretiuscula*	P1	Fair (ii)	Unknown (vi)	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Acacia trinalis	P1	as above	as above	as above	as above
Dampiera glabrescens	P1	as above	as above	Unknown	Unknown threatening processes
Dryandra lepidorhiza	P1	as above	as above	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Guichenotia seorsiflora	P1	as above	as above	as above	as above
Lysiosepalum abollatum	P1	as above	as above	as above	as above
Paraparmelia sammyii	P1	as above	as above	as above	as above
Paraparmelia sargentii	P1	as above	as above	as above	as above
Thomasia dielsii	P1	as above	as above	as above	as above
Thomasia sp. Arthur River (H.F.& M. Broadbent 1409)	P1	as above	as above	as above	as above
Thysanotus sabulosus	P1	as above	as above	as above	as above
Verticordia huegelii var. *tridens*	P1	as above	as above	as above	as above
Priority 2					
Acacia congesta subsp. *wonganensis*	P2	Fair (ii)	Unknown (vi)	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Acacia drewiana subsp. minor	P2	as above	as above	as above	as above
Acacia gemina	P2	as above	as above	as above	as above
Acacia sclerophylla var. *pilosa*	P2	as above	as above	as above	as above
Acacia tuberculata	P2	as above	as above	as above	as above
Andersonia carinata	P2	as above	as above	as above	as above
Boronia ericifolia	P2	as above	as above	as above	as above
Caladenia luteola	P2	as above	as above	as above	as above
Chordifex ornatus	P2	as above	as above	as above	as above
Conostylis seorsiflora subsp. *nyabing* (A. Coates s.n.)	P2	as above	as above	as above	as above
Dryandra acanthopoda	P2	as above	as above	as above	as above
Dryandra rufistylis	P2	as above	as above	as above	as above
Eucalyptus recta	P2	as above	as above	Unknown	Unknown threatening processes
Eucalyptus sparsicoma	P2	as above	as above	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Grevillea kennedyi	P2	as above	as above	Unknown	Unknown threatening processes
Lasiopetalum cardiophyllum	P2	as above	as above	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)
Leucopogon denticulatus	P2	as above	as above	as above	as above
Leucopogon florulentus	P2	as above	as above	as above	as above
Melaleuca ordinifolia	P2	as above	as above	as above	as above
Melaleuca pritzelii	P2	as above	as above	as above	as above
Persoonia hakeiformis	P2	as above	as above	as above	as above
Phyllangium palustre	P2	as above	as above	as above	as above
Pimelea neokyrea	P2	as above	as above	as above	as above
Synaphea platyphylla	P2	as above	as above	as above	as above
Thysanotus acerosifolius	P2	as above	as above	as above	as above
Verticordia wonganensis	P2	as above	as above	Unknown	Unknown threatening processes

Species	Status	Current condition	Trend in condition	Reliability	Threatening processes
Other Species at Risk					
Boronia rhomboidea		Fair (ii)	Declining (iii)	Qualitative (ii)	Broadscale clearing (i), fragmentation (ii), grazing pressure (iv), exotic weeds (vi), changed fire regimes (vii), salinity (ix), changed hydrology (x)

See Appendix C for condition (rank 2), trend (rank 3) and reliability (rank 1) and Appendix B for threatening processes (key e). Recent changes to the Declared Rare Flora List (2003) are not included here, please refer to the Addendum at the end of this case study. X = Extinct, CR = Critically Endangered, E = Endangered, V = Vulnerable, P1 = Priority 1, P2 = Priority 2.

Threatening processes

See Appendix B, key e for the full list of threatening processes.

Broadscale vegetation clearing:

- Broadscale clearing has ceased but its legacy is expressed through 'species relaxation' or 'extinction debt'. Across the AW2 subregion, where clearing averages 93%, this process is still continuing, and will do so for some time. Lack of habitat, and associated resources, is the single biggest threat to biodiversity conservation.
- Loss of nesting hollows for many bird species.

Increasing fragmentation, loss of remnants and lack of recruitment:

- The effects of habitat fragmentation have increased more rapidly as the cumulative effects of clearing reached the current levels.
- The major effects of fragmentation is to limit the ability of individuals to forage, disperse or recolonise amongst patches of remnant habitat. The consequences of this for species that exist as metapopulations in a landscape may be extinction at the patch, landscape and ultimately regional scale. The effects of habitat fragmentation are likely to occur across a wide range of plants and animals species.
- Remnant loss is now generally not as a result of direct clearing, but the incremental impacts of stock grazing, inappropriate fire regimes, weed invasion and altered hydrological regime (salinity and waterlogging).
- Lack of recruitment to a population is of significance for many threatened flora across the subregion. However many of these species could be considered 'disturbance opportunists', that when subject to an appropriate event such as fire or mechanical disturbance regenerate prolifically. Extant populations of many of these species are likely to exhibit a single age class (cohort), and recruitment between disturbance events is uncommon.
- For many other flora species recruitment is now absent through a combination of grazing pressure (stock, rabbits, kangaroos) and competition with weeds.
- Modification of the groundstorey vegetation has contributed significantly to the decline of many ground-feeding birds, either through the loss of woody debris (foraging substrate), weed invasion (displacement of native seed producing plants) or loss of the litter layer (foraging substrate).

Firewood collection:
Not recognised as a significant threat.

Grazing pressure:

- Domestic stock
- Rabbits
- Kangaroos – higher densities concentrated in small remnants.
- Australian ringneck parrots – have increased in numbers since clearing, and cause significant damage and mortality amongst *Xanthorrhoea* spp.

Feral animals:

- Fox predation – has a particularly pronounced impact on the Critical Weight Range (CWR) mammals, and is the most important factor limiting populations of these species at present. Where levels of fox predation are reduced through baiting, issues such as habitat area become the limiting factor to population growth and size.
- Other groups of species to suffer from fox predation include the ground nesting birds such as bush stone curlew and bustard (Saunders and Ingram 1995).
- The extent and level of cat predation is largely unknown. Cat populations are thought to be suppressed by foxes, but with the successful reduction in fox numbers in regularly baited reserves within the subregion, populations of cats may be increasing. Their impact on populations of reptiles, mammals and birds is largely unknown.
- Rabbit grazing is of localised concern for populations of some flora.

Exotic weeds:

- Weeds impact on flora and fauna in a number of ways. Weed invasion modifies habitat structure (such as for ground-feeding birds), smothers native species, out-competes them for nutrients, water and light, and prevents regeneration. Weed invasion also modifies fire regimes through altered fuel loads, structure and seasonality. Weeds of particular concern in the subregion are bridal

creeper (*Asparagus asparagoides*) and perennial veldt grass (*Ehrharta calycina*). A large number of threatened flora and some woodland communities are threatened by the combined effects of various annual grasses.

Changed fire regimes:

- In a highly cleared and fragmented landscape, the flora and fauna of small remnants are highly susceptible to localised extinction through the effects of a single fire. Such remnants are liable to be entirely burnt in a single event, with little chance of recolonisation. Weed invasion in these circumstances is likely to be significantly enhanced.
- Conversely the risk of fire on such remnants has declined significantly with clearing. This has important implications for species that require fire to regenerate, or for species that prefer various serial stages of vegetation following fire.

Pathogens:

- *Phytophthora* spp. – a wide range of plant species are susceptible to this pathogen, including several threatened species.
- *Armillaria* – known to cause localised deaths of *Eucalyptus wandoo.*
- Fungal stem cankers – known to be a contributing factor in widespread canopy decline in *E. wandoo* (Wills *et al.* 2000).

Changed hydrology (salinity):

- Broadscale vegetation clearing has altered hydrological regimes to such an extent that water tables are continuing to rise, bringing with them dissolved salts. Current predictions are that at least 30% of the wheatbelt will be affected by dryland salinity.
- Over 850 species of flora are found only in fresh or naturally saline lowlands directly threatened by rising groundwater and salinity.
- Naturally saline areas have major biodiversity values (at least 64 threatened or priority plant species and several new species discovered).
- More than 1,500 plant species occur low in the landscape; of these taxa 450 are endemic to the agricultural zone. These taxa are in danger of extinction because of rising saline groundwaters.
- Another 400 to 500 taxa are centred on the agricultural zone although not confined to it. These taxa are also under immediate threat of major genetic erosion, and are often the herbs that give richness to wetlands and woodlands.
- Areas affected by secondary salinisation show major declines in vascular plant biodiversity; rich complex communities are replaced by a few succulents and weeds. Most lowland communities, including tall woodlands, mallee and melaleuca shrublands, freshwater and naturally saline wetland systems, will be lost, and the wheatbelt will lose much of its local landscape character.
- Almost half of the aquatic invertebrates collected in the wheatbelt are restricted to freshwater, with about 40% of the fauna vulnerable to increasing salinity. Although many have ranges beyond the wheatbelt, their distribution and abundance will decline significantly.
- A significant decline in the biodiversity of terrestrial animals is apparent at secondarily saline quadrats, which have an average of 30% fewer species than equivalent, non-salinised quadrats (Keighery and Lyons 2001).

Changed hydrology (other than salinity):

- Refer to changed hydrology (salinity) in previous point as many of the impacts are observed are caused by a combination of both salinity and waterlogging, and the outcomes are generally the same.
- South-western Australia has a highly rich and endemic aquatic microinvertebrate fauna, and are under threat from the altered hydrological regime associated with secondary salinisation. Rising groundwaters increase the length of time playa lakes hold water each year. These endemic fauna are adapted to short periods of flooding, and so will be replaced by more widespread species as the lakes become wetter.

Pollution:

- Agricultural pesticides e.g. for plague locust control.
- Eutrophication of wetlands and remnant vegetation.

Other:

- Wide range of different threats, such as siltation, human recreational activities, mining, etc.

Known local extinctions and changes in status

Overview:

There have been few systematic studies on the status of individual species or taxonomic groups across many significant areas within the agricultural zone, including the AW2 subregion.

The work of Saunders and Ingram (1995) for birds is probably the most comprehensive for any taxonomic group. The forthcoming results of the Salinity Action Plan (SAP) Biodiversity Survey will provide much additional information for several other taxonomic groups. Safstrom *et al.* (2000) provides a good overview for major taxonomic groups for the Avon River Basin, which overlaps the northern and eastern portions of the AW2 subregion – the summaries here can probably be extended to the remainder of the subregion with some reliability.

Mammals:
A significant decline in the biodiversity of terrestrial animals is apparent at secondarily saline quadrats, which have an average of 30 per cent fewer species than equivalent, non-salinised quadrats. There have been major changes in the distribution and abundance of the Critical Weight Range (CWR) mammal fauna of the AW2 subregion. The species listed in Table 9 have become extinct within the subregion. However, several have been reintroduced to semi-captive fenced enclosures within Dryandra Woodland to breed and provide animals for translocations into suitable areas of habitat within their former range.

Table 9: Subregionally extinct CWR mammals in Avon Wheatbelt 2.

Species	Current Conservation Status (WA)	Status in AW2 Subregion
Mala (*Lagorchestes hirsutus*)	Threatened (Extinct in the wild)	Subregionally Extinct
Boodie (*Bettongia lesueur lesueur*)	Threatened (Vulnerable)	Subregionally Extinct
Banded hare-wallaby (*Lagostrophus fasciatus fasciatus*)	Threatened (Vulnerable)	Subregionally Extinct
Greater stick-nest rat (*Leporillus conditor*)	Threatened (Vulnerable)	Subregionally Extinct
Bilby (*Macrotis lagotis*)	Threatened (Vulnerable)	Subregionally Extinct
Western barred bandicoot (*Perameles bougainville bougainville*)	Threatened (Endangered)	Subregionally Extinct
Western ringtail possum (*Pseudocheirus occidentalis*)	Threatened (Vulnerable)	Subregionally Extinct

Flora:
- Little systematic data, due to the high level of endemicity and high rates of species turnover across the landscape, most regional extinctions have been species extinctions.
- Preliminary analysis of the SAP Biodiversity Survey of the Agricultural Zone (Keighery and Lyons 2001) indicate that areas affected by secondary salinisation show major declines in vascular plant biodiversity.
- Rich complex communities are being replaced by a few succulents and weeds.

Invertebrates:
- Virtually no data overall.
- Some data and calculations for the scorpion *Urodacus armatus* by Smith (1998) suggests that across the Avon Botanical District (roughly equivalent to the Avon Wheatbelt IBRA bioregion) prior to clearing there would have been a standing population of 1.2 billion individuals, with an annual influx of 2.6 billion individuals (a biomass of 690 tonnes and 210 tonnes respectively). Clearing reduced this to 103 million and 174 million annual recruits; a biomass of 59 tonnes and 14 tonnes respectively. This represents a reduction of 92 per cent. Also refer to Majer and Beeston (1996), and Safstrom *et al.* (2000), Appendix 7 "*A report on the invertebrate fauna in the Avon River Basin and the Biodiversity Integrity Index.*"
- Almost half of the aquatic invertebrates collected in the wheatbelt are restricted to freshwater, with about 40 per cent of the fauna vulnerable to increasing salinity (Keighery and Lyons 2001).
- A significant decline in the biodiversity of terrestrial animals is apparent at secondarily saline quadrats, which have an average of 30 per cent fewer species than equivalent, non-salinised quadrats.

Birds:
- The thick-billed grasswren (*Amytornis textilis textilis*) is regionally extinct.
- Declines in species because of habitat loss have best been documented among the birds (Saunders and Ingram 1995). Of the 195 species recorded (excluding vagrants), 95 (49 per cent) have declined in range and/or abundance.
- The majority of species declines in the wheatbelt are resident species that depend on native vegetation. See Saunders and Ingram (1995) for a detailed account of changes in abundance in the avifauna of the wheatbelt, and Barrett *et al* (2003) for an analysis of bird declines at the bioregional scale using Bird Atlas 1 and 2 data.

Frogs:
- There are no known subregional extinctions, but many species are declining because of clearing, draining, salinity, predation, disease etc. See Safstrom *et al.* (2000).
- A significant decline in the biodiversity of terrestrial animals is apparent at secondarily saline quadrats, which have an average of 30 per cent fewer species than equivalent, non-salinised quadrats (Keighery and Lyons 2001).

Herpetofauna:
- The Woma python (*Aspidites ramsayi*) may be subregionally extinct. See Safstrom *et al.* (2000) for discussion of other taxa.

Freshwater fish:
- See Morgan *et al.* (1998) and Safstrom *et al.* (2000).

Conservation through reserves

Reservation priorities of ecosystems

Table 10: Beard vegetation associations and ecosystems at risk, area held under different reserve tenures and priority for further reservation.

Beard Veg Assoc	Vegetation association description	% of total extent in IBRA subregion	Area in IBRA subregion (ha)	% in IUCN Reserve	% in Non-IUCN Reserve	Total % Area in CALM Estate	Priority
	Deep pools and natural braided sections of fresh to brackish rivers of the Avon Botanical District	100	17	0	0	0	H
	Heath community on chert hills of the Coomberdale Floristic Region - Heath dominated by one or more of *Regelia megacephala*, *Kunzea praestans* and *Allocasuarina campestris* on ridges and slopes of the chert hills of the Coomberdale floristic region.	100	630	45 (7%)	0	7	M
	Wheatbelt mottlecah (*Eucalyptus macrocarpa* subsp. *macrocarpa*) dominated heathland on deep white sands.	100	2	0	0	0	H
	Plant assemblages of the Wongan Hills System - mallee over *Petrophile shuttleworthiana/ Allocasuarina campestris* thicket on shallow gravelly soils over ironstone on summit and slopes; shrub mallee on slopes of lateritic hills; mallee over *Allocasuarina campestris* thicket on the slopes of the laterite plateaus; mallee over melaleuca thicket on red brown loam over gravel on slopes below the plateau; mallee over *Melaleuca coronicarpa* heath on shallow red soil on scarp slopes; *A. campestris/Calothamnus asper* thicket over red-brown clay/ironstone/greenstone on scree slopes; and in lower areas: *Eucalyptus longicornis/E. salubris* woodland, *E. salmonophloia* and *E. loxophleba* woodlands; *Acacia acuminata* low forest; *E. ebbanoensis* mallee over scrub; and open mallee of *E. drummondii*.	100	2410	759 (32%)	0	32	M
	Perched wetlands of the wheatbelt region with extensive stands of living swamp sheoak (*Casuarina obesa*) and paperbark (*Melaleuca strobophylla*) across the lake floor.	3	13	0	0	0	H
	Herbaceous plant assemblages on bentonite lakes	100	65.25	0	65.25 (100%)	0	H
	Salt flats plant assemblages of the Mortlock River (east branch)	100	6310.2	0	438.86 (6.9%)	0.05	H
	Banksia prionotes and *Xylomelum angustifolium* on low level sandplains	100	58.38	0	58.38 (100%)	0	H
	Tamma-dryandra-eremaea shrubland on cream sands of the Ulva landform unit	100	93	8.1	60.2 (64.7%)	19.46	H
49	Shrublands; mixed heath	0.2	55.8	0.0	0.0	0.0	L
392	Shrublands; *Melaleuca thyoides* thicket	0.2	3.3	0.0	0.0	0.0	M
551	Shrublands; *Allocasuarina campestris* thicket	0.8	807.7	0.0	0.0	0.0	M
631	Succulent steppe with woodland and thicket; York gum over *Melaleuca thyoides* and samphire	0.7	303.4	0.0	0.0	0.0	M
948	Medium woodland; York gum and river gum	100.0	138.8	0.0	0.0	0.0	H
950	Medium woodland; *Casuarina obesa*	98.8	222.2	0.0	0.0	0.0	H
954	Shrublands; thicket, Jam and *Allocasuarina huegeliana*	0.5	5.4	0.0	0.0	0.0	M

Beard Veg Assoc	Vegetation association description	% of total extent in IBRA subregion	Area in IBRA subregion (ha)	% in IUCN Reserve	% in Non-IUCN Reserve	Total % Area in CALM Estate	Priority
962	Medium woodland; mallet (*E. astringens*)	83.8	208.0	0.0	0.0	0.0	H
1022	Succulent steppe with woodland; *Casuarina obesa* and samphire	100.0	211.7	0.0	0.0	0.0	H
1025	Mosaic: Medium woodland; York gum, salmon gum and morrel/succulent steppe; saltbush and samphire	18.0	7.6	0.0	0.0	0.0	H
1040	Medium woodland; York gum and *Casuarina obesa*	0.7	5.0	0.0	0.0	0.0	M
1042	Succulent steppe with low woodland; sheoak over samphire	100.0	13.5	0.0	0.0	0.0	H
1044	Mosaic: Medium woodland; York gum and salmon gum/Shrublands; *Melaleuca thyoides* thicket	6.7	9.2	0.0	0.0	0.0	H
1046	Succulent steppe with woodland; York gum and samphire	100.0	65.0	0.0	0.0	0.0	H
1048	Mosaic: Shrublands; melaleuca patchy scrub/Succulent steppe; samphire	0.4	9.6	0.0	0.0	0.0	M
1077	Medium woodland; jarrah and river gum	50.0	718.8	0.0	0.0	0.0	M
1080	Succulent steppe with mallee and thickets; mallee and *Melaleuca uncinata* thickets on salt flats	45.9	42.3	0.0	0.0	0.0	H
1088	Medium woodland; mallet & blue mallet	82.8	158.8	0.0	0.0	0.0	H
1094	Mosaic: Medium woodland; York gum and salmon gum/shrublands; mallee scrub *Eucalyptus eremophila* and black marlock	5.1	251.6	0.0	0.0	0.0	L
1095	Medium woodland; York gum, yate and salmon gum	10.0	34.2	0.0	0.0	0.0	M
1149	Shrublands; scrub-heath *Acacia-Ecdeiocolia* association in the south-east Geraldton Sandplain Region	1.3	7.5	0.0	0.0	0.0	M

L = low, M = medium and H = high priority for reservation.

Subregional constraints

See Appendix B, key g for a full list of constraint categories.

Irreplacibility and limited opportunity to meet CAR criteria:
Most ecosystems have been extensively cleared well below CAR thresholds, generally to less than 10 per cent. Within the agricultural zone, virtually all remnants are important for biodiversity conservation and building towards CAR thresholds.

Other:
Many ecosystems low in the landscape are under threat from rising water tables. Most lowland communities, including tall woodlands, mallee and melaleuca shrublands, freshwater and naturally saline wetland systems will be lost. These systems support over 1,500 plant species, of which 450 are endemic to the agricultural zone and in danger of extinction due to rising saline groundwaters.

Economic constraints:
Insufficient resources to acquire and manage an increased conservation estate.

Competing land uses:
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 competition with other government agencies and local government for these areas. The process is also lengthy and ad hoc.

Other:
Inadequate systematic knowledge of biodiversity values at an appropriately fine scale.

Priority for reserve consolidation

Avon Wheatbelt bioregion:
The priority for reserve consolidation is Category 1, IBRA Reservation Class 1, indicating that between two per cent and 30 per cent of native vegetation cover remains in both subregions (see Appendix D). There is no change recommended for this class.

Avon Wheatbelt 2 subregion:
Category 1b (see Appendix C, rank 4) - Clearing has been extensive, and rising saline groundwater threatens up to 30 per cent of the landscape.

Reserve management standard

The Reserve Management Standard is poor (see Appendix C, rank 5). A significant threatening process (i.e. rising saline groundwater) is not managed (except in very localised circumstances) and is projected to cause major declines and extinctions in lowland communities, including tall woodlands, mallee and melaleuca shrublands, freshwater and naturally saline wetland systems. Some reserves are routinely fox baited (part of Dryandra Woodland and the Tutanning, Boyagin, Mt. Caroline, Mt. Stirling, Nangeen Hill, Dongolocking, Gundaring, East Yornanning, Weam, Pingeculling and Jaloran nature reserves). Approximately 9.7 per cent (17,600 ha) of the conservation estate is baited. Biodiversity values are poorly identified. The recent Salinity Action Plan Biodiversity Survey project represents the first systematic overview of the region's biota, and is due for publication in late 2004. However there is no systematic fine scale vegetation mapping (1:25,000 or better); the best available is Beard's at 1:250,000. Some reserves have had vegetation maps prepared, but there is little consistency between methodologies. Inappropriate fire regimes are also a major threat to biodiversity, but little is known of the response of individual species to fire. Fire histories for all reserves are also poorly known and documented.

Examples of appropriate management scenarios

Although there have been no reserve system planning approaches specifically for the AW2 subregion, there are a number of historical, existing or proposed reserve planning processes operating at similar scales within the south-west of Western Australia or interstate.

There are a number of current or completed projects under the auspices of the National Reserves System Cooperative Program, Environment Australia, that are relevant to the AW2 subregion. These projects have assessed the comprehensiveness, adequacy and representativeness (CAR) of the current reserve system using vegetation types mapped by Beard at a scale of 1:250,000, land tenure information, and the current extent of vegetation in the agricultural zones (Hopkins *et al.* 1996; Hopkins 2000; Morgan and Hopkins 1999). Analysis of this data for the Avon River Basin (Safstrom *et al.* 2000) shows that virtually all woody vegetation types overlapping the AW2 subregion have less than five per cent of their mapped extent within secure reserves, and generally have less than 10 per cent of their mapped pre-European extent remaining. A similar analysis for the South West Catchments NRM Region (Hopkins *et al.* 2000) shows similar patterns of vegetation units either poorly reserved or with limited extent across much of the upper Blackwood River catchment (which closely aligns with the southern portion of the AW2 subregion). One problem with these approaches in the wheatbelt is that two of the intersected themes (current extent of vegetation and Beard's vegetation associations) have been mapped at widely disparate scales (1:2,500 versus 1:250,000), and hence do not provide an adequate means of assessing CAR values, or translating gaps into reserve acquisition. Given the general extent of clearing across the wheatbelt (more than 90 per cent), existing CAR thresholds may be an inappropriate and unrealistic means of attempting to achieve biodiversity conservation goals. However it should be noted that at present there is no other systematic and complete vegetation or ecosystem mapping theme available at a more suitable scale.

Several of the processes described below do incorporate CAR thresholds into their criteria. Many of the current approaches below are also complimentary, and could exist as a nested hierarchy within a common planning framework to provide a more realistic set of biodiversity conservation goals and outcomes.

National Parks and Nature Reserves in Western Australia (Australian Academy of Science. Committee on National Parks. Western Australian Sub-Committee 1962):
An expert panel set up under the auspices of the Australian Academy of Science to review the existing reserve system, and to describe the areas of land that would form a representative national park and nature reserve system for Western Australia. Areas were selected to represent all major communities of natural wildlife and scenery types in Western Australia and included both reserved and unallocated Crown land. Reserves were also of a minimum size "to preserve biological communities for all time" in light of issues such as isolation, area/perimeter ratio, weeds and fire. Within the AW2 subregion, reserves at Dryandra, West Pingelly-Boyagin Rock (Boyagin Nature Reserve) and East Pingelly (Tutanning Nature Reserve) were proposed

Conservation Reserves for Western Australia (Conservation Through Reserves Committee 1975 and 1976):
The Conservation Through Reserves Committee was commissioned by the Environmental Protection Authority in 1972 to review and update recommendations of the Australian Academy of Science Committee on National Parks (Western Australian Sub-Committee 1962). The AW2 IBRA Subregion lies within System 4. Recommendations and endorsements were made for Wongan Hills, Dryandra Forest, Boyagin Wildlife Sanctuary, Tutanning Wildlife Sanctuary and several other smaller reserves and wetlands.

Conservation values of small reserves (Safstrom *et al.* 1995a, Safstrom *et al.* 1995b):
This study was commissioned by the CALM's Wheatbelt Region to investigate criteria for selecting reserves for nature conservation values. It reviewed the range of attributes that could be used to identify nature conservation values, and also investigated current methods for ranking reserves based on their nature conservation values. The project identified the most appropriate reserve attributes to use in determining nature conservation values, and concluded that current methods of ranking were generally not useful for a subset of the reserves or where there were multiple criteria to be considered. The Region currently uses this approach to assess nature conservation values and recommend additions to the reserve system. However it is not a strategic approach in the way it is currently applied.

Bush and Biodiversity (Hopkins *et al.* 2000):
This study was commissioned by the South West Catchments Council to assess the biodiversity values of the South West Catchments Natural Resource Management (NRM) Region as a precursor to the preparation of an NRM strategy. The datasets collated included threatened flora, fauna and ecological communities, and a CAR analysis of vegetation associations based on Hopkins *et al.* (1996). The strategy has not yet been completed but the CAR analysis suggests that this will form an important basis for goal and priority setting.

Avon River Basin (Safstrom *et al.* 2000):
This report is similar in scope to Hopkins *et al.* (2000), although it contains more detailed and descriptive information about biodiversity values and trends across the Avon River Basin. It also is intended as a precursor to an NRM strategy which is currently (December 2003) being written. Similarly there is a CAR analysis of vegetation associations based on Hopkins *et al.* (1996), which suggests that a CAR analysis will be an important component of goal and priority setting.

Dongolocking Pilot Planning Project for Remnant Vegetation (Wallace 1998):
This was project developed in response to a call from Environment Australia for expressions of interest in developing pilot projects for planning remnant vegetation management. The project was a collaborative effort between CALM, CSIRO and the Department of Agriculture. The project's goal was to maintain viable populations of all extant populations within a particular landscape. The Dongolocking area was chosen for many reasons, including:

- the diversity and amount of vegetation remaining (5,300ha in a 29,000ha landscape, or 18 per cent) both in reserves and private remnants;
- the diversity of fauna persisting, many of which have disappeared from other parts of the wheatbelt; and
- the relatively low threat from salinity.

The concept of conserving viable populations of all biota within specific landscapes developed here compliments the more traditional species and vegetation community based approaches to biodiversity conservation.

Managing Natural Biodiversity in the Western Australian Wheatbelt: A Conceptual Framework (Wallace *et al.* 2003):
This document has further developed and refined the planning concepts developed at Dongolocking (Wallace 1998) and incorporated them into an environmental management system for nature conservation in any fragmented landscape. This document underpins the nature conservation program in CALM's Wheatbelt Region based on:

a. A framework that identifies key components of the wheatbelt environment, including the cycles that drive component interactions. A description of this may be found in Wallace (1998).
b. An understanding of the broad goal options available.
c. Project and program specific goals based on (b) and refined for specific situations including the scale of management.
d. A description of threats to goal achievement, and their relative impacts.
e. Methods for identifying priority management strategies, and priority populations, reserves and landscapes for action.
f. Performance indicators (monitoring) that effectively link goals, on-ground outputs and outcomes.

Refer to Table 11 for demonstration of how the Wheatbelt Region is divided into discrete management units based on a combination of nature conservation goals and values, threats and management scales.

The identification of most of the management units in Table 11 is relatively straightforward. However the identification of large managed landscapes where significant areas of natural or semi-natural habitat exist and which operate as non-fragmented units has required some additional work. Using components of the GIS software package *Patch Analyst 2.0* (Rempel *et al.* 1999) together with *ArcView 3.1*, regions of the landscape, or 'polygons' larger than 10,000ha and containing various proportions of remnant vegetation (10, 15, 20, 25 and 30 per cent) were identified across the Wheatbelt Region. Map 2 (in the fold out section at the back of this document) shows landscapes of more than 10, 000 ha with more than 25 per cent remnant vegetation cover in Avon Wheatbelt 2. Refer to Beecham (2003) for a more complete description of this process. This data, together with other biophysical and social process information will now be combined and evaluated by staff to identify the priority landscape 'polygons' for more detailed planning and management actions. Of interest is that very few landscapes that are larger than 10,000ha and that contain more than 30 per cent remnant vegetation exist within the wheatbelt. This issue should be considered in relation to the work

by James and Saunders (2001) for the Murray-Darling Basin. It also suggests that current CAR thresholds will be largely unattainable uniformly across a subregion.

CALM Biodiversity Survey of the Agricultural Zone and Recovery Catchments (Keighery and Lyons 2001; Keighery *et al.* 2001):
This four year project commenced in 1997 with the aim of surveying the agricultural zone to document the biodiversity values of primary and secondary salinised areas, and equivalent non-salinised areas. This information is now being used to identify a series of natural diversity recovery catchments based on the biodiversity values identified during the survey, and other biophysical and social processes. These recovery catchments are generally low in the landscape and under threat from salinity. This is in contrast to some of the landscapes likely to be identified by the 'target' landscape process where the threat from salinity may be much lower. Both approaches are complementary. Initial results from the biodiversity survey on the effects of salinity on small terrestrial animals (McKenzie *et al.* 2003), and on the biodiversity of rivers and wetlands (Halse *et al.* 2003) suggest significant changes are occurring.

Budget

The AW2 subregion has an area of approximately 3 million ha, and approximately 300,000ha of remnant vegetation which includes approximately 120,000ha is in various Crown reserves. Assuming that 100,000ha of remnant vegetation outside the reserve system could be purchased for conservation purposes at $800/ha, the total budget required would be in the order of $80 million. This wouldn't include ongoing management costs, and any revegetation required in key areas.

For the landscape 'polygon' approach to be applied across the seven priority landscapes (see Map 2 at the back of this document), combined with slowing the rate of decline across the remainder of the landscape and managing populations of threatened species, the budget (including land purchases, and the purchase of land for revegetation at $800/ha on average; with a revegetation cost of at least $2,000/ha) over a 10 year timeframe would be:

- seven landscape polygons at $3.5 million per year, and
- other areas and threatened species at $0.5 million per year.

These estimates are based on the current costs of managing landscape units and other areas. It would take five years to build to these levels of expenditure, and a further five years of implementation would be required before undertaking a major review. Given the long time scales for assessing the impacts of many conservation programs, for example, in relation to salinity and fire, it could be expected that this level of funding would need to be allocated over several decades to achieve significant cross-generational benefits.

Table 11: The Wheatbelt Region is divided into discrete management units based on a combination of nature conservation goals and values, threats and management scales.

Landscape salinity risk	Management landscape type	Specific nature conservation goal
Management area lies within landscape units at very low risk from salinity.	Large (>5,000ha) nature reserve and adjoining lands.	To conserve all existing taxa of native species in natural or near natural ecosystems. (Minimum timescale of 50 years and 60 % probability of success.)
	Large (>30,000ha) managed landscape of which a minimum of 20% or 6,000ha of natural or semi-natural habitat exists and operates as a non-fragmented unit. Management of threatened communities often occurs within this category.	To conserve all existing taxa of native species (or threatened community) in natural or near natural ecosystems. (Minimum timescale of 50 years and 60% probability of success.)
	Small, managed landscape incorporating a threatened species.	To conserve the threatened species, or if this is not practicable, to manage the genetic material of the species to maintain it in perpetuity.
	All other areas.	To prevent or minimise the introduction of new threats and to slow the rate of decline.
Management area lies within a landscape, or includes landscape units, highly threatened by salinity.	Catchment that includes significant threatened community(ies) or species that it is feasible to manage so as to protect from the worst effects of salinity.	To conserve the threatened community(ies) or species. (Minimum timescale of 50 years and 70% probability of success.)
	All other areas.	To prevent or minimise the introduction of new threats and to slow the rate of decline; and/or Identify unique taxonomic elements that will be lost and conserve representative sample of genotypes.

Off reserve conservation

Priority species or groups

Mammals:

Table 12: Priority CWR mammals species for off reserve conservation in Avon Wheatbelt 2.

Species	Current conservation status (WA)	Status in AW2 subregion	Recovery Plan (refer to Table 17, page 25 for more information)
Boodie (*Bettongia lesueur lesueur*)	Threatened (Vulnerable)	Subregionally Extinct	No
Woylie (*Bettongia penicillata ogilbyi*)	Priority 4, Conservation Dependent	Conservation Dependent	No
Chuditch (*Dasyurus geoffroii*)	Threatened (Vulnerable)	Threatened (Endangered)	State
Quenda (*Isoodon obesulus fusciventer*)	Priority 4, Conservation Dependent	Conservation Dependent	No
Mala (*Lagorchestes hirsutus*)	Threatened (Extinct in the wild)	Subregionally Extinct	National (unpublished)
Banded hare-wallaby (*Lagostrophus fasciatus fasciatus*)	Threatened (Vulnerable)	Subregionally Extinct	No
Greater stick-nest rat (*Leporillus conditor*)	Threatened (Vulnerable)	Subregionally Extinct	No
Tammar wallaby (*Macropus eugenii derbianus*)	Priority 4, Conservation Dependent	Conservation Dependent	No
Western brush wallaby (*Macropus irma*)	Priority 4, Conservation Dependent	Conservation Dependent	No
Bilby (*Macrotis lagotis*)	Threatened (Vulnerable)	Subregionally Extinct	National
Numbat (*Myrmecobius fasciatus*)	Threatened (Vulnerable)	Threatened (Vulnerable)	National (unpublished)
Western barred bandicoot (*Perameles bougainville bougainville*)	Threatened (Endangered)	Subregionally Extinct	National (unpublished)
Black-flanked rock-wallaby (*Petrogale lateralis lateralis*)	Threatened (Vulnerable)	Threatened (Vulnerable)	No
Red-tailed phascogale (*Phascogale calura*)	Threatened (Endangered)	Threatened (Endangered)	No
Western ringtail possum (*Pseudocheirus occidentalis*)	Threatened (Vulnerable)	Subregionally Extinct	No
Common brushtail possum (*Trichosurus vulpecula*)	No listing	Conservation Dependent	No

Birds:

Table 13: Priority bird species for off reserve conservation. These are listed in the Western Wheatbelt Coordinated Conservation Plan for 14 bird species (Garnett and Crowley 2000). However only 11 species occur in the AW2 subregion and one is subregionally extinct.

Species	Current Conservation Status (WA)	Status in AW2 Subregion	Recovery Plan (refer to Table 17, page 25 for more information)
Thick-billed grasswren (western) (*Amytornis textilis textilis*)	Near Threatened	Locally Extinct	State
Australian bustard (*Ardeotis australis*)	Near Threatened	Threatened (Vulnerable)	No
Bush stone-curlew (*Burhinis grallarius*)	Near Threatened	Threatened (Vulnerable)	No
Rufous fieldwren (western wheatbelt) (*Calamanthus campestris montanellus*)	Near Threatened	Threatened (Vulnerable)	No
Carnaby's cockatoo (*Calyptorhynchus latirostris*)	Threatened (Endangered)	Threatened (Endangered)	State
Crested shrike-tit (western) (*Falcunculus frontatus leucogaster*)	Near Threatened	Threatened (Vulnerable)	No

Species	Current Conservation Status (WA)	Status in AW2 Subregion	Recovery Plan (refer to Table 17, page 25 for more information)
Shy heathwren (western) (*Hylacola cauta whitlocki*)	Near Threatened	Threatened (Vulnerable)	No
Malleefowl (*Leipoa ocellata*)	Threatened (Vulnerable)	Threatened (Endangered)	National
Barking owl (southern) (*Ninox connivens connivens*)	Near Threatened	Threatened (Vulnerable)	No
Western rosella (wheatbelt) (*Platycercus icterotis xanthogenys*)	Near Threatened	Near Threatened	No
White-browed babbler (western wheatbelt) (*Pomatostomus superciliosus ashbyi*)	Near Threatened	Threatened (Vulnerable)	No
Hooded plover (western) (*Thinornis rubricollis tregellasi*)	Near Threatened	Near Threatened	No

Flora and fauna of granite outcrops:
For example, Eucalyptus rhodantha var. rhodantha, and Verticordia staminosa subsp. staminosa.

General flora:
District Threatened Flora Recovery Teams (TFRTs) – Katanning, Narrogin, Merredin and Moora District, and the Swan Region cover the following species with IRPs:

- *Acacia pharangites*,
- *Acacia pygmaea*,
- *Adenanthos pungens* subsp. *effusus*,
- *Darwinia carnea*,
- *Daviesia euphorbioides*,
- *Drakonorchis drakeoides*,
- *Eremophila scaberula*,
- *Eremophila veneta*,
- *Grevillea curviloba* subsp. *incurva*,
- *Grevillea dryandroides* subsp. *dryandroides*,
- Grevillea scapigera,
- *Orthrosanthus muelleri*,
- *Sphenotoma drummondii*,
- *Synaphea quartzitica*,
- *Thomasia* sp. Green Hill (S.Paust 1322),
- *Verticordia staminosa* subsp. *staminosa*.

Table 14: Threatened flora species in the Wongan-Ballidu Threatened Flora Management Program for off reserve conservation. This management plan covers the following 28 flora taxa:

Species	Status WA[1]	Status EPBC[2]
Acacia botrydion	P4	-
Acacia cochlocarpa subsp. *velutinosa*	P1	-
Acacia congesta subsp. *wonganensis*	P2	-
Acacia pharangites	CR	CR
Acacia pygmaea	E	E
Acacia semicircinalis	V	V
Calothamnus accedens	X	X
Conostylis wonganensis	E	E
Dampiera glabrescens	P1	-
Daviesia spiralis	P4	-
Dryandra comosa	P4	-
Dryandra pulchella	P4	-
Dryandra wonganensis	P4	-
Eremophila ternifolia	V	E
Eucalyptus recta	P2	-
Gastrolobium glaucum	CR	E
Grevillea dryandroides subsp. *dryandroides*	CR	CR
Grevillea kenneallyi	P1	-
Hemigenia conferta	P4	-
Loxocarya albipes	P4	-
Lysiosepalum abollatum	P1	-
Melaleuca sciotostyla	E	E
Microcorys eremophiloides	V	V
Philotheca wonganensis	E	E
Rhagodia acicularis	V	V
Stylidium coroniforme	E	E
Verticordia staminosa subsp. *staminosa*	CR	CR
Verticordia wonganensis	P2	-

[1]Status under Western Australian legislation *Wildlife Conservation Act 1950*
[2]Status under Commonwealth legislation Environmental Protection and Biodiversity Conservation Act 1999
X = Extinct, CR = Critically Endangered, E = Endangered, V = Vulnerable, P1 = Priority 1, P2 = Priority 2, P4 = Priority 4.

Threatened flora of roadsides:
This includes *Banksia cuneata* and *Hakea aculeata*.

Threatened flora of lowland communities:
This includes tall woodlands, mallee and melaleuca shrublands, freshwater and naturally saline wetland systems, for example *Drakonorchis drakeoides.*

Table 15: Threatened flora of lowland communities for off reserve conservation.

Species	Status WA[1]	Status EPBC[2]
Acacia aphylla	CR	V
Acacia aristulata	-	E
Acacia ataxiphylla subsp. *magna*	CR	E
Acacia brachypoda	E	E
Acacia denticulosa	V	V
Acacia insolita subsp. *recurva*	CR	E
Acacia lanuginophylla	E	E
Acacia pharangites	CR	E
Acacia prismifolia	-	NO STAT
Acacia pygmaea	E	E
Acacia semicircinalis	V	V
Acacia subflexuosa subsp. *capillata*	CR	E
Acacia vassalii	CR	E
Adenanthos pungens subsp. *effusus*	CR	E
Adenanthos pungens subsp. *pungens*	E	V
Allocasuarina fibrosa	V	V
Asterolasia nivea	-	V
Banksia cuneata	CR	E
Banksia oligantha	-	E
Boronia capitata subsp. *capitata*	E	E
Boronia rhomboidea	-	NO STAT
Calectasia arnoldii	-	V
Chordifex chaunocoleus	-	V
Conostylis drummondii	E	E
Conostylis misera		E
Conostylis seorsiflora subsp. *trichophylla*	CR	E
Conostylis wonganensis	E	E
Darwinia carnea	CR	E
Darwinia macrostegia	-	V
Darwinia meeboldii	-	V
Darwinia oxylepis	-	E
Daviesia dielsii	-	V
Daviesia euphorbioides	CR	E
Daviesia spiralis	-	V
Drakonorchis drakeoides	-	E
Eremophila pinnatifida	CR	E
Eremophila resinosa	CR	E
Eremophila scaberula	-	E
Eremophila ternifolia	E	E
Eremophila veneta	CR	E
Eucalyptus olivacea	V	V
Eucalyptus rhodantha var. *petiolaris*	-	E
Eucalyptus rhodantha var. *rhodantha*	-	V
Gastrolobium appressum	-	V
Gastrolobium glaucum	E	E
Gastrolobium hamulosum	CR	E
Grevillea christineae	E	E
Grevillea curviloba subsp. *incurva*	-	E
Grevillea dryandroides subsp. *dryandroides*	CR	E
Grevillea dryandroides subsp. *hirsuta*	E	E
Grevillea flexuosa	-	V
Grevillea involucrata	E	E
Grevillea pythara	CR	E
Grevillea scapigera	CR	E
Hakea aculeata	E	V
Hemigenia viscida	-	V
Lasiopetalum rotundifolium	E	E
Lechenaultia pulvinaris	E	E
Melaleuca sciotostyla	E	E
Microcorys eremophiloides	V	V
Orthrosanthus muelleri	-	E
Philotheca wonganensis	E	E
Pultenaea pauciflora	V	V
Rhagodia acicularis	V	V
Rhizanthella gardneri	E	E
Roycea pycnophylloides	CR	E
Sphenotoma drummondii	-	E
Stylidium coroniforme	E	E
Stylidium merrallii	V	V
Synaphea quartzitica	-	E
Thomasia glabripetala	-	V
Thomasia sp. Green Hill (S.Paust 1322)	-	E
Verticordia carinata	-	V
Verticordia fimbrilepis subsp. *fimbrilepis*	CR	E
Verticordia hughanii	V	E
Verticordia staminosa subsp. *staminosa*	CR	E

[1]Status under Western Australian legislation *Wildlife Conservation Act 1950*
[2]Status under Commonwealth legislation Environmental Protection and Biodiversity Conservation Act 1999
CR = Critically Endangered, E = Endangered, V = Vulnerable.

Priority 1 and 2 flora:

Table 16: Priority 1 and 2 flora for off reserve conservation.

Species	Priority[1]
Acacia cochlocarpa subsp. *velutinosa*	P1
Acacia congesta subsp. *wonganensis*	P2
Acacia drewiana subsp. *minor*	P2
Acacia gemina	P2
Acacia microneura	P1
Acacia sclerophylla var. *pilosa*	P2
Acacia sclerophylla var. *teretiuscula*	P1
Acacia trinalis	P1
Acacia tuberculata	P2
Andersonia carinata	P2
Boronia cricifolia	P2
Caladenia lutcola	P2
Chordifex ornatus	P2
Chordifex ornatus	P2
Conostylis scorsiflora subsp. *nyabing* (A. Coates s.n.)	P2
Dampiera glabrescens	P1
Dryandra acanthopoda	P2
Dryandra lepidorhiza	P1
Dryandra rufistylis	P2
Eucalyptus recta	P2
Eucalyptus sparsicoma	P2
Grevillea kennedyi	P2
Guichenotia scorsiflora	P1
Lasiopetalum cardiophyllum	P2
Leucopogon denticulatus	P2
Leucopogon florulentus	P2
Lysiosepalum abollatum	P1
Melaleuca ordinifolia	P2
Melaleuca pritzelii	P2
Paraparmelia sammyii	P1
Paraparmelia sargentii	P1
Persoonia hakeiformis	P2
Phyllangium palustre	P2
Pimelea neokyrea	P2
Synaphea platyphylla	P2
Thomasia dielsii	P1
Thomasia sp. Arthur River (H.F.& M. Broadbent 1409)	P1
Thysanotus acerosifolius	P2
Thysanotus sabulosus	P1
Verticordia huegelii var. *tridens*	P1
Verticordia wonganensis	P2

[1]Status under Western Australian legislation *Wildlife Conservation Act 1950*
P1 = Priority 1, P2 = Priority 2.

Species recovery planning

Table 17: Recovery planning for species at risk, including relevant plans, major constraints, delivery framework/community capacity, targets/thresholds, costs and short or long term priorities.

Species/Group	Recovery plans	Action plans	Other management plans	Major constraints	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
Mammals								
Western barred bandicoot (*Perameles bougainville bougainville*)	Yes – National unpublished IRP (Short 1995)	Action Plan for Australian Marsupials and Monotremes - Recovery Outline (Maxwell *et al.* 1996)	Western Shield Fauna Recovery Program (Department of Conservation and Land Management 1999a)	Locally extinct, lack of suitably large habitat areas, predator control	Western Shield /Low	Reintroduce to subregion	10	1 – 5 years
Chuditch (*Dasyurus geoffroii*)	Yes – State (Orell and Morris 1994)	as above	as above	Lack of survey data, lack of suitably large habitat areas, predator control	as above	Maintain populations through ongoing fox control. Some translocations to extend range.	15	1 – 5 years
Numbat (*Myrmecobius fasciatus*)	Yes – National unpublished (Friend 1994)	as above	as above	Lack of suitably large habitat areas, predator control	as above	as above	10	1 – 5 years
Bilby (*Macrotis lagotis*)	Yes – National (Bellchambers and Johnson 1991)	as above	as above	Locally extinct, lack of suitably large habitat areas, predator control	as above	Reintroduce to subregion	10	1 – 5 years
Boodie (*Bettongia lesueur lesueur*)	No	as above	as above	as above	as above	Reintroduce to subregion	10	1 – 20 years
Banded Hare-wallaby (*Lagostrophus fasciatus fasciatus*)	No	as above	as above	as above	as above	Reintroduce to subregion	10	1 – 20 years
Greater stick-nest rat (*Leporillus conditor*)	No – old draft National RP but not used in WA	No	as above	as above	as above	-	-	
Woylie (*Bettongia penicillata ogilbyi*)	Yes – RP (now out of date) (Start *et al.* 1995)	Action Plan for Australian Marsupials and Monotremes - Taxon Summary (Maxwell *et al.* 1996)	as above	Lack of suitably large habitat areas, predator control	as above	Maintain populations through ongoing fox control. Some translocations to extend range.	7	1 – 5 years

Species/Group	Recovery plans	Action plans	Other management plans	Major constraints	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
Tammar wallaby (*Macropus eugenii derbianus*)	No (old draft) (Hall 1991)	Action Plan for Australian Marsupials and Monotremes - Taxon Summary (Maxwell *et al.* 1996)	Western Shield Fauna Recovery Program (Department of Conservation and Land Management 1999a)	Lack of survey data, lack of suitably large habitat areas, predator control	Western Shield/Low	Maintain populations through ongoing fox control. Some translocations to extend range.	7	1 – 5 years
Quenda (*Isoodon obesulus fusciventer*)	No	as above	as above	Lack of suitably large habitat areas, predator control	as above	as above	7	
Mala (*Lagorchestes hirsutus*)	Yes – National (unpublished) (Lundie-Jenkins and Moore 1996)	Action Plan for Australian Marsupials and Monotremes - Recovery Outline (Maxwell *et al.* 1996)	as above	Locally extinct, lack of suitably large habitat areas, predator control	as above	Reintroduce to subregion	10	1 – 20 years
Red-tailed phascogale (*Phascogale calura*)	No	as above	as above	Lack of suitably large habitat areas, predator control	as above	Maintain populations through ongoing fox control. Some translocations to extend range.	7	1 – 5 years
Common brushtail possum (*Trichosurus vulpecula*)	No	Action Plan for Australian Marsupials and Monotremes - Taxon Summary (Maxwell *et al.* 1996)	as above	as above	as above	Maintain populations through ongoing fox control.	5	1 – 5 years
Birds								
Thick-billed grasswren (western) (*Amytornis textilis textilis*)	Yes – Interim Recovery Plan (Cale 2000a)	Action Plan for Australian Birds - Coordinated Conservation Plan & Taxon Summary (Garnett and Crowley 2000)	No	Locally extinct	-	Reintroduction to former range in long term	-	1 – 20 years
Carnaby's cockatoo (*Calyptorhynchus latirostris*)	Yes – State (Cale 2000b)	Action Plan for Australian Birds - Coordinated Conservation Plan & Recovery Outline (Garnett and Crowley 2000)	No	Lack of survey data on breeding and habitat areas	Recovery Team/High	Retain breeding populations and reverse decline in remaining breeding areas	100	1 – 5 years

Species/Group	Recovery plans	Action plans	Other management plans	Major constraints	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
Western rosella (wheatbelt) (*Platycercus icterotis*)	No	Action Plan for Australian Birds – Taxon Summary (Garnett and Crowley 2000)	No	Lack of knowledge on habitat requirements	Coordinated Conservation Plan/High	Reverse decline in range and abundance.	10	1 – 20 years
Barking owl (southern) (*Ninox connivens*)	No	Action Plan for Australian Birds - Coordinated Conservation Plan & Taxon Summary (Garnett and Crowley 2000)	as above	Lack of survey data	as above	Identify range and abundance. Reverse decline in range and abundance.	10	1 – 20 years
Malleefowl (*Leipoa ocellata*)	Yes - National (Benshemesh 2000)	Coordinated Conservation Plan and Action Plan (Garnett and Crowley 2000)	as above	Lack of survey data, lack of resources to manage fire regimes	National Recovery Team, Malleefowl Preservation Society/High	Secure existing populations across the species' range. Achieve downlisting from Vulnerable to Lower risk within 20 years based on IUCN criteria	5	1 – 20 years
Western Wheatbelt birds	Some (Cale and Burbidge 1993)	Action Plan for Australian Birds - Coordinated Conservation Plans and individual Action Plans (Garnett and Crowley 2000)	as above	Lack of survey data, lack of knowledge on causes of declines	Coordinated conservation at regional level with CALM as the lead agency, but involving, CSIRO Sustainable Ecosystems, Birds Australia, Threatened Species Network, ATCV, Green Corps, Greening WA	Reverse decline in range and abundance of all species	100	1 – 20 years
Reptiles								
Western spinytailed skink (*Egernia stokesii badia*)	No	Action Plan for Australian Reptiles - Recovery Outline (Cogger *et al.* 1993)	No	-	CALM, WA Museum/Med	Determine current conservation status. Secure viable populations within the conservation estate. Implement land management practices which maintain viable	3	1 – 20 years

Species/Group	Recovery plans	Action plans	Other management plans	Major constraints	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
						populations outside the reserve system		
Aspidites ramsayi (South West population)	No	Action Plan for Australian Reptiles - Recovery Outline (Cogger *et al.* 1993)	No	Possibly locally extinct, lack of survey data	CALM, WA Museum/High	Determine current conservation status. Secure viable populations within the conservation estate. Implement land management practices which maintain viable populations outside the reserve system	5	1 – 5 years
Morelia spilota imbricata	as above	as above	as above	Lack of survey data	as above	as above	2	1 – 20 years
Lerista viduata	as above	No	as above	Lack of knowledge and data	CALM, WA Museum/Med	Determine current conservation status.	5	1 – 20 years
Invertebrates								
Idiosoma nigrum	No	No	No	Lack of survey data	CALM, WA Museum, Barbara York Main/Low	Determine current conservation status.	5	1 – 5 years
Kwonkan eboracum	as above	as above	as above	as above	as above	as above	5	1 – 5 years
Flora								
Threatened flora of roadsides e.g. *Boronia adamsiana*, *Acacia volubilis*	Few	N/A	Roadside Conservation Strategies (Roadside Conservation Committee and Shires) (Roadside Conservation Commission 1995)	Competing land use; loss of permanent staff and increased use of contractors makes the education process more difficult	Regional/District Threatened Flora Recovery Teams/High	Reduce the impact of current threatening processes. Maintain viable populations in-situ. Conduct translocations to establish new populations within the reserve system	30	1 – 5 years
Flora and fauna of granite outcrops e.g. *Eucalyptus rhodantha* var. *rhodantha*, *Verticordia staminosa* subsp. *staminosa*	as above	N/A	No	Competing use of water for supply purposes; loss of fringing vegetation in many instances.	CALM, WA Museum /High	Determine current conservation status of all biota. Reduce the impact of current threatening processes. Maintain viable populations of all	20	1 – 20 years

Species/Group	Recovery plans	Action plans	Other management plans	Major constraints	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
						species in-situ.		
Threatened flora of lowland communities, including tall woodlands, mallee and melaleuca shrublands, freshwater and naturally saline wetland systems.	Few	N/A	Eg. Buntine-Marchagee Recovery Catchment	Response to rising groundwater is unlikely to be of the magnitude required, lack of resources to collect and store sufficient germplasm, lack of resources to propagate and lack of suitable habitat to translocate sufficient numbers of all species.	Catchment Recovery Teams/High	Reduce the impact of current threatening processes. Maintain viable populations of all species in-situ. Ensure adequate and representative ex-situ collections of all biota	100	1 – 20 years
450 flora species endemic to the agricultural zone and in danger of extinction due to rising saline groundwaters.	No	N/A	Salinity Action Plan Biological Survey of the Agricultural Zone (Department of Conservation and Land Management 2000)	as above	Catchment Recovery Teams, Regional/District Threatened Flora Recovery Teams/High	as above	100	1 – 20 years
Wongan-Ballidu Threatened Flora Management Program	Draft in prep.	N/A	No	-	Merredin District Threatened Flora Recovery Team/High	Reduce the impact of current threatening processes. Maintain viable populations in-situ. Conduct translocations to establish new populations within the reserve system.	60	1 – 5 years
Priority 1 and 2 flora (41 species)	No	N/A	No	Insufficient number of qualified staff to undertake the extensive fieldwork	Regional/District Threatened Flora Recovery Teams/High	Determine current conservation status	50	1 – 5 years

Species/Group	Recovery plans	Action plans	Other management plans	Major constraints	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
				required.				
General Declared Rare Flora without an IRP (60 species)	No	N/A	No	General - Insufficient qualified staff and resources to undertake the extensive fieldwork required for survey, monitoring and management actions	Regional/District Threatened Flora Recovery Teams/High	Reduce the impact of current threatening processes. Maintain viable populations in-situ. Conduct translocations to establish new populations within the reserve system	100	1 – 5 years
Acacia pharangites	Yes – IRP (Evans and Brown 1999)	N/A	as above	as above	as above	as above	15	1 – 5 years
Acacia pygmaea	Yes – IRP (Holland *et al.* 1996)	N/A	as above	as above	as above	as above	2.5	1 – 5 years
Adenanthos pungens subsp. *effusus*	Yes – IRP (Evans *et al.* 2000)	N/A	as above	as above	as above	as above	23	1 – 5 years
Darwinia carnea	Yes – IRP (Holland *et al.* 1996)	N/A	as above	as above	as above	as above	5	1 – 5 years
Daviesia euphorbioides	Yes – IRP (Phillimore and Brown 2000)	N/A	as above	as above	as above	as above	35	1 – 5 years
Drakonorchis drakeoides	Yes – IRP (Holland *et al.* 1999)	N/A	as above	as above	as above	as above	10.5	1 – 5 years
Eremophila scaberula	Yes – IRP (Stack and English 1999)	N/A	as above	as above	as above	as above	22	1 – 5 years
Eremophila veneta	Yes – IRP (Kershaw *et al.* 1997)	N/A	as above	as above	as above	as above	3.5	1 – 5 years
Grevillea curviloba subsp. *incurva*	Yes – IRP (Phillimore and English 2000)	N/A	as above	as above	as above	as above	43	1 – 5 years

Species/Group	Recovery plans	Action plans	Other management plans	Major constraints	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
Grevillea dryandroides subsp. *dryandroides*	Yes – IRP (Phillimore and Brown 2000)	N/A	No	General - Insufficient qualified staff and resources to undertake the extensive fieldwork required for survey, monitoring and management actions	Regional/District Threatened Flora Recovery Teams/High	Reduce the impact of current threatening processes. Maintain viable populations in-situ. Conduct translocations to establish new populations within the reserve system	25	1 – 5 years
Grevillea scapigera	No – draft RP (Rosetto *et al.* undated)	N/A	No	as above	as above	as above	63.5	1 – 5 years
Orthrosanthus muelleri	Yes – IRP (Phillimore *et al.* 2001)	N/A	as above	as above	as above	as above	38	1 – 5 years
Sphenotoma drummondii	Yes – IRP (Holland *et al.* 1999)	N/A	as above	as above	as above	as above	-	-
Synaphea quartzitica	Yes – IRP (Stack and English 1999)	N/A	as above	as above	as above	as above	29	1 – 5 years
Thomasia sp. Green Hill (S.Paust 1322)	Yes – IRP (Evans and English 1999)	N/A	as above	as above	as above	as above	42	1 – 5 years
Verticordia staminosa subsp. *staminosa*	Yes – IRP (Evans and Brown 2001)	N/A	as above	as above	as above	as above	10	1 – 5 years

RP = Recovery Plan
IRP = Interim Recovery Plan

Appropriate species recovery actions

Table 18: Actions that are required for the recovery of the following species at risk, as well as the major constraints as to why not all recovery actions may not be possible.

Species/group	Recovery actions	Recovery description	Major constraints
Western barred bandicoot (*Perameles bougainville bougainville*)	vii, i, x, xiv, ix, xii	Feral animal control (particularly predators); habitat retention through reserves; translocation; other – captive breeding and monitoring; fire management; research.	Locally extinct, lack of suitably large habitat areas, predator control.
Chuditch (*Dasyurus geoffroii*)	vii, i, x, xiv, ix	Feral animal control (particularly predators); habitat retention through reserves; translocation; other – monitoring; fire management.	Lack of survey data, lack of suitably large habitat areas, predator control.
Numbat (*Myrmecobius fasciatus*)	vii, i, x, xiv, xii, ix	Feral animal control (particularly predators); habitat retention through reserves; translocation; other – captive breeding and monitoring; research; fire management.	Lack of suitably large habitat areas, predator control.
Bilby (*Macrotis lagotis*)	vii, i, x, xiv, ix, xii	Feral animal control (particularly predators); habitat retention through reserves; translocation; other – captive breeding and monitoring; fire management; Research.	Locally extinct, lack of suitably large habitat areas, predator control.
Boodie (*Bettongia lesueur lesueur*)	vii, i, x, xiv, ix, xii	as above	as above
Banded hare-wallaby (*Lagostrophus fasciatus fasciatus*)	vii, i, x, xiv, ix, xii	as above	as above
Greater stick-nest rat (*Leporillus conditor*)	vii, x, i	Feral animal control (particularly predators); translocation; habitat retention through reserves.	Locally extinct, lack of suitably large habitat areas, predator control.
Woylie (*Bettongia penicillata ogilbyi*)	vii, i	Feral animal control (particularly predators); habitat retention through reserves.	Lack of suitably large habitat areas, predator control.
Tammar Wallaby (*Macropus eugenii derbianus*)	vii, i, x, xiv, ix	Feral animal control (particularly predators); habitat retention through reserves; translocation; other – monitoring; fire management.	Lack of survey data, lack of suitably large habitat areas, predator control.
Quenda (*Isoodon obesulus fusciventer*)	vii, i, ii, x	Feral animal control (particularly predators); habitat retention through reserves and on private lands; translocation.	Lack of suitably large habitat areas, predator control.
Mala (*Lagorchestes hirsutus*)	vii, i, x, xiv, ix, xii	Feral animal control (particularly predators); habitat retention through reserves; translocation; other – captive breeding and monitoring; fire management; research.	Locally extinct, lack of suitably large habitat areas, predator control.
Red-tailed phascogale (*Phascogale calura*)	i, ii, vii, ix, x	Habitat retention through reserves and on private lands; feral animal control (particularly predators); fire management; translocation.	Lack of suitably large habitat areas, predator control.
Common brushtail possum (*Trichosurus vulpecular*)	vii, i	Feral animal control (particularly predators); habitat retention through reserves.	as above
Thick-billed grasswren (western) (*Amytornis textilis textilis*)	x, i, iii, vii, xiv	Translocation; habitat retention through reserves and on other state lands; feral animal control (particularly predators); other - survey and monitoring.	Locally extinct.
Carnaby's cockatoo (*Calyptorhynchus latirostris*)	i, ii, iii, xiv, xii	Habitat retention through reserves, on private lands and on other state lands; other - protect known nesting trees and breeding areas, survey work, captive breeding and public awareness programme; research.	Lack of survey data on breeding and habitat areas.
Western whipbird (western mallee) (*Psophodes nigrogularis*)	i, iii, ii, viii, xiv, xii	Habitat retention through reserves, on other State lands and on private lands; revegetation; other – monitoring; research.	Lack of knowledge on habitat requirements.

Species/group	Recovery actions	Recovery description	Major constraints
Western rosella (wheatbelt) (*Platycercus icterotis*)	xiv, xii, i, ii, iii	Other – monitoring, promote community nestbox program, and mitigate food limitations; research; habitat retention through reserves, on private lands and on other State lands.	Lack of survey data.
Barking owl (southern) (*Ninox connivens*)	i, iii, ii, xii, xiv, xiii, viii, vii	Habitat retention through reserves, other State lands and on private lands; research; other – survey work; capacity building - extension to promote habitat management; revegetation; feral animal control (particularly predators).	Lack of survey data, lack of resources to manage fire regimes.
Western wheatbelt birds	i, iii, ii, viii, vii, v, vi, xi, xiv	Habitat retention through reserves, on other State lands and on private lands; revegetation; feral animal control (particularly predators); fencing; weed control; reinstatement of hydrology; other – tree hollow protection and monitoring.	Lack of survey data, lack of knowledge on causes of declines.
Western spinytailed skink (*Egernia stokesii badia*)	i, iii, ii, vii, v, xiv	Habitat retention through reserves, other State lands and on private lands; feral animal control (particularly predators); fencing; other – survey and monitoring.	Lack of survey data, lack of knowledge on causes of declines.
Aspidites ramsayi (South West population)	i, iii, ii, xiv, vii, xiii, x	Habitat retention through reserves, on other state lands and on private lands; other – survey and captive breeding; feral animal control (particularly predators); capacity building - develop guidelines and incentives to manage population outside reserves; translocation.	Possibly locally extinct, lack of survey data.
Morelia spilota imbricata	i, iii, ii, xiv, vii, xiii, x	as above	Lack of survey data.
Lerista viduata	Unknown	Unknown	Lack of knowledge and data.
Idiosoma nigrum	i, iii, vii, xiv, vi, ix	Habitat retention through reserves and on other state lands; feral animal control (particularly predators); other - minimise soil disturbance and survey; weed control; fire management.	Lack of survey data.
Kwonkan eboracum	Unknown	Unknown	Lack of survey data
Threatened flora on roadsides e.g. *Boronia adamsiana*, *Acacia volubilis*	iii, xiii, vi, v, x, viii	Habitat protection on other State lands; capacity building - shire officers; weed control; translocation; revegetation.	Competing land use; loss of permanent staff and increased use of contractors makes the education process more difficult.
Flora and fauna of granite outcrops e.g. *Eucalyptus rhodantha* var. *rhodantha*, *Verticordia staminosa* subsp. *staminosa*	i, iii, ii, xi, vi, vii, ix, xiii, xii	Habitat retention through reserves, other State lands and on private lands; reinstatement of hydrology; weed control; feral animal control (particularly predators); fire management; capacity building with landholders; research.	Competing use of water for supply purposes; loss of fringing vegetation in many instances.
Threatened flora of lowland communities, including tall woodlands, mallee and melaleuca shrublands, freshwater and naturally saline wetland systems.	xi, xiii, viii, x, xiv	Reinstatement of hydrology; capacity building with landholders; revegetation; translocation; other - germplasm storage.	Response to rising groundwater is unlikely to be of the magnitude required, lack of resources to collect and store sufficient germplasm, lack of resources to propagate and lack of suitable habitat to translocate sufficient numbers of all species.

Species/group	Recovery actions	Recovery description	Major constraints
450 flora species endemic to the agricultural zone and in danger of extinction due to rising saline groundwaters.	xi, x, xiv, i, iii, ii	Reinstatement of hydrology; translocation; other - germplasm storage; habitat retention through reserves, other State lands and on private lands.	Response to rising groundwater is unlikely to be of the magnitude required, lack of resources to collect and store sufficient germplasm, lack of resources to propagate and lack of suitable habitat to translocate sufficient numbers of all species.
Wongan-Ballidu Threatened Flora Management Program	i, iii, ii, vii, v, vi, xiv, x, ix, xii	Habitat retention through reserves, on private land and on other State lands; feral animal control; fencing; weed control; other - survey work; translocation; fire management; research.	
Priority 1 and 2 flora (41 species)	xiv	Other - additional survey to locate new populations.	Insufficient number of qualified staff to undertake the extensive fieldwork required.
General Declared Rare Flora without an IRP (60 species)	General – iii, ii, i, vi, xi, v, viii, ix, xiii (shires, landholders, utilities), xiv, x	Habitat retention on other state lands, private lands and through reserves; weed control; reinstatement of hydrology; fencing; revegetation; fire management; capacity building with shires, landholders and utilities; other – additional survey work to locate new populations; translocation.	General - insufficient qualified staff and resources to undertake the extensive fieldwork required for survey, monitoring and management actions.
Acacia pharangites	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	Habitat retention through reserves, on other state lands and on private lands; feral animal control; fencing; weed control; other – survey work; translocation; fire management; reinstatement of hydrology; research.	Same as DRF General above.
Acacia pygmaea	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	as above	Same as DRF General above.
Adenanthos pungens subsp. *effusus*	i, xiv, x, xi, xiv	Habitat retention through reserves; other - protect from mining, disease management *Phytophthora* sp. and seed collection; translocation; reinstatement of hydrology.	Same as DRF General above.
Darwinia carnea	ii, iii, v, vii, x, xii, xiv	Habitat protection on private lands and on other State lands; fencing; feral animal control; translocation; research; other - survey and monitoring.	Same as DRF General above.
Daviesia euphorbioides	iii, i, ix, x, xiii, xii, xiv	Habitat protection on other State lands and through reserves; fire management; capacity building with the shire and Westrail; research; other - survey and monitoring.	Same as DRF General above.
Drakonorchis drakeoides	ii, i, xi, ix, vi, vii, xiv, xiii	Habitat protection on private lands and through reserves; reinstatement of hydrology; fire management; weed control; revegetation; other - survey and monitoring; capacity building with landholders.	Same as DRF General above.
Eremophila scaberula	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	Habitat retention through reserves, other State lands and private lands; revegetation, fencing; weed control; other - survey work; translocation; fire management; reinstatement of hydrology; research.	Same as DRF General above.
Eremophila veneta	i, iii, xiii, ix	Habitat retention through reserves and on other State lands; capacity building with Westrail; fire management.	Same as DRF General above.

Species/group	Recovery actions	Recovery description	Major constraints
Grevillea curviloba subsp. *incurva*	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	Habitat retention through reserves, other State lands and private lands; revegetation, fencing; weed control; other – survey work; translocation; fire management; reinstatement of hydrology; research.	Same as DRF General above.
Grevillea dryandroides subsp. *dryandroides*	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	as above	Same as DRF General above.
Grevillea scapigera	iii, x, vi, xii	Habitat protection on other State lands; translocation; weed control; capacity building with local community groups.	Same as DRF General above.
Orthrosanthus muelleri	iii	Habitat protection on other state lands.	Same as DRF General above.
Sphenotoma drummondii	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	Habitat retention through reserves, other State lands and private lands; revegetation, fencing; weed control; other – survey work; translocation; fire management; reinstatement of hydrology; research.	Same as DRF General above.
Synaphea quartzitica	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	as above	Same as DRF General above.
Thomasia sp. Green Hill (S.Paust 1322)	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	as above	Same as DRF General above.
Verticordia staminosa subsp. *staminosa*	i, iii, ii, vii, v, vi, xiv, x, ix, xi, xii	as above	Same as DRF General above

See Appendix B for recovery actions (key h).

Ecosystem recovery planning

Table 19: Recovery planning for ecosystems at risk, including relevant plans, major constraints, delivery framework/community capacity, targets/thresholds, costs and short or long term priorities.

Community	Recovery plan	Management plans	Constraints/priority locations	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
Avon Pools Deep pools and natural braided sections of fresh to brackish rivers of the Avon Botanical District.	No	Wheatbelt Management Plan (draft)	The extent of hydrological reinstatement required.	CALM/High	To improve the overall health of the community and reduce the level of threat so that the community does not move into the higher category of Critically Endangered.	50	1 – 20 years
Heath community on chert hills of the Coomberdale Floristic Region Heath dominated by one or more of *Regelia megacephala*, *Kunzea praestans* and *Allocasuarina campestris* on ridges and slopes of the chert hills of the Coomberdale floristic region.	Yes – IRP (Hamilton-Brown 2000)	as above		Moora District Threatened Flora Recovery Team/High	as above	20	1 – 20 years
Mottlecah Wheatbelt mottlecah (*Eucalyptus macrocarpa* subsp. *macrocarpa*) dominated heathland on deep white sands.	No	as above		Narrogin District Threatened Flora Recovery Team/High	as above	5	1 – 20 years
Plant assemblages of the Wongan Hills System, mallee over *Petrophile shuttleworthiana /Allocasuarina campestris* thicket on shallow gravelly soils over ironstone on summit and slopes; Shrub mallee on slopes of lateritic hills; Mallee over *Allocasuarina campestris* thicket on the slopes of the laterite plateaus; Mallee over melaleuca thicket on red brown loam over gravel on slopes below the plateau; mallee over *Melaleuca coronicarpa* heath on shallow red soil on scarp slopes; *A. campestris/Calothamnus asper* thicket over red-brown clay/ironstone/greenstone on scree slopes; and in lower areas: *Eucalyptus longicornis/E. salubris* woodland, *E. salmonophloia* and *E. loxophleba* woodlands; *Acacia acuminata* low forest; *E. ebbanoensis* mallee over scrub; and open mallee of *E. drummondii*.	No	as above		Merredin District Threatened Flora Recovery Team/High	as above	20	1 – 20 years

Community	Recovery plan	Management plans	Constraints/priority locations	Delivery framework /community capacity	Targets /thresholds	Cost $ '000 per year	Priority
Toolibin Lake Perched wetlands of the Wheatbelt region with extensive stands of living swamp sheoak (*Casuarina obesa*) and paperbark (*Melaleuca strobophylla*) across the lake floor.	Yes – IRP (Hamilton-Brown and Blyth 2000)	as above	Extent of revegetation required to manage groundwater in the long-term	Toolibin Recovery Team/High	Maintain watertable below the rootzone	500	1 – 20 years

RP = Recovery Plan
IRP = Interim Recovery Plan

Appropriate ecosystem recovery actions

Table 20: Actions that are required for recovery of the following ecosystems at risk.

Community	Ecosystem recovery actions	Recovery descriptions
Deep pools and natural braided sections of fresh to brackish rivers of the Avon Botanical District	xi, vi, vii, xii	Reinstatement of hydrology; weed control; feral animal control (stock); research.
Heath community on chert hills of the Coomberdale Floristic Region - heath dominated by one or more of *Regelia megacephala*, *Kunzea praestans* and *Allocasuarina campestris* on ridges and slopes of the chert hills of the Coomberdale floristic region.	ii, i, iii, xiii, v, vi, xiv, ix, xii, viii	Habitat protection on private lands, through reserves and on other state lands; capacity building with landholders, Water Authority; fencing; weed control; other - survey and monitoring; fire management; research; revegetation.
Wheatbelt mottlecah (*Eucalyptus macrocarpa* subsp. *macrocarpa*) dominated heathland on deep white sands.	iii, vii, ix, xiv, xiv	Habitat protection on other state lands; feral animals control (control); fire management; other – survey work and prevention of the introduction of *Phytophthora* sp.
Plant assemblages of the Wongan Hills System - mallee over *Petrophile shuttleworthiana* / *Allocasuarina campestris* thicket on shallow gravelly soils over ironstone on summit and slopes; shrub mallee on slopes of lateritic hills; mallee over *Allocasuarina campestris* thicket on the slopes of the laterite plateaus; mallee over melaleuca thicket on red brown loam over gravel on slopes below the plateau; mallee over *Melaleuca coronicarpa* heath on shallow red soil on scarp slopes; *A. campestris*/ *Calothamnus asper* thicket over red-brown clay/ironstone/greenstone on scree slopes; and in lower areas: *Eucalyptus longicornis*/*E. salubris* woodland, *E. salmonophloia* and *E. loxophleba* woodlands; *Acacia acuminata* low forest; *E. ebbanoensis* mallee over scrub; and open mallee of *E. drummondii*.	i, iii, ii, vii, ix, vi, xiv	Habitat retention through reserves, on other state lands and on private lands; feral animal control (stock); fire management; weed control; other - controls on mining activities.
Perched wetlands of the Wheatbelt region with extensive stands of living swamp sheoak (*Casuarina obesa*) and paperbark (*Melaleuca strobophylla*) across the lake floor.	xi, i, xiii, viii, xii, xiv	Reinstatement of hydrology; habitat retention through reserves; capacity building with landholders; revegetation; research; other - groundwater pumping.
Herbaceous plant assemblages on bentonite lakes.	i, ii, v, vi, xii	Habitat retention through reserves and on private lands; fencing; weed control; research.
Salt flats plant assemblages of the Mortlock River (East Branch)	i, ii, v, vi, vii, x, xi, xii, xiii	Habitat retention through reserves and on private lands; fencing; weed control; feral animal control; translocations; reinstatement of hydrology; research; capacity building.

See Appendix B for recovery actions (key h).

For all the unreserved vegetation types listed, the following recovery actions would generally apply: i, iii, ii, xi, vii, vi, ix, xiii (landholders).

Subregion priority for off-reserve conservation

There are major constraints (see Appendix C, rank 6) to achieving conservation outcomes. These include the level of habitat loss and degree of fragmentation (leaving insufficient resources across most of the landscape to support viable populations of many species), significant landscape scale threatening processes such as salinity (affecting up to 30 per cent of the landscape) and fox/cat predation, and competing land uses i.e. broadacre cropping and grazing.

Protected area initiatives on non-reserve tenures

Table 21: Conservation covenant schemes in Western Australia, contrasts between different agencies.

	CALM	National Trust	Agriculture WA
Attribute			
Purpose of covenant	Nature Conservation	Natural Heritage	Soil and Land Conservation
Term of covenant	Permanent (but negotiable)	Permanent (but negotiable)	Permanent (but negotiable, 30 Years minimum)
Removability	By mutual agreement	By mutual agreement	By mutual agreement
Criteria for assessing covenant applications	Area, shape, intactness, pests/diseases, adjacent land use, long term viability, threatened flora/fauna, regional significance, corridor function.	Area, shape, intactness, pests/diseases, adjacent land use, long term viability, threatened flora/fauna, corridor function.	Applications are assessed based on a scoring system. This incorporates vegetation type, size, position in the landscape and rare species.
Stewardship program	Yes, annual contact and three year management plan review/site visit.	Yes, regular (annual) contact/visit.	No
Covenant details flexible and negotiable	Yes, all or part of property, compatible land use (e.g. small dwelling) can be negotiated.	Yes, all or part of property, compatible land use (e.g. small dwelling) can be negotiated.	Generally no; covenant only applies to area of remnant vegetation.
Incentives:			
Fencing assistance	May be available on a case by case basis.	May be available on a case by case basis.	AgWA remnant vegetation protection scheme.
Cover administrative costs of covenanting (registration, survey etc)	Yes	Yes	Yes, on ground survey not required.
Independent Legal Opinion	Yes, funded up to the value of $500	No	No
Management Advice	Yes, as well as Western Wildlife and covenant newsletter	Yes, including assistance with grant applications. Yes, plus National Trust membership	No
Management costs (e.g. herbicide costs, seeds)	Yes, but on a limited case by case basis	Yes, but on a limited case by case basis.	No
Assistance with land sale issues (e.g. property advertising, talking to buyers, real estate agents)	Yes	Yes	No

A range of programs to assess the conservation values of remnant vegetation on non-park tenures is also under way across part or all of the AW2[1].

Focal species approach and Conservation Management Zones (Lambeck 1999):
This approach, still under development, aims to partition (within agricultural landscapes) IBRA regions into landscape 'types' which reflect the patterns of anthropogenic change superimposed over the biophysical patterns. These areas are termed Conservation Management Zones (CMZ). This, when combined with the focal species approach (Lambeck 1997), would allow conservation management solutions identified in one part of a CMZ to be applied elsewhere within that zone. This approach does not identify priorities across an area such as an IBRA region, but simply identifies the magnitude of the management and revegetation required to meet a particular conservation goal within each defined CMZ. More recent work by Parsons *et al.* (2003) at Wallatin Creek (within the Avon Wheatbelt bioregion) uses a modified focal species approach to undertake landscape planning for bird conservation.

[1] This document was originally drafted in 2001 and since then several new remnant vegetation planning and management schemes have been developed or implemented. Changes will be addressed in subsequent editions of the Biodiversity Audit.

Living Landscapes (Dilworth *et al.* 2000):
The Living Landscapes project is a planning process, managed by Greening Australia (WA) that aims to incorporate nature conservation planning into productive agricultural landscapes. It uses a focal species planning approach (Lambeck 1999) with landholders from a single catchment to develop on-ground management outcomes. Management actions are generally aimed at protecting existing remnant vegetation and undertaking revegetation. There are currently six Living Landscapes; Gabbi Quoi Quoi, Tin Dog Creek, Wyalkatchem, Morbinning, South Tammin and Wallatin Creek. However only the Morbinning and Gabbi Quoi Quoi Living Landscapes are within the AW2.

Conservation values of remnant vegetation (Shepherd 1996):
A process to assess the conservation value of remnant vegetation using a GIS was developed by Shepherd (1996). The spatial model uses several thematic layers to generate a series of remnant metrics (area, area-perimeter ratio, remnant to remnant proximity, distance to nearest nature reserve) and other non-spatial attributes (vegetative composition based on 1:250,000 mapping, vegetation representativeness, salinity hazard). These are scored, and a cumulative score assigned to each remnant representing its conservation value. This approach was adopted by the Blackwood Basin Group and applied to all non-reserve remnants across the Blackwood Basin, giving a ranking of all remnants for priority purposes.

Woodland Watch:
The Woodland Watch is a collaborative project between the World Wide Fund for Nature (WWF) and CALM. Its objective is to conserve private remnants of threatened eucalypt woodlands within the Avon Wheatbelt (Western Australian Herbarium 2002). A floristic survey of each woodland site is conducted, and management advice is provided to the landholder, in order to better protect the woodland from threats.

Regional Natural Resource Management Strategies:
The AW2 subregion lies across four Natural Resource Management Divisions; the South Coast Regional Initiative Planning Team (SCRIPT), the South West Catchments Council (SWCC), the Avon Catchment Council (ACC) and the Northern Agricultural Catchment Council (NACC). All four of these Regional NRM Groups are currently (December 2003) developing natural resources management strategies. The strategies will be accredited for Federal and State funding under the Bilateral Agreement for the Extension to the Natural Heritage Trust (NHT2) and the National Action Plan for Salinity and Water Quality (NAP). Although slightly different, each strategy recognises biodiversity conservation as a key NRM issue, and identifies the assets, threats, goals, target and actions required for management. The strategies are all due to be accredited and released in 2004.

South-west Australia Ecoregion Initiative (SWAEI):
In September 2003, more than 20 key government, business, conservation, academic and community leaders formed the South-west Australia Ecoregion Initiative to combat the decline of biodiversity within a large bioregion of global biological significance – the South-west Australia Ecoregion. By using a visionary approach - thinking long-term and large-scale and by seeking strong political and grassroots support - it will bring together community, government and industry initiatives under one umbrella. The initiative will define the biological status of the ecoregion, identify high conservation priorities and foster collaborative approaches among community, industry and government groups.

Metapopulation viability and conservation of blue-breasted fairy-wren in fragmented habitat in the Western Australian Wheatbelt (Brooker and Brooker 2003):
Using presence records of blue-breasted fairy-wren across 12 million hectares of the central wheatbelt (including the AW2) the authors were able to define a hierarchy of population 'neighbourhoods' related to remnant vegetation area and patch isolation. Using this model as a guide they are able to rank remnant vegetation across the landscape and assess future population persistence. While the method has been developed using data for the blue-breasted fairy-wren, it has the potential to be used to map the 'probability of persistence' for a suite of different species and identify conservation priorities at regional scales.

The experiences in the AW2 of impediments and landholder capacity to be involved in biodiversity conservation on-farm are similar to those documented by Elix and Lambert (1997), and Jenkins (1998). More recent work at Dongolocking involving landholders in a revegetation planning project (Wallace 1998) also documented some of the issues influencing successful on-ground revegetation for biodiversity benefits. These included cost sharing arrangements, revegetation machinery and tools, seedling quality, site preparation, level of interaction with staff, profitability, sense of ownership and level of involvement (Mullan 2003).

Limitations on reserve consolidation initiatives

Limitations for reserve consolidation include:
- funding to purchase sufficient land at market value (average of $800/ha);
- funding to complete adequate revegetation in critical locations to either provide additional habitat or link patches currently inaccessible to key biota (at least $2,000/ha);
- technical capacity to recreate habitat e.g. seed germination requirements, revegetation methods, capacity to introduce more than a small fraction of

the biota present in natural habitat (five species of fungi in 'best practice' revegetation, compared to more than 50 species in highly degraded woodland habitat – I. Tommerup, pers. comm.); and

- resources to adequately manage additions to the nature reserve system.

Natural Resource Management (NRM)

Existing actions

See Appendix B, rank i for a full list of NRM action categories.

Incentives:
There are incentives for a range of on-ground actions through State, Federal and some other programs. These incentives generally involve revegetation and remnant vegetation fencing, but in some cases (State government in particular) may involve earthworks. Examples include:

- State funding through recovery catchments and other components of the Salinity Program, such as the Crown Reserves Program (refer to Wallace 2001 for summary);
- the Land for Wildlife Program (managed by CALM);
- Bushcare funding, through joint projects with State government (which contributes significant dollars) projects and regional NRM groups;
- the Search Project (State-Federal program) with significant funding of commercially prospective native species of regional provenance; and
- other NHT programs (National Landcare, Endangered Species).

Three main options also exist to derive a financial benefit from on-farm remnant vegetation. These are:

- land purchases by government agencies, the Australian Bush Heritage fund and interested individuals through the Bush Brokers scheme;
- land revaluation as unproductive, or differential rating by covenanting; and
- the gifting of the land to a tax conservation body for taxation deductions.

Legislation:
The most relevant legislation is the *Wildlife Conservation Act (1950)* and the *Conservation and Land Management Act (1984)* There is no 'duty of care' legislation, and no evidence that such legislation is practicable.

Institutional reform:
The purchase of bushland by CALM is a real contribution to helping to re-align land use and free up money for landholders. This is a form of new tenure.

The operation of regional NRM groups is in a state of flux but represents an on-going case of institutional reform. (See also recommendations in Frost *et al.* 2001 and Wallace 2001). Some State agencies in the NRM area have been restructured and reoriented over the past 12 months, and this is continuing.

Capacity building with landholders:
In September 1999 Bush Brokers was established with a formal Memorandum of Understanding by all partners. The MOU sets out a range of projects to be undertaken within the next 12 months. These include:

- establishing a united base for promoting improvements to government policies, particularly subdivision policies and procedures to streamline the separation of bush from agricultural titles and placement on a separate title;
- a web site register of properties/blocks currently for sale, and buyers seeking bushland;
- research on the size of the bushland market, and the most cost-effective measures to stimulate that market;
- a case studies handbook of individuals and groups who have already bought bush;
- holding 'Marketing Bushland' information seminars for rural agents; and
- including a 'Marketing Bushland' component in the accredited REIWA course.

Other planning opportunities (with local government):
Draft Statement of Planning Policy under Section 5AA of the *Town Planning and Development Act (1928).* Its purpose is to inform local governments and the Town Planning Appeals Tribunal of State planning policies about the environment and natural resources which should be taken into account in planning decision-making. The policy will guide the WAPC's planning responsibilities. It will also integrate and coordinate State agencies' activities that influence the use and development of land. This policy includes a section on biodiversity.

Valuing ecosystem services and tradable rights:
These concepts are being tested in the eastern states. Results are being followed with great interest.

Threat abatement planning:
Action is largely through CALM, with internal reports and policies on threats such as dieback, feral animal control, fire, etc. Other reports available are:

- CALM's salinity review (Wallace 2001),
- State Salinity Strategy (State Salinity Council 2000),

- Report of the Salinity Taskforce (Frost *et al.* 2001),
- weed management strategies (Department of Conservation and Land Management 1999b; Department of Agriculture 2001; Agriculture and Resource Management Council of Australia and New Zealand *et al.* 2000a; Agriculture and Resource Management Council of Australia and New Zealand *et al.* 2000b; and Agriculture and Resource Management Council of Australia and New Zealand *et al.* 2001), and
- local government dieback guidelines document (Lewis and Colquhoun 2000),

Specialist plans, including those related to the management of locust control and the interaction of control measures on conservation lands, are also published.

Industry codes of practice:
These include:

- the Environmental Code of Practice – Extractive Industries (Environmental Protection Authority 1991),
- Environmental Management in the WA Mining Industry (Chamber of Mines and Energy of Western Australia 1993),
- Code of Practice for Timber Plantations in Western Australia (Anon. undated),
- Roadside Conservation Committee – a Code of Practice for Roadside Conservation in Road Construction and Road Maintenance. The aim of this code is to balance road design and road safety requirements with all other values associated with roadsides in each Shire.

Environmental management systems and ecological sustainable product marketing:
CALM's Wheatbelt Region is preparing an EMS to identify values, threats, goals and prioritise management across the landscape.

Capacity building:
There is significant interaction between State agencies, regional NRM groups (e.g. the Avon Catchment Network), Greening Australia WA (for example, Living Landscapes) and the World Wide Fund for Nature (through Woodland Watch in particular). These groups interact jointly and independently to contribute to capacity building among landholders. Other groups such as the Threatened Species Network and Malleefowl Preservation Society also make significant contributions to capacity building in the community.

An opportunity for capacity building is the NHT Meta Project. The project was a joint Department of Agriculture, CALM and Water and Rivers Commission venture partly funded by NHT. One of the aims was to improve the delivery of revegetation programs designed to achieve biodiversity conservation outcomes. The project has delivered many products, including a series of reports which document the solutions developed and make them widely available. The report authored by Gavan Mullan, Susie Murphy-White and Peter White (CALM Wheatbelt Region), can be downloaded from *http://www.calm.wa.gov.au/projects/habitat/revegetation.html*. Topics include:

- cost-sharing arrangements,
- revegetation designs and case studies from various landscape positions and vegetation types in the eastern and central the wheatbelt,
- revegetation site preparation, ripping and mounding, and
- details of a newly designed multi-tyned ripper, including blueprints.

Other planning opportunities:

- The Department of Planning and Infrastructure is developing relevant rural land use plans.
- Some local governments are acting together to produce joint programs – for example, Kondinin Bush Heritage Committee.
- Regional NRM planning processes continue.
- CALM's Wheatbelt Regional Plan is being developed.
- The National Action Plan for Salinity and Water Quality is being developed.

Salinity Investment Framework (Department of Environment 2003)
The Salinity Investment Framework (SIF) is a State Government planning process to guide the investment of public funds into projects protecting assets from the effects of waterlogging and salinity. The investment of funds is guided by eight key principles relating to the need for strategic investment to protect high quality public assets using the Regional NRM Strategies and the National Action Plan for Salinity. There are four major asset classes, including biodiversity. The SIF sets out a series of steps to establish goals, identify the asset required to meet the goal and assess the future viability of the assests in relation to their importance. It also identifies threats (related to salinity), and the State's capacity to manage these threats. Refer to Wallace *et al.* (2003) for details of the SIF process specifically relating to biodiversity.

Integration with property management planning, catchment planning and Landcare:
Integration occurs in various ways. Examples include:

- a contribution to property planning by Land for Wildlife;
- Aglet's Land Management (Department of Agriculture) which includes a soil survey, land capability assessment and farm planning information;
- catchment planning through recovery catchments (natural diversity, water resources and rural towns);
- a rapid catchment appraisal process managed by Department of Agriculture;
- regional planning through State agency plans and NRM regional group plans, and
- Department of Planning and Infrastructure rural land use planning.

Other:
On-ground actions by CALM are the most significant single, focussed contribution to biodiversity conservation in the subregion. One of the most significant aspects of this is the development of new industries based on native biota, particularly plants, that ameliorate threats without jeopardising conservation values. This includes the oil mallees, melaleucas, and a range of other species being investigated as part of CALM's Search program. This is a vital element of success in NRM.

Opportunities and impediments

See Appendix B, rank i for a full list of NRM action categories.

Opportunities and impediments or constraints are often different sides of the same issue, and as such are examined together in this section.

A key constraint is the lack of resources – including human and infrastructure resources – for implementation. This point reflects the relative importance of biodiversity conservation and environmental issues in the public and political mind. Unless there is much wider recognition that biodiversity conservation makes a vital contribution to each individual's quality of life, the situation is unlikely to change. See Burbidge and Wallace (1995) for a discussion of some of the relevant issues.

NRM is variously and poorly defined. This is a significant impediment to progress, and reflects a much wider lack of rigour in the NRM area, and the generally very poor understanding of the relevant socio-political processes. An example of these issues is documented in Wallace (2003). A range of problems, opportunities and constraints in relation to salinity are dealt with in Wallace (2001). Many of these are relevant to the broader field of NRM.

Incentives:
Potential for changes in taxation law for philanthropy exists. It is important to note that in many important cases – such as salinity – it is not an incentive that is required, but technical solutions that are economically viable to implement. While the lack of technical solutions is a barrier, it is also an opportunity. CALM is, particularly in the case of revegetation, working hard to find economically viable technical solutions. The lack of resources is an impediment to a quick solution. If we do not develop economically viable solutions using regional plants and animals, there is a severe risk that new invasive weeds and pest animals (for example, through aquaculture and more aggressive grazing animals) will be introduced. Financial measures are a significant issue. Priority: one to five years.

Legislation:
The proposed re-writing of the *Wildlife Conservation Act (1950)* is a key opportunity for change. More effective legislation and regulation in relation to land clearing and drainage would combat some existing threats. This is both an opportunity and a barrier. The existing Memorandum of Understanding is being reviewed. Financial measures are a significant issue (enforcement). Priority: one to 20 years.

Institutional reform:
While institutional reform is an issue, even greater opportunities for progress lie in improving the current institutions and ensuring that they are staffed at a sufficient level and with appropriate people. Put simply, bad operators will still be bad irrespective of institutional reform while good operators will do comparatively well despite institutional structures. This does not deny the need for institutional reform in some cases. It has become clear that the recruitment, training and management of an effective NRM group is a far more significant impediment to progress than institutional structures and arrangements. Institutional reforms that would help include:

- minimising institutional change and avoiding structural change to organisations within an eight to 10-year timeframe without good reason. Significant structural changes cause organisational inefficiencies that last for a minimum of three years;
- implementing institutional reform only where there is a clearly articulated and convincing case that there is a well-identified problem to be fixed and that the proposed reform has a high probability of success;
- appointing contract officers to minimum terms of five years; and
- reversing the current trend of duplicating services in the NRM area.

Financial measures are a significant issue. Priority: one to 20 years.

Valuing ecosystem services and tradable rights:
These are being tested in the eastern states and results are being followed with great interest.

Threat abatement planning as part of NRM:
The environmental management system being developed by CALM for the subregions should, for these areas, provide a greatly improved platform for threat abatement planning. Wallace *et al.* (2003) present the generalised framework for this.

Environmental management systems and ecologically sustainable product marketing:

See threat abatement (above).

Capacity building:
This needs to be redefined with more clearly stated goals, objectives and strategies.

Other planning opportunities:
Historically there has been a tendency to over-plan. For example, there are a series of overlapping planning processes for biodiversity conservation in the South West. This has, and remains, a barrier. A key opportunity is to proceed and implement plans, and to monitor their value in a more strictly 'adaptive management' style than has been done to date.

Integration with property management planning, catchment planning and landcare:
See comment under Other planning above.

Other:
A significant aspect is in the development of new industries based on native biota, particularly plants, that ameliorate threats without jeopardising conservation values. This includes the oil mallees, melaleucas and a range of other species being investigated as part of CALM's Search program. This is a vital element of success in NRM.

Data gaps

Vegetation and regional ecosystem mapping:
In order to plan and establish a Comprehensive, Adequate and Representative (CAR) conservation reserve system we need biodiversity surrogates mapped at a scale that reflects the degree of species turnover across the wheatbelt landscape. At present little mapping has been done of vegetation remnants to the sub-association level (*sensu.* National Vegetation Information System NVIS) at a scale of 1:25,000 or better. To complement this approach, equivalent scale mapping of soil-landscape units is required to facilitate the revegetation of cleared lands, and to provide an alternative biodiversity surrogate, particularly for small terrestrial vertebrates and invertebrates (see McKenzie *et al* 2003). Additional research is needed to identify patterns and rates of species turnover and endemism, and the environmental gradients and landscape processes driving them in the wheatbelt landscape. A standardised database and GIS application is also essential for data querying and management.

Ecological and life history data:
It is critical to identify priorities and appropriate management responses in the fragmented and largely cleared landscape. Data on various population demographic parameters, resource requirements and landscape variables is required to model population viability for a range of species with different life history strategies. This is essential to ensure that management actions are of an appropriate magnitude to achieve the desired biodiversity conservation goals.

Systematic fauna surveys:
These are required for birds, small terrestrial mammals, reptiles and select invertebrate groups across the landscape, as well as measures of various habitat and landscape variables. A standardised database and GIS application is essential for data querying and management. The assumption that vegetation characteristics can be used as habitat surrogates for fauna needs to be investigated more thoroughly in conjunction with vegetation and ecosystem mapping above. The continued use of the focal species approach (Lambeck 1997; Lambeck 1999) and a modified version (Lambeck 1998) for biodiversity conservation planning across the subregion requires further research and survey data to address:

- the validity of vegetation as a habitat surrogates for all fauna,
- the validity of using birds as indicators for all fauna, and
- what constitutes a viable population (Lambeck 1998) and an understanding of metapopulation dynamics for various flora and fauna species in a fragmented landscape.

Data management:
A significant amount of biodiversity information exists across an enormous variety of media and platforms, and should be used in biodiversity conservation planning and the audit process. However much of this material is unknown, inaccessible or difficult to contextualise with other historical and contemporary datasets. Although metadata information is available for some contemporary datasets, such as through WALIS (Western Australian Land Information System), the NLWRA process has clearly demonstrated the difficulties in identifying, locating and interpreting (particularly in relation to the various boundaries used to capture and collate data, and its regional context) this data.

Planning tools:
There is a huge range of potential planning tools that can assist in biodiversity conservation planning. However there are significant barriers to organisations directly involved in biodiversity conservation planning and land management in being able to effectively use any of them. The data requirement of most systems exceeds what is realistically available, and the expertise within most organisations to understand and implement them is insufficient or scattered. Current biodiversity conservation planning tools generally focus on patch or remnant attributes, species-specific attributes or rely on general ecological principles.
Planning processes to prioritise biodiversity conservation at landscape and regional scales are generally inadequate.

Other priority data gaps include:

- Fire: There needs to be an increased knowledge of fire regimes and histories for reserves and areas of remnant vegetation, and data on the effects of fire on flora and fauna based on their life history attributes. This information is essential if the role of altered fire regimes in biodiversity conservation is to be understood and managed.

Addendum

As hoped the data within this case study is subject to constant change and the structure of the case study provides an opportunity for the collation of such data as it becomes available.

The following ecosystem at risk has not yet been endorsed by the Western Australian Minister for Environment but has been approved by the Threatened Ecological Community Scientific Committee and is likely to become a TEC in the future:

Natural organic saline seeps of the Avon Botanical District

Further changes to species at risk are expected when the 2004 versions of the Fauna Gazette and Declared Rare Flora are produced.

The following recovery plans have been written in 2003:

Pythara Grevillea (*Grevillea pythara*), by R. Phillimore, D. Papenfus, F. Bunny and A. Brown.
Hook Point Poison (*Gastrolobium hamulosum*) by G. Stack and V. English
Pinnate-leaved Eremophila (*Eremophila pinnatifida*) by G. Stack and A. Brown
Branched Hemigenia (*Hemigenia ramosissima*) by R. Phillimore and A. Brown
Varnish Bush (*Eremophila viscida*) by R. Phillimore, R. Evans, A. Brown and V. English
Recurved-leaved Swordfish Dryandra (*Dryandra mucronulata* subsp. *retrors*) by R. Phillimore, A. Brown and B. Loudon
Hinged Dragon orchid (*Caladenia drakeoides*) by E. Holland, A. Brown and K. Kershaw
Wongan Hills Triggerplant (*Stylidium coroniforme*) by G. Stack, N. Willers and A. Brown

The following recovery plans have been updated since in 2003:

Green Hill Thomasia (*Thomasia* sp. Green Hill) by V. English
Thick-billed Grasswren (western subspecies) (*Amytornis textilis textilis*) by B. Cale

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Appendix A - Terms of reference and structure

The structure and the categories used in the case studies are provided below, taking the form of directions provided to the author.

Description, biodiversity values and conservation issues

Description and area

Area of subregion and an integrated description of geology, landforms, soils and dominant vegetation types.

Dominant land use

List from one or more of 15 land-use categories in Key b of Appendix B. These include land-uses such as grazing, forestry and conservation.

Continental Stress Class

Continental Stress Class (Morgan 2001a, Morgan 2001b) values range from 1 (extremely high stress) to 6 (no stress). If the Continental Stress Class value seemed inappropriate author commented on why and what the number should be.

Known special values

Details of special values in relation to landscape, ecosystem, species and genetic values, including high species or ecosystem diversity, rare features (e.g. volcanic plugs), rare ecosystems (e.g. ironstone range flora), rare species, centres of endemism, and refugia. In each case, describe and/or list species or taxonomic groups present.

Existing plans or reviews of biodiversity and threats

Provide information on available sources of information, including databases, results of scientific studies, previous surveys and regional management plans if they exist.

Wetlands of national significance (DIWA listings)

Assess wetlands of national significance including information on wetland name and Directory of Important Wetlands of Australia (Environment Australia 2001) 'code', condition (Rank 2 of Appendix C), trend in condition (Rank 3 of Appendix C), threatening processes (Key e of Appendix B) and reliability of assessment (Rank 1 of Appendix C).

Wetlands of subregional significance

Assess wetlands of subregional significance (in addition to nationally significant wetlands, above), including information on wetland name, location (grid reference or latitude and longitude), description (Key d of Appendix B), special values (Key c of Appendix B), condition (Rank 2 of Appendix C), trend in condition (Rank 3 of Appendix C), threatening processes (Key e of Appendix B) and reliability of assessment (Rank 1 of Appendix B).

Riparian zone vegetation

The riparian zone is the area which has a functional influence on watercourses and their biota. Provide information on condition (Rank 2 of Appendix C), trend (Rank 3 of Appendix C), threatening processes (Key e of Appendix B) and reliability of the assessment (Rank 1 of Appendix C).

Threatened Ecological Communities

The ecosystems shown here are listed by WATSCU as Threatened Ecological Communities (TECs) AND endorsed by the West Australian Environment Minister. Status data in the tables are Western Australian.

Identify each threatened ecosystems (based on status across its geographical range), describe it in terms such as its vegetation, dominant species, preferred substrate and landform. For each, list a reliability rank (Rank 1 of Appendix C), relate the identified threatened ecosystem to NVIS Major Vegetation Sub Groups (Key f of Appendix B), identify its West Australian status (CR = Critically Endangered, E = Endangered, V = Vulnerable, P = Priority), condition (Rank 2 of Appendix C), trend in condition (Rank 3 of Appendix C), and threatening processes (Key e of Appendix B).

Other ecosystems at risk

Describe any other ecosystems considered at risk by regional ecologists and others, as well as TECs that are not yet formally approved by the Minister for the Environment. The required information for each is the same as for Threatened Ecological Communities above.

Fauna species at risk

From Commonwealth and State listings of threatened species of fauna (including invertebrates), list of species name, status (most recent listing of the Western Australian *Wildlife Conservation Act (1950)* - CR = Critically Endangered, E = Endangered, V = Vulnerable and P = Priority), condition (Rank 2 of Appendix C), trend in condition (Rank 3), reliability of assessment (Rank 1) and threatening processes (Key e of Appendix B).

Declared rare and priority flora

For each declared species of plant, list species name, status (most recent listing of the *Western Australian Wildlife Conservation Act (1950)* - CR = Critically Endangered, E = Endangered, V = Vulnerable and P = Priority), condition (Rank 2 of Appendix C), trend in condition (Rank 3 of Appendix C), reliability of assessment (Rank 1 of Appendix C) and threatening processes (Key e of Appendix B).

Due to constraints of space, time and knowledge, Priority species are limited to priorities 1 and 2. Many other priority species, particularly 'priority 4' species in the forest subregions, are considered to be threatened. These have not been included at this stage to maintain consistency with the other WA subregions.

Threatening processes

Specific aspects of the threatening processes (Key e of Appendix B) are detailed.

Known local extinctions

Information provided on species and groups of species that have become extinct, or have had contractions in range or abundance. These species are mostly those on WA lists of threatened species, but can include species that are not yet listed but under some form of threat.

Conservation through reserves

Reservation priorities of ecosystems

Although most regional ecologists in Western Australia carried this analysis out at the IBRA subregional level, NLWRA requested, for each IBRA V bioregion (Environment Australia 2000; Thackway and Cresswell 1995), a list of: Threatened Ecological Communities, other ecosystems at risk and vegetation associations (Hopkins *et al.* 1996; Shepherd *et al.* 2000) according to their reservation status (IUCN I-IV, V-VI, CALM leasehold or other) and priority for acquisition (L = low, M = medium, H = high).

Although more detailed vegetation mapping is available for some WA subregions, the 1:250 000 scale maps (Hopkins *et al.* 1996; Shepherd *et al.* 2000) which cover the entire State allow consistent inter-regional comparisons.

Subregional constraints

List the subregional constraints on the reservation of poorly reserved ecosystem (Key g of Appendix B).

Priority for reserve consolidation

Bioregional NRS Priority based on reservation extent and vegetation cover only (Cummings and Hardy 2001) is listed in Appendix D, values between 1 and 5. Regional ecologists were asked to examine the value that has been allocated to their bioregion and comment on whether or not this is appropriate. Sometimes other prioritisation is listed (Rank 4i of Appendix C).

Reserve management standard

Assessment of reserve management, as individual reserves or groups of reserves (Rank 5 of Appendix C).

Examples of appropriate management scenarios

Examples of current or completed projects that involve appropriate management of reserves.

Budget

Estimates of costs of acquiring reserves and on-going management.

Off reserve conservation

Priority species or groups

Species or priority groups of threatened species found off CALM reserve.

Species recovery planning

Listing of information that has been done or is in progress regarding each of the species at risk, such as recovery plans, major constraints, community capacity, delivery, targets, costs and an assessment of requirements for short or long term plan for species and groups of species at risk.

Appropriate species recovery actions

Specific recovery actions (Key h of Appendix B) that would or do apply to species or groups identified. Describing major constraints if necessary.

Ecosystem recovery planning

Listing of information that has been done or is in progress regarding each of the species at risk, such as recovery plans, major constraints, community capacity, delivery, targets, costs and an assessment of requirements for short or long term plan for ecosystems at risk.

Appropriate ecosystem recovery actions

Specific recovery actions (Key h of Appendix B) that would or do apply to ecosystems at risk identified. Describing major constraints if necessary.

Subregion priority for off reserve conservation

Off reserve conservation priority for component subregions for (Rank 6 of Appendix C).

Natural Resource Management (NRM)

Existing actions

Identify existing NRM actions (Key i of Appendix B) in place that contribute significantly to biodiversity conservation and describe type of action and effectiveness.

Opportunities and impediments

Identify feasible opportunities for NRM actions to specifically address biodiversity (Key i of Appendix B) and describe type of action and effectiveness. Discuss impediments or constraints where opportunities are identified.

Data gaps

Gaps in the data needed to identify biodiversity values and define appropriate management responses. (Key a of Appendix B).

Sources

References cited

References that appear within the text.

Other relevant publications

Other publications that are relevant to the subregion but are not referred to in the text (see References).

Appendix B - Keys

a. Data gaps (priority data needs relative to existing information)
   - (i) Survey information – vegetation/regional ecosystem mapping
   - (ii) Survey information – systematic fauna survey
   - (iii) Floristic data
   - (iv) Ecological and life history data e.g. habitat requirements for threatened species - describe
   - (v) Other - describe e.g. salinity threat.

b. Dominant land use categories
   - (i) Urban, includes industrial, airfields
   - (ii) (a) Rural residential; (b) Mining (the combined BRS data provided can not be easily split between the two)
   - (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
   - (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
   - (xv) Other – describe. Includes other waterbodies, mangroves and water courses

c. Wetlands of subregional significance
   - (i) Wetlands are identified in State or Territory lists of important wetlands
   - (ii) Significant for the maintenance of ecological processes at a subregional scale (refers to criteria 2 in DIWA)
   - (iii) Important for breeding, feeding, roosting, moulting or nursery areas, or refugia for animal taxa (refers to criteria 3 in DIWA)
   - (iv) Supports significant number of plant and animal taxa including migratory species (refers to criteria 4 in DIWA)
   - (v) Contains rare or threatened species/ecosystems (refers to criteria 5 in DIWA)

d. Wetland Classes (from "A Directory of Important Wetlands in Australia", ANCA 1996)

Coastal Wetlands

A1	Not Applicable
A2	Not Applicable
A3	Not Applicable
A4	Rocky marine shores; includes rocky offshore islands, sea cliffs
A5	Sand, shingle or pebble beaches; includes sand bars, spits, sandy islets
A6	Estuarine waters; permanent waters of estuaries and estuarine systems of deltas
A7	Intertidal mud, sand or salt flats
A8	Intertidal marshes; includes salt-marshes, salt meadows, saltings, raised salt mashes, tidal, brackish and freshwater marshes
A9	Intertidal forested wetlands; includes mangrove swamps, nipa swamps, tidal freshwater swamp forests
A10	Brackish to saline lagoons and marshes with one or more relatively narrow connections with the sea
A11	Freshwater lagoons and marshes in the coastal zone
A12	Non tidal freshwater forested wetlands

Inland Wetlands

B1	Permanent rivers and streams; includes waterfalls
B2	Seasonal and irregular rivers and streams
B3	Inland deltas (permanent)
B4	Riverine floodplains; includes river flats, flooded river basins, seasonally flooded grassland, savannah and palm savannah
B5	Permanent freshwater lakes (>8ha); includes large oxbow lakes
B6	Seasonal/intermittent freshwater lakes (>8ha), floodplain lakes
B7	Permanent saline/brackish lakes
B8	Seasonal/intermittent saline lakes
B9	Permanent freshwater ponds (>8ha), marshes and swamp on inorganic soils; with emergent vegetation and waterlogged for at least most of the growing season
B10	Seasonal/intermittent freshwater ponds and marshes on inorganic soils; includes sloughs, potholes; seasonally flooded meadows, sedge marshes
B11	Permanent saline/brackish marshes
B12	Seasonal saline marshes
B13	Shrub swamps; shrub-dominated freshwater marsh, shrub carr, alder thicket on inorganic soils
B14	Freshwater swamp forest; seasonally flooded forest, wooded swamps; on inorganic soils
B15	Peatlands; forests, shrub or open bogs
B16	Alpine and tundra wetlands; includes alpine meadows, tundra pools, temporary waters from snow melt
B17	Freshwater springs, oases and rock pools
B18	Geothermal wetlands
B19	Inland, subterranean karst wetlands

Human-Made Wetlands

C1	Water storage areas; reservoirs, barrages, hydro electric dams, impoundments (generally >8ha)
C2	Ponds, including farm ponds, stock ponds, small tanks (generally <8ha)
C3	Aquaculture ponds, fish ponds, shrimp ponds
C4	Salt exploitation; salt pans, salines
C5	Excavations; gavel pits, borrow pits, mining pools
C6	Wastewater treatment; sewage farms, settling ponds, oxidation basins
C7	Irrigated land and irrigation channels; rice fields, canals, ditches
C8	Seasonally flooded arable land, farm land
C9	Canals

e. Threatening Processes

(i) Broad scale vegetation clearing
(ii) Increasing fragmentation, loss of remnants and lack of recruitment
(iii) Firewood collection
(iv) Grazing pressure
(v) Feral animals - list in order of significance
(vi) Exotic weeds - list in order of significance
(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 – describe

f. **NVIS** (National Vegetation Inventory System) Major Vegetation Sub-groups:

(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 (Acacia harpophylla) forests and woodlands
(14.) Other Acacia forests and woodlands
(15.) Melaleuca forests and woodlands
(16.) Other forests and woodlands
(17.) Alpine and sub-alpine woodlands, shrublands, sedgelands and herbfields
(18.) Arid eucalyptus low open woodlands with hummock grass
(19.) Arid eucalyptus low open woodlands with tussock grass

(20.) Mulga (Acacia aneura) 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.) Casuarina and Allocasuarina forests and woodlands
(27.) Mallee eucalyptus low open woodlands
(28.) Tall shrublands
(29.) Mallee heath and shrublands
(30.) Heath + Banksia woodlands and shrublands
(31.) Chenopod shrublands
(32.) Other shrublands
(33.) Spinifex Hummock Grasslands
(34.) Mitchell Grass (Astrebla) tussock grasslands
(35.) Blue Grass (Dicanthium) and Tall Bunch Grass (Chrysopogon) tussock grasslands
(36.) Other tussock grasslands
(37.) Other Grasslands
(38.) Herbland, Sedgeland and Rushland
(39.) Mixed Chenopod, Samphire and Forblands
(40.) Mangroves, tidal mudflat and coastal samphire
(41.) Bare areas, rock, sand, claypan, salt lakes and lagoons
(42.) Freshwater lakes
(43.) Unclassified native vegetation
(44.) Not natural

g. Subregional Constraints to Consolidate NRS

(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- describe
(v) Other - describe

h. Species/Ecosystem Recovery Actions

(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 building required with community, landholders, industry and institutions (specify)
(xiv) Other – describe

i. NRM Actions

(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 (specify)
(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.
(xi) Other –describe

Appendix C - Rankings

1. Reliability Rank
   - (i) Anecdotal
   - (ii) Qualitative
   - (iii) Quantitative and qualitative
   - (iv) Quantitative

2. Rank - Condition
   - (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)
   - (iv) Near pristine

3. Rank – Trend in status/condition
   - (i) Extinction e.g. targeted research has not observed species in recent times or no record in last 20 years
   - (ii) Status/condition rapidly declining e.g. < 10 year time frame
   - (iii) Status/condition declining
   - (iv) Status/condition static
   - (v) Status/condition improving
   - (vi) Unknown

4i. Rank – NRS (Bioregional Priority 1-5)

Refer to Appendix D

The draft classification in Appendix D is based only on extent reserved (adequacy) and level of vegetation cover remaining at a subregional level.

Review this classification of priority bioregions for reserve consolidation and change to a higher primary classification (1-5) if:

- (i) Significant threatening processes exist
- (ii) The reserve system is highly biased in terms of C.A.R. criteria and is not comprehensive or representative in terms of ecosystem representation

Or, to a lower priority if:

- (i) No perceived significant threatening processes
- (ii) There is limited opportunity remaining to consolidate the reserve system

Note reasons for any change to classification.

4ii Rank – NRS (Subregional Priority a,b,c)

i.e. priority <u>within</u> bioregion with (a) being highest priority eg. if 4 [i] was 5 and 4 [ii] was c the subregional rank is 5c

5. Rank – Reserve management standards
   - (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.
(iii) Good e.g. major biodiversity issues effectively managed
(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.

6. Rank – Off park conservation
   (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 park measures required, capacity exists and some achieved biodiversity outcomes
   (v) Off park measures significantly in place

7. Rank - NRM
   (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
   (v) Conservation outcomes well integrated into production/development systems

Appendix D - Reserve System Priorities, WA and national

Preliminary Bioregional National Reserve System Priorities based on reservation extent & vegetation cover only (Cummings and Hardy 2001). Western Australian bioregions are italicized and bolded.

Category	Attributes	IBRA Regions
1	IBRA Reservation Class 1 (<2%) and <30% of native vegetation cover remaining (All subregions)	***AW***, CA, CK,TNM,VVP
1	IBRA Reservation Class 1 and >30% of native vegetation cover remaining (All subregions)	***CR, DL,*** FIN, STU, ***TAN***
1	IBRA Reservation Class 1 (<2%) and <30% of native vegetation cover remaining, and > 50% IBRA region Reservation Class #	NSS
1	IBRA Reservation Class 1 (<2%) and >30% of native vegetation cover remaining, and > 50% IBRA region Reservation Class #	BBN, BHC, BRT, CP, DRP, GFU, GUC, MGD, NAN
2	IBRA Reservation Class 2 (2-5%) and <30% of native vegetation cover remaining (All subregions)	
2	IBRA Reservation Class 2 and >30% of native vegetation cover remaining (All subregions)	DAB
2	IBRA Reservation Class 2 and <30% of native vegetation cover remaining, and > 50% IBRA region NRS Class #	
2	IBRA Reservation Class 2 and >30% of native vegetation cover remaining, > 50% IBRA region NRS Class #	ARC, BBS, DMR, EIU, FLB, ***GSD***, GUP, ***JF, LSD***, MII, ML, ***MUR***, RIV
3	IBRA Reservation Class 3 (5-10%) and <30% of native vegetation cover remaining (All subregions)	
3	IBRA Reservation Class 3 and >30% of native vegetation cover remaining (All subregions)	DEU, TSE
3	IBRA Reservation Class 3 and <30% of native vegetation cover remaining, and > 50% IBRA region NRS Class #	NCP, SCP, VM
3	IBRA Reservation Class 3 and >30% of native vegetation cover remaining, > 50% IBRA region NRS Class #	CHC, CMC, ***COO***, EYB, ***GAS***, MAC, NET, ***OVP, PIL***, SEQ, STP
4	IBRA Reservation Class 4 (10-15%) and <30% of native vegetation cover remaining (All subregions)	
4	IBRA Reservation Class 4 and >30% of native vegetation cover remaining	BEL, ***HAM***, TNS, ***YAL***
4	IBRA Reservation Class 4 and <30% of native vegetation cover remaining, and > 50% IBRA region NRS Class #	***GS***
4	IBRA Reservation Class 4 and >30% of native vegetation cover remaining, > 50% IBRA region NRS Class #	***CAR***, GAW, ***GD***, MDD, ***NK***, SEH, ***SWA, VB***
5	IBRA Reservation Class 5 (>15%) and <30% of native vegetation cover remaining (All subregions)	SEC
5	IBRA Reservation Class 5 and >30% of native vegetation cover remaining (All subregions)	AA, DAC, KIN, NNC, PCK, SB, TCH, TSR, TWE, ***WAR***
5	IBRA Reservation Class 5 and <30% of native vegetation cover remaining, and > 50% IBRA region NRS Class #	KAN, MAL, ***NUL***
5	IBRA Reservation Class 5 and >30% of native vegetation cover remaining, > 50% IBRA region NRS Class #	ARP, CYP, ***ESP***, FLI, ***GVD***, SSD, TIW, WT

Appendix E - Acronyms

Acronym	Description
AFFA	Department of Agriculture, Fisheries and Forestry Australia
ANCA	Australian Nature Conservation Agency (now known as Environment Australia)
BDAC	Biodiversity Advisory Committee
CALM	Department of Conservation and Land Management
CAR	*Comprehensiveness* - includes the full range of communities recognised by an agreed national scientific classification at appropriate hierarchical levels. *Adequacy* - the maintenance of ecological viability and integrity of populations, species and communities. *Representativeness* - those sample areas that are selected for inclusion in reserves should reasonably reflect the biotic diversity of the communities
CSIRO	Commonwealth Scientific and Industrial Research Organisation
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
DRF	Declared Rare Flora
GIS	Geographic Information Systems
IBRA	Interim Biogeographic Regionalisation for Australia (version 5.1 is used for this document)
IRP	Interim Recovery Plan
IUCN	International Union for Conservation of Nature and Natural Resources (now the World Conservation Union)
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 landscaped seascapes (managed mainly for landscape or seascape conservation and recreation) and managed resource protected areas (managed mainly for the sustainable use of natural ecosystems)
NFF	National Farmers Federation
NHT	Natural Heritage Trust
NLWRA	National Land and Water Resources Audit
NRM	Natural Resource Management
NRS	National Reserve System
NVIS	National Vegetation Inventory System
REIWA	Real Estate Institute of Western Australia
RP	Recovery Plan
SAP	Salinity Action Plan
TEC	Threatened Ecological Community
TFRT	Threatened Flora Recovery Team
UCL	Unallocated Crown Land
WA039 (etc)	Labeling system for wetlands in Western Australia to be cross referenced with the Directory of Important Wetlands in Australia
WATSCU	Western Australian Threatened Species and Communities Unit
WWF	World Wildlife Fund/World Wide Fund for Nature

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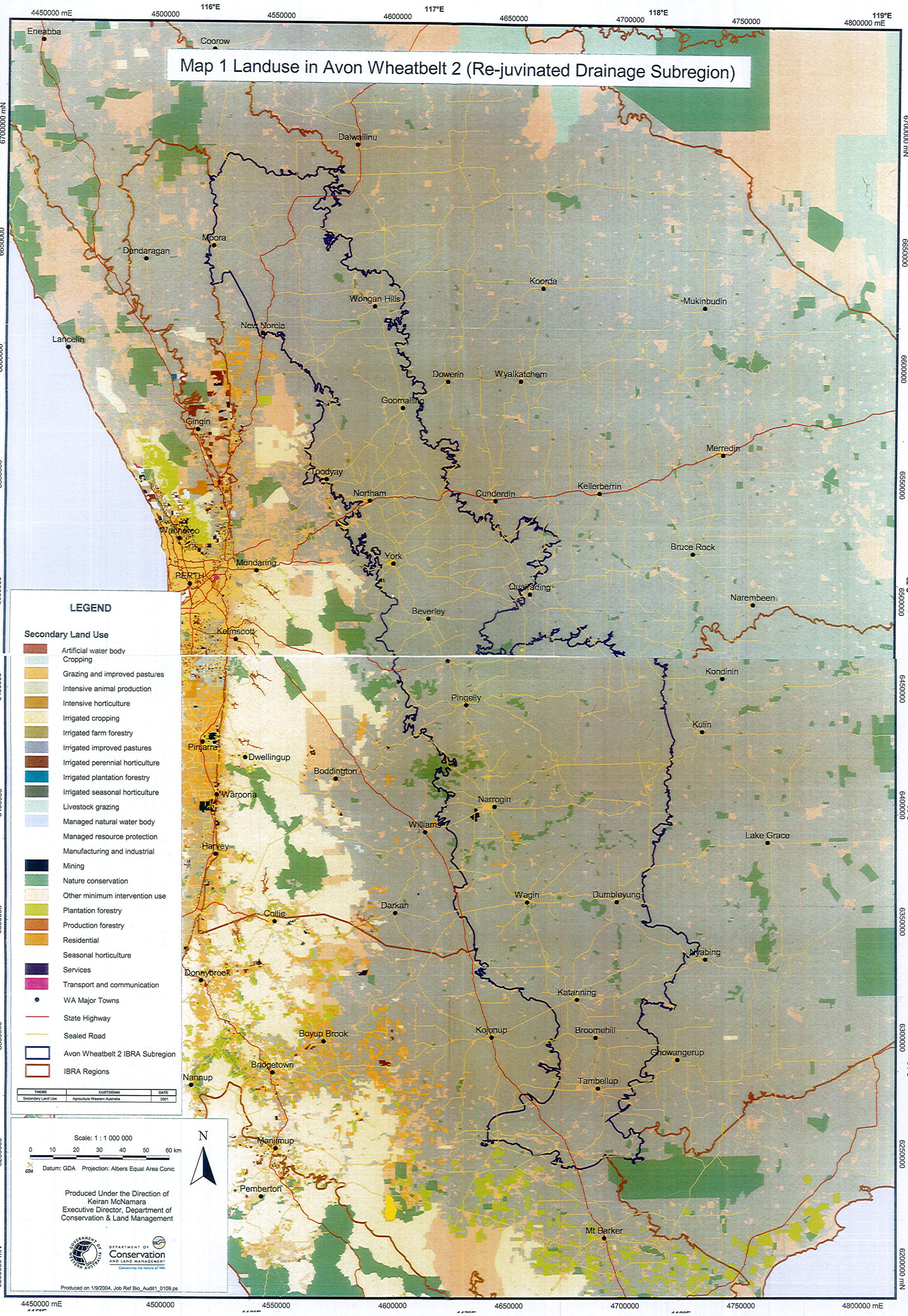
Map 1 Landuse in Avon Wheatbelt 2 (Re-juvinated Drainage Subregion)



LEGEND

Secondary Land Use

- Artificial water body
- Cropping
- Grazing and improved pastures
- Intensive animal production
- Intensive horticulture
- Irrigated cropping
- Irrigated farm forestry
- Irrigated improved pastures
- Irrigated perennial horticulture
- Irrigated plantation forestry
- Irrigated seasonal horticulture
- Livestock grazing
- Managed natural water body
- Managed resource protection
- Manufacturing and industrial
- Mining
- Nature conservation
- Other minimum intervention use
- Plantation forestry
- Production forestry
- Residential
- Seasonal horticulture
- Services
- Transport and communication
- WA Major Towns
- State Highway
- Sealed Road
- Avon Wheatbelt 2 IBRA Subregion
- IBRA Regions

THEME	CUSTODIAN	DATE
Secondary Land Use	Agriculture Western Australia	2001

Scale: 1 : 1 000 000

0 10 20 30 40 50 60 km

GDA Datum: GDA Projection: Albers Equal Area Conic

N

Produced Under the Direction of
Keiran McNamara
Executive Director, Department of
Conservation & Land Management

Government of Western Australia

Department of Conservation and Land Management
Conserving the nature of WA

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Map 2 Landscapes of more than 10,000 ha with more than 25% remnant vegetation in Avon Wheatbelt 2 (Re-juvinated Drainage Subregion)

Eneabba
Coorow
Dalwallinu
Moora
Dandaragan
Wongan Hills
Koorda
Mukinbudin
New Norcia
Lancelin
Dowerin
Wyalkatchem
Goomalling
Gingin
Merredin
Toodyay
Northam
Cunderdin
Kellerberrin
Wanneroo
Bruce Rock
York
Mundaring
PERTH
Quairading
Narembeen
Fremantle
Beverley
Kelmscott
Brookton
Kondinin
Pingelly
Mandurah
Kulin
Pinjarra
Dwellingup
Boddington
Waroona
Narrogin
Williams
Lake Grace
Harvey
Wagin
Dumbleyung
Darkan
Bunbury
Collie
Nyabing
Donnybrook
Katanning
Kojonup
Broomehill
Boyup Brook
Gnowangerup
Bridgetown
Tambellup
Manjimup
Pemberton
Mt Barker

LEGEND

- Target Landscapes
- Avon Wheatbelt 2 IBRA Subregion
- IBRA Regions
- Remnant Vegetation
- WA Major Towns
- State Highway
- Sealed Road

THEME	CUSTODIAN	DATE
Target Landscapes	CALM	2003
Remnant Vegetation	Agriculture Western Australia	2003

Scale: 1 : 1 000 000

0 10 20 30 40 50 60 km

GDA Datum: GDA Projection: Albers Equal Area Conic

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4450000 mE 115°E 4500000 4550000 116°E 4600000 4650000 117°E 4700000 4750000 118°E 4800000 mE 119°E

6700000 mN 6650000 6600000 6550000 6500000 6450000 6400000 6350000 6300000 6250000 6200000 mN

30°S 31°S 32°S 33°S 34°S