A Conservation Case Study of Western Australia's Mitchell Subregion (North Kimberley 1) 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 G. Graham and N.L. McKenzie

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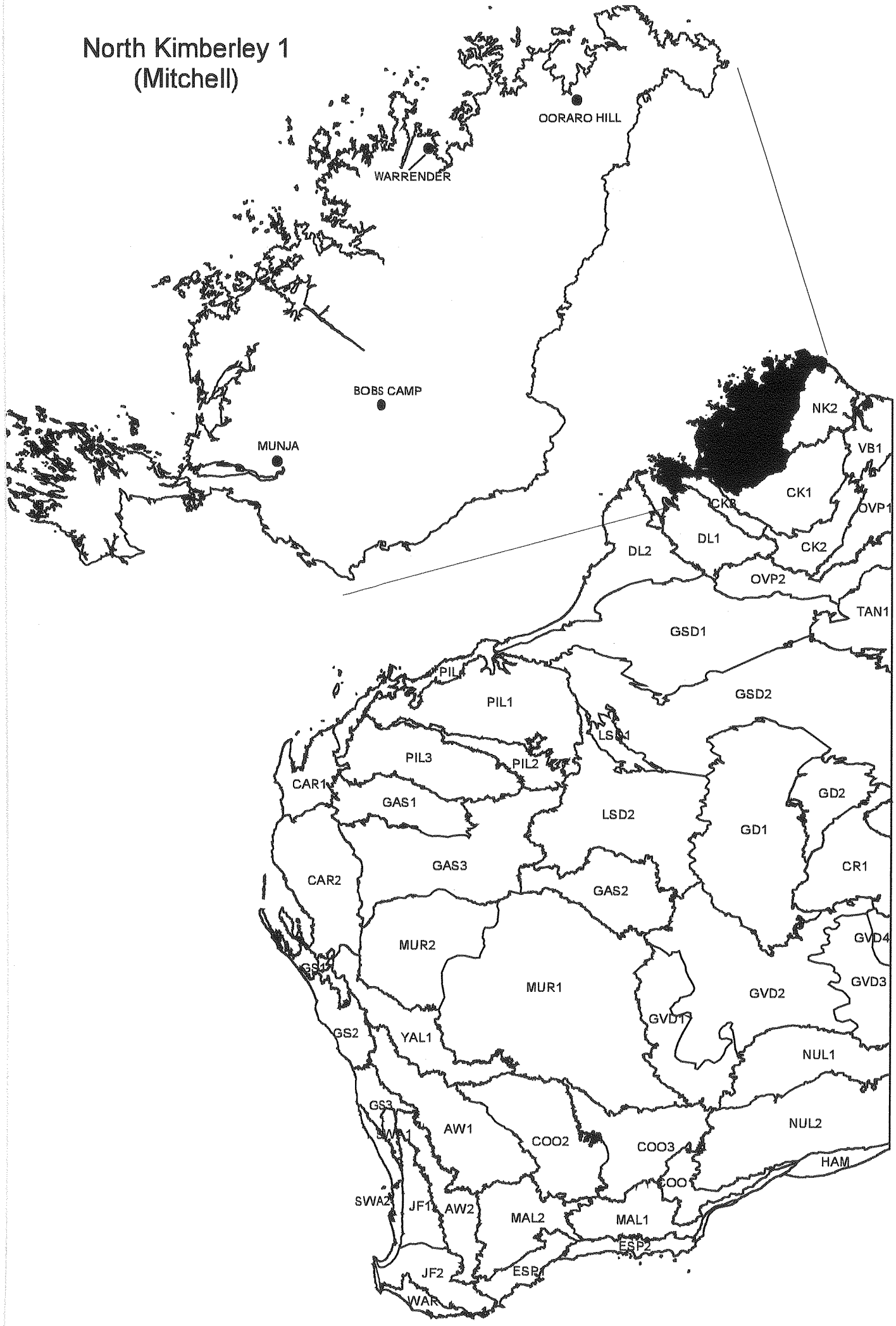
Front cover photography
Common rock rat. Photo by Babs and Bert Wells/CALM.

Back cover photography
Screw pines on the edge of Surveyors Pool, Mitchell Plateau.
Photo by Norm McKenzie.


North Kimberley 1
(Mitchell)
OORARO HILL
WARRENDER
BOBS CAMP
MUNJA
NK2
VB1
CK1
CK3
OVP1
DL1
DL2
CK2
OVP2
TAN1
GSD1
GSD2
PIL
PIL1
LSD1
PIL3
PIL2
CAR1
GAS1
LSD2
GD2
GD1
CR1
GAS3
CAR2
GAS2
MUR2
GVD4
GS1
MUR1
GVD3
GVD2
GVD1
GS2
YAL1
NUL1
GS3
NUL2
SWA1
AW1
COO2
COO3
HAM
COO
SWA2
JF1
AW2
MAL2
MAL1
ESP2
JF2
ESP1
WAR

Foreword

This booklet is an environmental case study of the Mitchell subregion, within the North Kimberley Bioregion, and a follow-up to Western Australia's first published biodiversity conservation snapshot – the Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002.

The investigations undertaken to date have shown that the Mitchell subregion, whilst still having its full suite of flora and fauna, is experiencing a decline in environmental health caused by threatening processes including altered fire regimes, weeds, cats, cattle, donkeys and pigs. Future risks include the imminent arrival of cane toads.

This publication offers specific management recommendations for the subregion in the wake of the threatening processes already identified.

Unfortunately, indications are that there will be a continuing general deterioration of land, water, flora and fauna unless management action is taken.

The Gouldian finch, crested shrike-tit, loggerhead turtle and olive turtle are endangered while three mammals (golden bandicoot, golden-backed tree rat and Butler's dunnart), three birds (red goshawk, Australian painted snipe and partridge pigeon) and four turtle species are vulnerable. The State Government is supporting the design and implementation of recovery actions for several animals including the Gouldian finch, golden bandicoot, golden-backed tree rat and turtles, and is supporting the urgent need to undertake systematic benchmark surveys of the subregion's natural resources. Although many important fauna species are present, there is little current information to quantify their status and trend. The subregion's island archipelagos are expected to become increasingly important as refuges.

Through a variety of agency and community oriented programs, including the development of regional strategies by Natural Resource Management groups, the State Government will continue to address the environmental threats posed to this and other Western Australian subregions. It is recognised that effective outcomes will only be achieved through partnerships and improved understanding of the processes affecting biodiversity.

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 Terrestrial Biodiversity Audit (National Land and Water Resources Audit 2002). This project was followed by 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, North Kimberley 1 (Mitchell subregion). It provides a more thorough appraisal of the subregion's conservation requirements and includes three maps relevant to these issues. It is a companion volume to a case study written about the Avon Wheatbelt's Re-juvenated Drainage subregion (AW2) as 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 authors. 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) and are referred to in this document. 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 Mitchell 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. More 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 changed fire regimes, 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. Compared to elsewhere in WA, conservation issues in the Mitchell subregion can be categorised as needing rehabilitation, rather than restoration or resurrection. As such, success should be manageable.

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 authors thank the Western Australian Museum, Perth Herbarium, Western Australian Threatened Species and Communities Unit (WATSCU), Nathan Eaton, Greg Keighery, Sue McKenna, John Woinarski and many others.

This case study was carried out with the assistance of Jelena May (scientific editor and page layup), David Robinson and 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. Authors Gordon Graham and Norm McKenzie invite 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'.

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Description, biodiversity values and conservation issues

Description and area

The Mitchell subregion is the dissected plateau of the Kimberley Basin. Savannah woodland over tall *Sorghum* grasses and hummock grasses occur on shallow sandy soils associated with outcropping Proterozoic siliceous sandstone strata. Savannah woodlands over tall *Sorghum* grasses occur on red and yellow earths mantling basic Proterozoic volcanic strata. Riparian closed forests of *Melaleuca* and *Pandanus* occur along drainage lines. Areas of laterite upland support open eucalypt forests. A prominent feature is the rugged sunken coastline with extensive mangal occurring in estuaries and deep, sheltered embayments. Numerous small patches of monsoon rainforest are scattered through the district. The climate is sub-humid hot tropical, with a high summer rainfall of between 1,100mm and 1,500mm. The subregional area is 6,079,985ha.

Broad scale vegetation mapping of the area describes the following components:

- mangroves;
- *Eucalyptus* spp., *Eucalyptus miniata* (woollybutt) often with *Eucalyptus tetrodonta* (Darwin stringybark) open-woodland, with *Triodia bitextura* (curly spinifex) and *Sorghum* spp. grasses;
- *Eucalyptus tectifica* (Darwin box) often with *Eucalyptus grandifolia* (large-leaved cabbage gum) and/or *Corymbia byrnesii* (fan-leaved bloodwood) woodland, with *Sorghum* spp. and *Sehima nervosum* (whitegrass) tall grasses;
- *Eucalyptus miniata* (woollybutt) grassy woodland;
- *Eucalyptus tetrodonta* (Darwin stringybark) and *Eucalyptus miniata* (woollybutt) and/or *Corymbia bleeseri* (rusty-barked bloodwood) woodland with *Sorghum* spp. tall grasses; and
- monsoon rainforests and semi-deciduous vine thickets (on scree slopes, mudflats, riparian zones and in gullies).

Dominant land use

Land uses in the Mitchell subregion (NKI) include grazing - native pastures (ix), Aboriginal reserves (x), unallocated Crown land (UCL) and Crown reserves (xi), and conservation (xiii). Refer to Map 1 – Landuses in North Kimberley 1 (Mitchell subregion) in the fold out section at the back of this document. Appendix B, key b contains the full list of landuses defined by the National Land and Water Resources Audit (2002).

Continental Stress Class

The Mitchell subregion has a Continental Stress Class of 6. This stress class indicates that the subregion is in relatively good condition and provides the opportunity for cost-effective and sustainable biodiversity conservation (Morgan 2001).

Known special values

Rare features:
These include:

- a sunken coastline with extensive coastal archipelagos from Buccaneer to Sir Graham Moore Island that form a microcosm of the subregion and present an opportunity to protect intact ecosystems - in particular Augustus Island (17,952ha) and Bigge Island (17,190ha) are large, near-coastal, uninhabited islands with no known feral animals and a diverse, intact terrestrial fauna;
- mound springs and swamp rainforest;
- Middle Osborn Island, which is a volcanic plug;
- tropical laterite flora characterised by *Livistona eastonii* fan palm community - this is the only palm-dominated landscape in Western Australia;
- largely intact flora and fauna of the north-western margin;
- No hooved feral animals on the Cape Bougainville rainforest on laterite and volcanics. The total area of rainforest is approximately 1,000ha, comprised of a series of disjunct patches, some of which reach 100ha in size. This represents the largest area of rainforest in the Kimberley);
- Airfield Swamp on the Mitchell Plateau (a large, perched, paperbark forest wetland);
- the Prince Regent lineament encompassing the Prince Regent River;
- Critical Weight Range mammal fauna persists in this subregion (Burbidge and McKenzie 1989).

There are animals of special interest such as:

- golden bandicoot (*Isoodon auratus*),
- scaly-tailed possum (*Wyulda squamicaudata*),
- Monjon (*Petrogale burbidgei*),
- Nabarlek (*Peradorcas concinna*),
- golden-backed tree-rat (*Mesembriomys macrurus*),
- Kimberley rock-rat (*Zyzomys woodwardi*),
- rough-scaled python (*Morelia carinata*) and
- black grasswren (*Amytornis housei*)

The subregion is fox and rabbit free and essentially uninhabited. It is estimated that the total number of permanent residents is less than 500 people.

Centres of endemism:
Endemic vertebrates:

- mammal species including the scaly-tailed possum (*Wyulda squamicaudata*) and the Monjon (*Petrogale burbidgei*) (Strahan 1995);
- the black grasswren (*Amytornis housei*);
- snake species *Ramphotyphlops howi*, *R. yampiensis* and the rough-scaled python (*Morelia carinata*);
- dragon species *Diporiphora convergens*, *D. superba* and *Pogona microlepidota*;
- gecko species *Diplodactylus mcmillani*, *Gehyra occidentalis*, *G. xenopus*, *Oedura filicipoda*, *O. gracilis*, *O. obscura* and *Pseudothecadactylus cavaticus*;
- skink species *Carlia johnstonei*, *Ctenotus burbidgei*, *C. ehmanni*, *C. mastigura*, *C. yampiensis*, *Cyclodomorphus maximus*, *Glaphyromorphus brongersmai*, *Lerista kalumburu*, *L. praefrontalis* and *L. walkeri*;
- frog species including the cave-dwelling frog (*Litoria cavernicola*), fat toadlet (*Uperoleia crassa*) and the marbled toadlet (*U. marmorata*).

Endemic plants
Vascular plants include:

- *Acacia kenneallyi*,
- *A. smeringa* (Packhorse Range),
- *Gossypium londonderriense* (Cape Londonderry),
- *Grevillea cravenii* (Princess May Range, Prince Regent Nature Reserve),
- *G. donaldiana* (Sale River),
- *G. maherae* (Mount Elizabeth),
- *G. microstyla* (Bachsten Creek),
- *Hibiscus peralbus*,
- *Typhonium peltandroides* (Grevillea Gorge, Beverley Springs),
- *Auranticarpa resinosa* (Hunter River – this species may be extinct) and
- *Hibbertia ledifolia*.

The cycads, *Cycas basaltica* and *Cycas lane-poolei* appear to be endemic to this subregion (Wheeler *et al.* 1992).

Rainforest patches
Rainforest patches are particularly important to invertebrates such as Camaenid land snails and annelids (eg. Solem 1991). The Camaenid land snails (currently approx 100 known species) show strongly localised patterns of endemism, with large numbers of endemic species and several endemic genera. All the rainforest patches studied to date have endemic earthworm species associated with them. There is one rainforest endemic plant (*Hibiscus peralbus*).

Refugia:
The nature of this aspect is poorly known. All rainforest patches provide dry season refuge, as do mangroves and riparian zones. Further research is required to define the extent to which this aspect may apply to sandstone country because the structure of this landscape provides areas protected from fire (McKenzie *et al.* 1991).

High species and ecosystem diversity:
While further documentation is required, the authors consider that sandstone communities may provide areas of high species and ecosystem diversity. Rainforests are of note as they are defined by their vegetation associations and are resource centres for a variety of faunal taxa that are either directly linked to rainforests or are more widely ranging species that are dependent on them. Examples include fruit pigeons and flying foxes (McKenzie *et al.* 1991).

Existing plans or systematic reviews of biodiversity and threats

The Conservation Through Reserves Committee (CTRC) report in 1974 (System 7) formed the basis of the Department's publication "Nature Conservation Reserves in the Kimberley" (Burbidge *et al.* 1991) and recommendations from this will be incorporated in a Departmental Draft Regional Management Plan (Portlock *et al.* 2001). These reports were focused on non-production lands and areas not likely to be prospective for minerals. Action statements and strategies in the draft regional management plan did not go to the scale of bioregion or subregion. There has been some biological survey work published for the islands of the north-west Kimberley coast, the Prince Regent Nature Reserve and the Mitchell Plateau. These surveys occurred more than 20 years ago and there is a need to resample these areas for comparative purposes (McKenzie *et al.* 1991).

Apart from specific survey work, there has been no systematic review of biodiversity but on-going changes to the status of fauna (particularly mammals) are reported. There is reasonable evidence about continuing changes to vegetation structure (e.g. loss of shrub layer), composition (e.g. perennial vs. annual grasses), vegetation cover, leaf litter, and organics in the upper soil horizon. It is generally recognised that flow-on effects of changes in the physical components of the environment, vegetation structure changes and other factors (e.g. exotic predators) can have significant effects on fauna, as has been shown in the Northern Territory.

Wetlands of national significance (DIWA listings)

Table 1: Name, category, condition, trend, reliability and threatening processes of DIWA listed wetlands.

Name and Code	Description	Current Condition	Trend in Condition	Reliability	Threatening Processes
Mitchell River System WA063	Permanent rivers and streams; includes waterfalls (B1)	Near pristine (iv)	Unknown (vi)	Quantitative and qualitative (iii)	Changed fire regimes (vii), grazing pressure (iv)
Prince Regent River System WA064	Permanent rivers and streams; includes waterfalls (B1)	Near pristine (iv)	Unknown (vi)	Quantitative and qualitative (iii)	Changed fire regimes (vii)
Yampi Sound Training Area WA115	Primarily coastal environments with some inland wetlands.	Good (iii)	Declining (iii)	Quantitative and qualitative (iii)	Changed fire regimes (vii)

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 2: Name, location, category, special values, condition, trend, reliability and threatening processes affecting wetlands of subregional significance (in addition to DIWA listed wetlands in Table 1).

Name	Location	Description	Special values	Current condition	Trend in condition	Reliability	Threatening processes
Walcott Inlet System including Munja Lagoon, lower reaches of Isdell and Charnley Rivers.	16°25'S 124°50'E	Riverine floodplains (B4), Seasonal freshwater lakes (B6)	Significant for maintenance of ecological processes at subregional scale (ii)	Near pristine (iv)	Static (iv)	Qualitative (ii)	Threatening processes not yet identified
Airfield Swamp – Mitchell Plateau	14°46'14"S, 125°49'02"E	Freshwater swamp forest (B14)	Supports significant number of plant and animal taxa including migratory species (iv)	Near pristine (iv)	Static (iv)	Qualitative (ii)	Grazing pressure (iv)
Glauerts Lagoon – Mitchell Plateau		Permanent freshwater lakes (B5)	Supports significant number of plant and animal taxa including migratory species (iv)	Near pristine (iv)	Static (iv)	Qualitative (ii)	Grazing pressure (iv)

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

This includes all fringing vegetation of riparian zones. The condition of these areas is described as good (iii), recovery would occur in short term with minimum intervention (see appendix C, rank 2) and their trend in status and condition is declining (see appendix C, rank 3).

The threatening process (see appendix B, key e) known to be affecting the zones include changed fire regimes (vii), grazing pressure by introduced herbivores (iv), feral animals (primarily unmanaged stock but including predation by cats) (v), changed hydrology (x) and exotic weeds (vi). This information is based on quantitative and qualitative data (iii) (see appendix C, rank 1).

Threatened Ecological Communities

Table 3: 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
Black Spring organic mound spring community.	E	Sub-tropical rainforest (2)	Good (iii)	Static (iv)	Quantitative and qualitative (iii)	Grazing pressure (iv), changed fire regimes (vii)
Organic mound springs of the southern North Kimberley Bioregion.	V	Sub-tropical rainforest (2)	Fair (ii)	Declining to rapidly declining (ii-iii)	Quantitative and qualitative (iii)	Grazing pressure (iv), changed fire regimes (vii)
Roe River swamp rainforest.	V	Sub-tropical rainforest (2)	Unknown	Static (iv)	Quantitative and qualitative (iii)	Threatening processes not yet identified, though cattle are likely to be having an impact
Theda Soak rainforest.	V	Sub-tropical rainforest (2)	Good (iii)	Static (iv)	Quantitative and qualitative (iii)	Grazing pressure (iv), changed fire regimes (vii)
Walcott Inlet rainforest swamp.	V	Sub-tropical rainforest (2)	Unknown	Static (iv)	Quantitative and qualitative (iii)	Threatening processes not yet identified, though cattle are likely to be having an impact

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). E = Endangered, V = Vulnerable.

Other ecosystems at risk

Table 4: 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
Savannah communities of which *Callitris intratropica* is a component.	V	Tropical mixed species forests and woodlands (11)	Fair (ii)	Declining (iii)	Quantitative and qualitative (iii)	Changed fire regimes (vii)
Rainforest patches of the Kimberley savannah generally. Examples are rainforest patches on the Mitchell Plateau and in the supratidal flats.	V	Sub-tropical rainforest (2)	Fair to good (ii-iii)	Declining (iii)	Quantitative and qualitative (iii)	Grazing pressure (iv), Changed fire regimes (vii)
Flora and fauna assemblages of upland swamps of the Kimberley. On laterite plateaus and sandstone (Airfield Swamp and Beverley Springs Station).	V	Melaleuca forest and woodlands (15), Herbland, sedgeland and rushland (38)	Good to near pristine (iii-iv)	Static (iv)	Qualitative (ii)	Grazing pressure (iv)
Assemblages of permanent/ephemeral wetlands, damplands, and riparian habitat of the Kimberley region.	V	Melaleuca forest and woodlands (15), Herbland, sedgeland and rushland (38),	Fair (ii)	Declining (iii)	Qualitative (ii)	Grazing pressure (iv), Changed fire regimes (vii)

Ecosystem	WA status	NVIS	Current condition	Trend in condition	Reliability	Threatening process
		Freshwater lake (42)				
Invertebrate community in creek near Pago Mission.	V	N/A	Unknown	Static (iv)	Quantitative and qualitative (iii)	Threatening processes not yet identified
Eucalyptus tectifica community of the Gibb River and Mt. Barnett areas.	V	Low tropical eucalyptus forests and woodlands (10)	Fair (ii) - needs investigation	Declining (iii)	Qualitative (ii)	Changed fire regimes (vii)
Eucalyptus jensenii woodlands of Gibb River and Mt. Barnett areas.	V	Low tropical eucalyptus forests and woodlands (10)	Fair to good (ii)-(iii) - needs investigation	Declining (iii)	Qualitative (ii)	Changed fire regimes (vii)
Plant assemblages of sand plain seepage areas between and near sandstone ridges	V	Herbland, sedgeland and rushland (38)	Fair to good (ii)-(iii)	Unknown (vi)	Anecdotal (i)	Grazing pressure (iv), Changed fire regimes (vii)
Riparian communities dominated by *Phragmites karka*. Charnley River on Beverley Springs Station.	V	Unclassified native vegetation (43)	Fair (ii) - needs investigation	Unknown (vi)	Anecdotal (i)	Grazing pressure (iv), Changed fire regimes (vii)
Herbfields of sandstone pavements of the northwest Kimberley.	V	Herbland, sedgeland and rushland (38)	Good (iii)	Unknown (vi)	Anecdotal (i)	Possibly changed regimes but investigation needed (vii)

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

The threatening process of changed fire regimes is of primary concern and this affects a wide variety of vegetation associations at the landscape level. Ongoing research is required to identify the scale of the impact as it relates to ecosystems at risk that have not yet been recognised. There is an urgent need to undertake studies to identify the current status of biodiversity at the specific (species, ecosystem) and landscape scales.

Fauna species at risk

Table 5: 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)					
Isoodon auratus auratus	V	Fair (ii)	Declining (iii)	Qualitative (ii)	Changed fire regimes (vii), Feral animals (v)
Mesembriomys macrurus	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified – possibly changed fire regimes (vii) and feral animals (v)
Sminthopsis butleri	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Rhinonicteris aurantius	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Schedule 1; Rare/likely to become extinct, Division 2 (Birds)					
Erythrura gouldiae	E	Fair (ii)	Declining (iii)	Qualitative (ii)	Changed fire regimes (vii)

Species	Status	Current condition	Trend in condition	Reliability	Threatening processes
Falcunculus frontatus whitei	E	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Erythrotriorchis radiatus	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Malurus coronatus coronatus	V	Fair (ii)	Declining (iii)	Qualitative (ii)	Changed fire regimes (vii), Grazing pressure (iv)
Petrophassa smithii blaauwi	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Changed fire regimes (vii)
Schedule 1; Rare/likely to become extinct, Division 3 (Reptiles)					
Caretta caretta	E	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified. Threats on other subregions include fishing bycatch (xii), overhunting (xii), pollution (xi), feral animals (v)
Lepidochelys olivacea	E	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified. Threats on other subregions include fishing bycatch (xii), overhunting (xii), pollution (xi), feral animals (v)
Chelonia mydas	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified. Threats on other subregions include fishing bycatch (xii), overhunting (xii), pollution (xi), feral animals (v)
Dermochelys coriacea	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified. Threats on other subregions include fishing bycatch (xii), overhunting (xii), pollution (xi), feral animals (v)
Eretmochelys imbricata	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified. Threats on other subregions include fishing bycatch (xii), overhunting (xii), pollution (xi), feral animals (v)
Natator depressus	V	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified. Threats on other subregions include fishing bycatch (xii), overhunting (xii), pollution (xi), feral animals (v)
Schedule 1; Rare/likely to become extinct, Division 6 (Snails) – See Addendum on page 29					
Amplirhagada astuta	V	Further investigation required	Unknown (vi)	Qualitative (iii)	Threatening processes not yet identified, possible mining operations on Koolan Island (xii)
Carinotrachia carsoniana	V	Further investigation required	Unknown (vi)	Qualitative (iii)	Threatening processes not yet identified
Schedule 3; Birds protected under an international agreement					
Chalcophaps indica yamashinai	Schedule 3	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Schedule 4; Other specially protected fauna, Division 2 (Birds)					
Falco peregrinus	Schedule 4	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Tadorna radjah	Schedule 4	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified

Species	Status	Current condition	Trend in condition	Reliability	Threatening processes
Schedule 4; Other specially protected fauna, Division 3 (Reptiles)					
Crocodylus johnstoni	Schedule 4	Near pristine (iv)	Static (iv)	Quantitative and qualitative (iii)	No major threatening process
Crocodylus porosus	Schedule 4	Good (iii)	Improving (v)	Quantitative and qualitative (iii)	Threatening process removed - hunting
Other species at risk in the subregion					
Ardeotis australis	Near threatened	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Dasyurus hallucatus	Near threatened	Further investigation required	Unknown (vi)	Qualitative (ii)	Threatening processes not yet identified – possibly changed fire regimes (vii) and feral animals (v).
Falco hypoleucos	Near threatened	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Heteromunia pectoralis	Near threatened	Further investigation required	Declining (iii)	Anecdotal (i)	Threatening processes not yet identified – possibly changed fire regimes (vii) and feral animals (v)
Macroderma gigas	Near threatened	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Mesembriomys gouldii		Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified – possibly changed fire regimes (vii) and feral animals (v)
Peradorcas concinna	Near threatened	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Petrogale burbidgei	Near threatened	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified
Wyulda squamicaudata	Near threatened	Further investigation required	Unknown (vi)	Anecdotal (i)	Threatening processes not yet identified

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.

Declared Rare and Priority Flora

Under Western Australian legislation plant species can be listed as declared rare or priority species. There are no declared rare plant species in the Mitchell subregion.

The species listed as Priority 1 are:

- *Acacia paula*,
- *A. vincentii*,
- *Ailanthus triphysa*,
- *Colubrina asiatica*,
- *Corchorus capsularis*,
- *Didymoplexis pallens*,
- *Euphorbia sarcostemmoides*,
- *Fimbristylis pilifera*,
- *Gossypium enthyle*,
- *G. marchantii*,
- *G. pilosum*,
- *Hydrocotyle grammatocarpa*,
- *Ondinea purpurea* subsp. *petaloidea*,
- *Phyllanthus aridus*,
- *P. indigoferoides*,
- *Ptilotus crispus*,
- *Schizachyrium mitchelliana*,
- *Thysanotus banksii*,
- *Triumfetta saccata*,
- *T. trisecta* and
- *Typhonium peltandroides*.

The species listed as Priority 2 are:

- *Acacia deltoidea*,
- *Boronia filicifolia*,
- *Cleome kenneallyi*,
- *Erpodium australiense*,
- *Eucalyptus fitzgeraldii*,
- *Glycine albicans*,
- *Gossypium pulchellum*,
- *Grevillea donaldiana*,
- *G. latifolia*,
- *Lindernia macrosiphonia*,
- *Minuria macrorhiza*,
- *Myriophyllum callitrichoides* subsp. *striatum*,

- *M. costatum*,
- *Pertusaria trachyspora*,
- *Ricinocarpos marginatus*,
- *Sauropus torridus*,
- *Stylidium fimbriatum*,
- *S. rubriscapum* and
- *Triumfetta rubiginosa*.

Little is known about these species, including the condition, trend, reliability of data and threatening processes. However, changed fire regimes are likely to be a key threatening process for a number of these species. Recent changes to the Declared Rare Flora List (2003 onwards) are not included here, please refer to the Addendum at the end of this case study

Threatening processes for fauna

Isoodon auratus auratus (golden bandicoot):
The former distribution of this species was virtually the entire arid, sub-humid tropical and tropical regions of Central Australia, the Northern Territory and Western Australia extending into western New South Wales and north-western Victoria. The current distribution on the mainland is confined to the near coastal north-west Kimberley. Populations are also extant on islands of the north-west Kimberley, Arnhem Land and Pilbara coasts (the population on Barrow Island is a different sub-species, *Isoodon auratus barrowensis*).

In the last 30 years the species has been recorded at nine sites on the mainland of the Mitchell subregion. Revisits to these sites in 1988, 1994 and 1995 detected the species at three of five apparently suitable locations along the north-west Kimberley coastline (N. McKenzie *et al.* in 1988 and G. Graham in 1994-1996). DNA analysis or blood samples collected in the 1994-1996 period has determined that it is clearly a separate species to the northern brown bandicoot *Isoodon macrourus* and distinct from the animal currently considered a subspecies found on islands (*I. a. barrowensis*).

It has disappeared from more than 95 per cent of its former distribution, including sub-humid areas of the Arnhem Land escarpment. This area is equivalent to the areas in the Mitchell subregion, where it persists today as fragmented populations associated with the periphery of rainforest patches set in long unburnt savannah woodland. All sites recently identified are situated on or at the foot of sandstone scree slopes, in a few cases extending onto the adjacent volcanic soil slopes.

On Marchinbar Island (one of the Wessel Islands off the Northern Territory), the bandicoot occurs in sandstone country. While there is rainforest on the islands, it is not the preferred habitat (J. Woinarski pers. comm.). On Augustus Island, adjacent to the north-west Kimberley, populations occur both at the edge of rainforest in sandstone country and in rugged sandstone country generally. It is inferred that persisting populations on the north Kimberley mainland have contracted to an optimum niche in a productive ecotone. These areas appear to be burnt less frequently by intense wildfire activity. The locations may well afford some level of fire protection within the sandstone habitats.

The species disappeared from the south-west and eastern Kimberley and areas of the top end of the Northern Territory soon after the advent of the pastoral industry and in the absence of foxes. This appears to be linked to the introduction of a variety of species of stock and changes in fire regimes.

Activity of feral cattle and donkeys and annual broad scale burning of the savannah have only become widespread in the rugged north-west Kimberley during the last 30 years, and the apparent fragmentation of *Isoodon auratus* populations suggests the process of their extinction on the mainland is now well advanced. Many areas of apparently suitable habitat for this species in the northwest Kimberley that have been assessed, have not yielded evidence of the persistence of this easily detected species. Populations known from work in 1974 were not detected in 1988 or 1995.

Isoodon auratus forages in the organic litter layer of the soil mainly for small vertebrates and invertebrates. The elimination of these layers due to frequent burning, elimination of perennial plants and insolation drying the soil profile and oxidising the organics effectively reduces their food resource base as overall environmental productivity drops. In combination, cattle and fire shift the savannah community towards annual grassland and changes in the hydrology reduce the growing season and productivity of the soil profile. The loss of vegetation cover also increases predation risk.

In Western Australia, their persistence in the wettest, most productive periphery of their former mainland range implies productivity based mechanisms for their disappearance (Burbidge and McKenzie 1989).

Mesembriomys macrurus (golden-backed tree-rat):
The former distribution of this species includes sub-fossil records from the Exmouth area and historical records from the vicinity of Port Hedland, Dampierland, southern and eastern Kimberley and the Northern Territory. The current distribution on the mainland is from the near coastal parts of the Mitchell subregion, although populations are thought to persist in and adjacent to the Arnhem Land Plateau of the Northern Territory (N.L. McKenzie pers. comm.). Populations are also extant on islands of the north-west Kimberley.

In the north-west Kimberley of Western Australia it has been found at five island and seven mainland (rainforest patches) sites over the last 40 years. Several collections were taken from the Mitchell Plateau in 1998 to establish a captive breeding population.

The historical distribution of this animal shows it as having occupied relatively arid zones of the Northern Territory and Western Australia. It currently occupies locations in the relatively wet Mitchell subregion in locations with an annual rainfall greater than 1,000 millimetres. In 1998 the greatest success in trapping was achieved by placing traps at the interface between a patch of rainforest and the surrounding savannah. It is also regularly recorded at the Kimbolton homestead and at the pearling lease facilities at Kuri Bay where it has been reported as being a nuisance in the past. It is also known to be associated with mangroves.

All records of this species from mainland Australia in the last 25 years are from within 10km of the Mitchell subregion coastline and the relevant threatening processes have only become pervasive in this part of the region in the last 30 years. The conclusion is that its mainland extinction is imminent.

It is surmised that the threatening processes affecting this species are related to changed fire regimes (an increase in the frequency of broad scale, late dry season fires) with this possibly being linked to an increased susceptibility to predation and stock impacts on the vegetation. These threatening processes operate in the subregion at the landscape scale. It is noted that in the areas where the golden-backed tree-rat is still found the landscape offers some level of protection from fire or changes associated with threatening process impacts are either less evident or just beginning.

Sminthopsis butleri (Butler's dunnart):
This animal has been found in the vicinity of Kalumburu and on Bathurst and Melville Islands in the Northern Territory. There are no sub-fossil or historical records for the Mitchell subregion though there are several records for the period from 1910 to the 1920's in the Northern Territory. There has been very little collection effort to determine the animal's status so nothing can be conclusively stated as to its current status in Western Australia. While collected in the Northern Territory in 2002, there have been no recent collections of this animal in Western Australia. P.A. Woolley, in the treatment of this animal for 'The Mammals of Australia', did mention recent burning and the presence of cats at the original collection site near Kalumburu when visited in 1991 (Strahan 1995).

Phascogale pirata (northern phascogale):
This animal has been recorded across semi-arid and mesic parts of northern Australia from Cape York to Western Australia. There have been contractions in its historical distribution from the north east coast of Queensland and southern and eastern margins of the Kimberley and the 'Top End'.
A review of the currently accepted distribution for the Kimberley region of Western Australia (and potentially the Northern Territory) is warranted. A brief attempt at locating the animal on the Mitchell Plateau occurred in the early 1990's but was unsuccessful. During 2001 and 2002 there were several collections of this animal on the Yampi Peninsula as part of fire monitoring work undertaken by CALM for the Department of Defence. It is clear that work is required on this particular species to determine if there has been a decline.

Given that this animal is primarily arboreal in habit, needing hollows for shelter and nesting, the types of threatening process mentioned for other species are likely to be of concern. This species appears to be quite general in its use of woodlands and as such processes that operate at the landscape scale are likely to affect it.

Dasyurus hallucatus (northern quoll):
The historical distribution of this animal was across extensive areas of the Pilbara and Northern Australia to south-eastern Queensland. Its distribution appears to have contracted significantly to parts of the Pilbara, the north-west Kimberley coast, the northern parts of the Northern Territory and several coastal locations in Queensland.

This animal has been found to be quite common within the Mitchell subregion and is found in a variety of habitats from woodland to coastal vine thickets. During searches for the golden bandicoot (*Isoodon auratus*) this animal was always encountered in locations thought likely to have bandicoots present even when golden bandicoots were not trapped.

It is clear that there has been a decline of this animal from the drier parts of its former distribution. In the Kimberley it is now located only in areas with an annual rainfall greater than 1,000mm.

The threatening processes in the Mitchell subregion are uncertain. However susceptibility to disease and predation are mentioned as the most likely processes leading to its loss from parts of its former range. Investigations are warranted into the possible impacts of broad scale processes in the Kimberley such as changed fire regimes.

Macroderma gigas (ghost bat):
This bat is currently located in the Pilbara and then in a continuous distribution from the Kimberley, across northern Australia, with an extensive distribution across much of Queensland. Historical occurrences are recorded in the central mid-west of Western Australia and parts of the central and southern Northern Territory. Sub-fossil records occur through most of the Northern Territory extending into central eastern Western Australia. Sub-fossil records are also present for mid-west coastal areas.

This animal occurs in a wide range of habitats but has specific requirements during its daytime resting as an obligate troglodyte.

It is generally considered that there has been a northward range contraction in the species' distribution, indicating a contraction to better rainfall

areas in their former distribution and a generally more tropical climate.

Little is known of what threatening processes might have caused a decline in the range of this bat throughout its distribution. It can be surmised that its specialised roosting requirements have changed little since European settlement and in some locations there has been an increase in the availability of this type of habitat with the establishment of mine shafts. Indications are that the problem is one of resource availability for foraging through the decline in available prey. Nothing is known of the threatening processes in the Mitchell subregion.

Peradorcas concinna (Nabarlek):
This species is found in the northern parts of the Northern Territory and the islands and mainland of the north-west Kimberley. Further work is required on the distribution and biology of this species. It has been recorded only occasionally in recent years in the Kimberley.

For the Kimberley there is no information on threatening process. However changed fire regimes may be causing a decline and feral cats are found throughout its distribution.

Wyulda squamicaudata (scaly-tailed possum):
This species is endemic to the Kimberley and is restricted to a patchy distribution within the Mitchell subregion. It is found in very rugged, rocky country and has only been recorded occasionally. Its status and the threatening processes that might affect it are unknown.

There is one historical record from the south-east Kimberley but some doubt has been cast on its veracity. All current records are in areas that receive greater than 900mm of annual rainfall; the south-east Kimberley is in a zone receiving less than 600mm of annual rainfall.

There is no information on threatening processes.

Petrogale burbidgei (Monjon):
This relatively recently described species (1978) is restricted in its distribution to the Mitchell subregion.

It has been seen in very remote, rugged sandstone country where, at the Mitchell Plateau and on Bigge Island, large numbers have been recorded.

Current threatening processes are unknown. However it has been postulated that future exploitation of bauxite deposits on the Mitchell Plateau could possibly have a negative impact. Predation by feral cats may be affecting its abundance on the mainland. Changed fire regimes since Aboriginal people moved to settlements may also be affecting the species (Maxwell *et al* 1996).

Mesembriomys gouldii (black-footed tree-rat):
This rodent is currently found in north-east Queensland including parts of the Cape York Peninsula, northern parts of the Northern Territory, Melville Island and the north-west Kimberley. There are historical records for all of the northern areas of the Northern Territory.

There are general indications that there has been a contraction in distribution from more inland areas. This implies that the species is contracting to the wetter areas of its distribution.

Nothing is known of the threatening processes in the Mitchell subregion but it is highly likely that there have been changes in the understorey and a decline in hollow availability due to altered fire regimes.

Rhinonicteris aurantius (orange horseshoe bat):
This animal is distributed from the gulf country of eastern Queensland, through the top end of the Northern Territory, across much of the Kimberley region and parts of the Pilbara region of Western Australia.

Little is known of threatening process that might affect it but it is known to be highly sensitive to human disturbance and will abandon caves if subject to frequent human disturbance.

Erythrura gouldiae (Gouldian finch):
This finch is found from Queensland to the Kimberley region of Western Australia. The distribution of the species is highly fragmented with this showing a decline from a previously more continuous occurrence throughout its range. The species is recorded irregularly in Queensland but is consistently seen in the east Kimberley where flocks of up to a hundred birds have been recently recorded. It is also regularly seen in the vicinity of Kalumburu in the Mitchell subregion.

A parasitic mite was originally thought to be a primary reason for the decline of the species but it is now thought that threatening processes operating at the landscape scale are more likely to help explain the situation. In particular the impact of cattle grazing and changed fire regimes are held responsible for the decline of this, and many other, granivorous bird species.

Falcunculus frontatus whitei (crested shrike-tit):
The distribution of the crested shrike-tit was from the top end of the Northern Territory across the Kimberley to the western Kimberley. While found within the range of its former distribution, this is now very fragmented and the bird is recorded only very occasionally.

Generally it is considered that birds that forage on bark are naturally in lower densities in northern Australia

than southern Australia but the decline of this species indicates that a number of populations are at such low densities as to be no longer viable. Indications are that hot fires affecting large areas of the landscape in a single event is the primary threatening process that is operating. There is a resource impact in that the populations of invertebrates upon which the species feeds do not reach the necessary levels to support the bird across its range. There is a lack of information on the status and the trends in that status for this species.

Erythrotriorchis radiatus (red goshawk):
This bird is distributed from eastern Australia through Queensland, the top end of the Northern Territory and the Kimberley region of Western Australia. There are several recent records from Central Australia. The bird may naturally be at a low density across its distribution.

No data exists for the threatening processes that may be operating within the Mitchell subregion. Elsewhere land clearing for agriculture has been identified as a major threat however the death of nesting trees caused by fire and the general disruption by large fires in the breeding season may be contributing factors.

Malurus coronatus coronatus (purple-crowned fairy-wren):
This bird was formerly found in Western Australia along major rivers and creeks such as the Fitzroy, Isdell, Drysdale, Durack, Pentecost and Ord Rivers. In the Northern Territory it was found along the Victoria River and its tributaries. There has been a rapid and dramatic reduction in its distribution with it no longer found on the upper reaches of the Pentecost River or lower reaches of the Fitzroy River. It is no longer found at several locations on the Ord River where it was recorded in the 1960's and early 1970's.

It is considered that cattle accessing water eat and trample the favoured riparian habitat of this species. This is linked with changed fire regimes damaging the riparian vegetation and increasing the prevalence of weeds. General rangeland degradation, with increased run-off, has also led to increased flood energy that damages riparian vegetation. At one location at the southern end of Lake Argyle a good population of this fairy-wren was found in a dense and well-established stand of the declared weed, *Parkinsonia aculeata*.

Petrophassa smithii blaauwi (partridge pigeon):
This subspecies was found only within 100 kilometres of the coast in the west and north-west of the Kimberley region. At times it was reported as being very numerous. Since the 1970's it has not been seen in large numbers and there appears to be a contraction in its distribution, although it is seen regularly on the Mitchell Plateau.

Indications are that the best habitat for this bird displays a spatial and temporal mosaic that was mostly due to the traditional burning practices of Aboriginal people. For this reason the loss of a traditional burning regime and the shift to predominantly late, dry season fires affecting large areas is the most likely primary threatening process.

Falco hypoleucos (grey falcon):
This bird is found in sparse numbers over much of arid and semi-arid Australia. There is evidence that there are regular movements into northern Australia and it is known to move from areas affected by drought. There is little evidence that the bird is in decline across its range and the status of the bird as a visitor or resident to the Mitchell subregion is unknown.

There is no data on the threatening processes that might impact upon this species in the Mitchell subregion.

Heteromunia pectoralis (pictorella mannikin):
This bird's distribution is across much of the Kimberley region, the top end of the Northern Territory to north-eastern Queensland. The highly mobile nature of this species makes it difficult to assess the species' status and trends in that status.

It is considered that the primary threatening processes that are affecting all northern Australian granivorous bird species are also affecting this species but there is no specific documentation of this. Those processes are cattle grazing and changed fire regimes.

Ardeotis australis (Australian bustard):
The Australian bustard was historically found throughout Australia but has disappeared from south-eastern Australia and is considered less abundant south of the tropics. It is regularly seen in the Mitchell subregion but there have been no systematic surveys to determine its status or the trends in that status.

There is a perceived decline in northern Australia generally where illegal hunting and traditional hunting using modern techniques is considered to be affecting the population at some locations.

Caretta caretta (loggerhead turtle):
This species has a global distribution with nesting occurring mostly in subtropical areas. Within Western Australia breeding occurs on Dirk Hartog Island and the Muiron Islands. Nothing is known of the threatening processes that might be occurring in Western Australia except that there is some annual mortality from the impact of pelagic long line fisheries, the extent of which is unknown.

Lepidochelys olivacea (olive ridley):
This species has a global distribution with large numbers nesting in India and the east Pacific. There are no records of nesting for Western Australia and little is known of the threatening processes operating in Western Australia. The only known threat to this species in Western Australia is as a bycatch in prawn trawling operations, where low numbers being taken has been recorded.

Chelonia mydas (green turtle):
This species has a global distribution with nesting occurring mostly in tropical areas. In Western Australia breeding has been recorded at the Lacepede Islands, Barrow Island, Montebello Islands, Dampier Archipelago in the North West Cape area, Scott Reef, Browse Island and Ashmore Reef. The impacts of threatening processes are not quantified in Western Australia but possibly include as a bycatch of trawling operations and harvesting of adults and eggs by indigenous communities.

Dermochelys coriacea (leathery turtle or leatherback turtle):
This species has a global distribution with nesting occurring in tropical areas. The animal is rarely encountered in Australia, where it is estimated that there are between two and six sightings off the mid-west coast per year. It is occasionally caught in lobster pot float lines in the south-west of the State.

Eretmochelys imbricata (hawksbill turtle):
This species has a global distribution with nesting occurring mostly in tropical areas. The Western Australian population is the only large population for the species remaining in the entire Indian Ocean. Breeding in Western Australia occurs at Rosemary Island, Varanus Island and the Montebello Islands. Threatening processes affecting the Western Australian population are unknown.

Natator depressus (flat-backed turtle):
This species is confined to the tropical areas of the Australian continental shelf. Island nesting is centred on the Muiron Islands, Thevenard Island, Barrow Island, Montebellos Islands, the Dampier Archipelago in the North West Shelf area and on some Kimberley Islands, such as Troughton Island. Mainland nesting occurs at Mundabullangana Station in the Pilbara and at Cape Domett in the Kimberley. Nothing is known of the threatening processes affecting this species although there is some indigenous harvesting of eggs.

Threatening processes for flora

There are no Declared Rare Flora species listed under State legislation in the Mitchell subregion. Presented here are plant species listed under State legislation as either Priority 1 or Priority 2. Priority 1 are taxa which are known from one or a few (generally less than five) populations which are under threat, either due to small population size or being on lands under immediate threat (road verges, urban areas, farmland, active mineral leases, etc.) or the plants are under threat from disease or grazing by feral animals. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey. Priority 2 are taxa known from one or a few (generally less than five) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

For all the species within the Mitchell subregion the records have come from opportunistic collection and not from any rigorous scientific survey process.

Acacia deltoidea subsp. *ampla*:
Forty-one collections of this Priority 2 plant are held at the Western Australian Herbarium. This shrub is endemic to the Kimberley region with the subspecies being recorded in the Mitchell subregion on the Bougainville Peninsula and at the Lawley River associated with sparse shrub communities with *Triodia*, shrubland, and *Eucalypt* woodland, primarily on sand over sandstone, but also with quartzite outcrops

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Acacia paula:
Three collections of this Priority 1 plant are held at the Western Australian Herbarium. It is endemic to the Mitchell subregion, being found in the Mitchell Plateau area. This low sub-shrub has only been found on laterite soils associated with eucalypt/*Livistona eastonii* woodland. This habitat is very extensive within the subregion but is not accessed easily, such as from a limited number of tracks or from the coast.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Acacia vincentii:
The four collections of this Priority 1 plant held at the Western Australian Herbarium are those made by W.V. Fitzgerald in August 1905 from the Edkins Range Area. The plant is a shrub growing up to three metres high. No habitat details are given with these collections.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Ailanthus triphysa (white bean):
Two collections of this Priority 1 plant are held at the Western Australian Herbarium. It has been recorded from near King Cascade within the Prince Regent Nature Reserve. This evergreen tree is also found in Queensland and New South Wales and ranges from India through Southeast Asia.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Boronia filicifolia:
Ten collections of this Priority 2 plant are held at the Western Australian Herbarium. This many-branched

shrub is apparently endemic to the Mitchell subregion, being recorded from Montague Sound, Port Warrender, Mitchell River and Kalumburu. It has been collected from open, tall, eucalypt woodland on sandstone and from amongst sandstone and quartzite rocks.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Cleome kenneallyi:
Two collections of this Priority 2 plant are held at the Western Australian Herbarium. This is considered as endemic to the Mitchell subregion being recorded from the Mitchell Plateau and the Prince Regent River where it has been found in dense thickets in shallow sandy soil on dissected sandstone.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Colubrina asiatica:
One collection of this Priority 1 plant is held at the Western Australian Herbarium. The collection of this perennial, scrambling shrub was from Koolama Bay where it was collected on white sand next to mangroves at the base of sandstone cliffs.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Corchorus capsularis:
One specimen from the St. George Basin of this Priority 1 plant is held at the Western Australian Herbarium and this sub-shrub was collected from the edge of a vine thicket. In 'Flora of the Kimberley Region' (Wheeler 1992) this is called *Corchorus* sp. A. The plant also occurs in the Northern Territory, in India and Southeast Asia.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Didymoplexis pallens:
Two collections of this Priority 1 plant are held at the Western Australian Herbarium. This leafless orchid has been collected at Bachsten Creek in the Edkins Range where it was found in wet grassland.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Erpodium australiense:
Three collections of this Priority 2 plant are held at the Western Australian Herbarium. This moss has been collected from Adcock Gorge, at Beverley Springs Station and in Windjana Gorge where it was taken from the bark of trees in vine thickets and riparian situations.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Eucalyptus fitzgeraldii:
Nineteen collections of this Priority 2 plant are held at the Western Australian Herbarium. This tree is endemic to the Kimberley Region and has been recorded from Cape Bougainville to Beverley Springs Station. It is found in open savannah woodland on red clay soils on basalt and in red soils on rocky basalt hillsides.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Euphorbia sarcostemmoides:
Two collections of this Priority 1 plant are held at the Western Australian Herbarium. This shrub was collected in the 1970's on Mount Augustus Station (Gascoyne Bioregion) and in the Barnett Gorge from a rocky hillside.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Fimbristylis pilifera:
A single collection by W.V. Fitzgerald in 1905 of this Priority 1 plant is held at the Western Australian Herbarium. This annual herb is considered endemic to the Kimberley Region and was collected at the southern edge of the Mitchell subregion at Bold Bluff in the King Leopold Range.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Glycine albicans:
Five collections of this Priority 2 plant are held at the Western Australian Herbarium. It is endemic to the Mitchell subregion where it is found at the Mitchell Plateau.

This sub-shrub is has been mostly found in loam laterite and gravelly soils in open savannah woodland comprised of either *Eucalypt* or *Terminalia* species.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Gossypium enthyle:
Three collections of this Priority 1 plant are held at the Western Australian Herbarium. This perennial, multi-stemmed sub-shrub has been found west of the Mitchell Falls, east of York Sound and south east of Donkin's Hill on laterite in *Eucalyptus miniata/E. tetrodonta* woodland and in woodland on an open boulder strewn slope in skeletal sandy soil on sandstone.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Gossypium marchantii:
Three collections of this Priority 1 plant are held at the Western Australian Herbarium. All collections of the spreading, perennial shrub have come from the Bougainville Peninsula. The locations it has been collected from were the edge of a vine thicket along the base of a basalt cliff, skeletal soil over laterite, in a vine thicket and in shrubland with *Terminalia canescens*, *T. volucris*, and from an area of *Hakea* and vine thicket species along a rocky ridge with a sandstone substrate.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Gossypium pilosum:
Twenty three collections of this Priority 1 plant are held at the Western Australian Herbarium. This shrub is endemic to the region, occurring between Port Warrender and the Mitchell Plateau where it has been found in black, sandy soil overlying sandstone in Eucalypt woodland, on lateritic loam in low open woodland, on deep red clay over laterite in *Eucalyptus miniata/E. tetrodonta* woodland and in *Eucalyptus/Livistona eastonii* woodland.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Gossypium pulchellum:
Six collections of this Priority 2 plant are held at the Western Australian Herbarium. This shrub is apparently endemic to the region occurring around Vansittart Bay where it has been collected from sandy areas among tall *Sorghum* grasses.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Grevillea donaldiana:
Four collections of this Priority 2 plant are held at the Western Australian Herbarium. This large shrub or tree is endemic to the Mitchell subregion being so far recorded only along the Sale River where it has been collected from sandstone scree slopes below massive sandstone cliff faces.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Grevillea latifolia:
Fourteen collections of this Priority 2 plant are held at the Western Australian Herbarium. This shrub is endemic to the Kimberley Region, recorded from the Mitchell Plateau to Pentecost Downs Station being collected from laterite and quartz soils and deep alluvial sandy soils in woodland.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Hydrocotyle grammatocarpa:
A single record from Mt. Elizabeth Station of this Priority 1 plant is held at the Western Australian Herbarium. This annual herb also occurs in the Northern Territory.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Lindernia macrosiphonia:
Six collections of this Priority 2 plant are held at the Western Australian Herbarium. This annual herb is endemic to the region being recorded from the Mitchell Plateau to Kalumburu where it has been collected from sandstone, among boulders or on skeletal soil and in pockets of sandy soil in open vegetation.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Minuria macrorhiza:
Fifteen collections of this Priority 2 plant are held at the Western Australian Herbarium. It has been collected from red clay sites over basalt and exposed sheets of basalt, on laterite in *Eucalyptus/Livistona* woodland and in *Eucalyptus* woodland with very dense grasses. This perennial herb occurs from Carson River to Walcott Inlet and near Mt. Barnett. It also occurs in the Northern Territory.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Myriophyllum callitrichoides subsp. *striatum*:
Three collections of this Priority 2 plant are held at the Western Australian Herbarium. This aquatic annual herb is also found in the Northern Territory but in Western Australia it is known only from along the Mitchell River where it occurs in still waterholes over sandstone. This subspecies is endemic to the subregion.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Myriophyllum costatum:
Two collections of this Priority 2 annual, aquatic herb are held at the Western Australian Herbarium. This species appears to be endemic to the subregion where it is found in mud and billabongs.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Ondinea purpurea subsp. *petaloidea*:
Thirty-three collections of this Priority 1 plant are held at the Western Australian Herbarium. The subspecies *petaloidea* is found only in a few seasonal creeks in the Mitchell River region. Likewise the subspecies *purpurea* is restricted to the Kalumburu area. The two subspecies of this perennial aquatic plant are endemic to the subregion.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Pertusaria trachyspora:
One collection of this Priority 2 plant is held at the Western Australian Herbarium. The holotype collection of the species came from the Camp Creek area on the Mitchell Plateau where it was collected from the upper surfaces of branches.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Phyllanthus indigoferoides:
Three collections of this Priority 1 plant are held at the Western Australian Herbarium. All collections of the erect, many-branched shrub are from York Sound by A. Cunningham in 1820. There have been no subsequent collections and as such there is little information on this species.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Ptilotus crispus:
Seven collections of this Priority 1 plant are held at the Western Australian Herbarium. This ephemeral, prostrate herb is probably endemic to the subregion, as it has only been recorded north of Kalumburu where it was found on outcropping sandstone rocks with yellow sand, broken sandstone in *Eucalyptus* woodland and on coastal dunes behind mangroves.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Ricinocarpos marginatus:
Two collections of this Priority 2 plant are held at the Western Australian Herbarium. This shrub is endemic to the subregion, as it has only been found on the Mitchell Plateau, near the Mitchell River and at the Montague and York Sounds in fissures in massive sandstone adjacent to a creek and in *Eucalyptus* woodland on rocky slopes.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Sauropus torridus:
Three collections of this Priority 2 plant are held at the Western Australian Herbarium. The only collections of this erect, perennial shrub have been from the vicinity of the Mitchell Plateau airstrip where it has been found on a flat plain adjacent to a creek and in damp clay on a laterite scree slope amongst *Eucalyptus miniata* and *Livistona eastonii*.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Schizachyrium mitchelliana:
One collection of this Priority 1 plant is held at the Western Australian Herbarium. This tufted annual is an endemic to the subregion, being known from a single specimen from the Mitchell Plateau.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Stylidium fimbriatum:
Four collections of this Priority 2 plant are held at the Western Australian Herbarium. All collections of this ephemeral, short-lived herb are from the Bachsten Creek area where it has been found in a damp, sandy herbfield near a creek.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Stylidium rubriscapum:
Nine collections of this Priority 2 plant are held at the Western Australian Herbarium. This sprawling, annual herb is endemic to the subregion being found from Prince Regent River, Mt. Elizabeth Station and the Packhorse Range where it is found in damp herbfields on loamy soils usually adjacent to watercourses.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Thysanotus banksii:
Six collections of this Priority 1 plant are held at the Western Australian Herbarium. This perennial herb has

been recorded at the Mitchell Plateau in seepage areas on sandstone in skeletal alluvium, in sand associated with hummock grassland and on rocky laterite loam in a *Eucalyptus/Livistona* low open forest. It also occurs in the Northern Territory, Queensland and New Guinea.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Triumfetta rubiginosa:
Two collections of this Priority 2 plant are held at the Western Australian Herbarium. The collections came from Kings Cascade and Blyxa Creek in the Prince Regent Nature Reserve among sandstone boulders in low open woodland.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Triumfetta saccata:
Two collections of this Priority 1 plant are held at the Western Australian Herbarium. This perennial herb has been found on the southern side of Langgi Cove and north east of Halls Creek (Hart Subregion) from hummock grassland on sandstone scree slopes.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Triumfetta trisecta:
One collection of this Priority 1 plant is held at the Western Australian Herbarium. This low shrub was collected in 1980 adjacent to the King Edward River from shallow sand on a sandstone pavement.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Typhonium peltandroides:
Three collections of this Priority 1 plant are held at the Western Australian Herbarium. It is a large geophyte found in Grevillea Gorge on Beverley Springs Station among boulders in a rainforest, in humus soil.

The full extent of its current distribution is not known nor any changes in its distribution in the recent past. No threatening processes have been identified.

Threatening processes for ecological communities

Black Spring organic mound spring community:
This community is categorised as Endangered at the State level and is found on a Crown reserve within Drysdale River Station towards the eastern side of the Mitchell subregion.

The community is a raised peat mound that is permanently moist to wet and supports a small patch of low woodland of *Melaleuca viridiflora*, *Ficus spp.*, *Timonius timon*, and *Pandanus spiralis* over taro *Colocasia esculenta* and the fern *Cyclosorus interruptus*. The very tall grass *Phragmites karka* dominates the outer edge of the mound and the entire mound is ringed by a moat of water supporting sedges and grasses.

The mound is a small unique feature within a broader savannah woodland environment and is approximately 0.25 hectares in extent. It is considered that floristic and vegetation structural changes have occurred to this community because of the impact of threatening processes but the size of the mound has remained unchanged. Conservation measures were attempted when the spring was fenced in 1993.

Prior to fencing significant damage to the mound was occurring through cattle trampling and grazing. Trampling of the mound was causing pugging of the soil and this disturbance may have exacerbated the drying out of the mound. Also at that time weeds such as *Hyptis suaveolens* invaded the central area and a mango tree (*Mangifera indica*) had been planted. Since fencing, the main threat to the community has come from frequent, and often intense, wildfire. With the fencing of the community, and no fire management activity, a significant build up of fuel in the surrounds of the spring occurs. There are indications that as a result of frequent fires, the fire prone plant species of the mound are being gradually killed. Further documentation of this is required.

Organic mound spring community of the southern North Kimberley Bioregion:
This group is categorised as Vulnerable at the State level and there are four independent occurrences listed. The mounds generally support sedgeland with sparse *Melaleuca nervosa*, *Pandanus spiralis*, and/or *Banksia dentata*. Visually there is usually a large, moist to wet area dominated by sedges and grasses surrounded by a ring of the larger plant species. They usually do not display the same structural characteristics of other mound springs that have a central raised humus and clay mound surrounded by an ephemeral wet moat. The sedge species present on these mound springs are those restricted to the periphery of wetlands and creeks, or broad drainage depressions on sandier soils where grasses dominate. Other mound springs surveyed in the Kimberley Region have rainforest woodland components. Further work is urgently required to describe the four mound springs in more floristic detail.

These mounds are small unique features in a broader savannah woodland environment and are approximately 10 hectares in extent in total. It is considered that floristic and vegetation structural changes have

occurred to this community because of the impact of threatening processes but the size of the mounds has remained unchanged. Conservation measures have been implemented for two of the mounds with fencing being undertaken by the station leaseholder with material being purchased using Commonwealth grant funds.

For those springs not fenced the ongoing threatening process is the trampling and grazing activity of cattle. At times these areas are affected by inappropriate fire regimes.

Roe River swamp rainforest:
This community is categorised as Vulnerable at the State level. The lithology of the site is Quaternary alluvium and King Leopold Sandstone and Hart dolerite. The subsurface soil is very dark grey sand. The Kimberley Rainforest Survey recorded a leaf litter depth of five centimetres, rainforest canopy height as 16 metres and perennial plant species richness at 29, bird species richness at 24 and total community species richness at 67 (McKenzie *et al.* 1991). This community is two hectares in size and is located in the Prince Regent Nature Reserve.

The vegetation found in this community identifies it as being a rainforest patch. Tree species include:

- *Aglaia elaeagnoidea*,
- *Alphitonia excelsa* (red ash),
- *Alstonia actinophylla*,
- *Antidesma ghaesembilla*,
- *Bombax ceiba* (kapok tree),
- *Carallia brachiata*,
- *Cryptocarya cunninghamii*,
- *Ficus hispida*,
- *Lophostemon grandiflorus*,
- *Melaleuca viridiflora*,
- *Melastoma malabathricum*,
- *Memecylon pauciflorum*,
- *Nauclea orientalis* (Leichhardt),
- *Polyalthia australis*,
- *Pouteria sericea*,
- *Syzygium angophoroides*,
- *Syzygium forte* (wild apple),
- *Timonius timon*,
- *Trema tomentosa* var. *viridus* (poison peach), and
- *Vitex acuminata*.

When surveyed in 1987 it was reported that the impact of cattle on this community was widespread and severe. The impact of fire was recorded as severe throughout the stand. Studies are under way documenting the deleterious combined impacts of cattle and inappropriate fire regimes on rainforest patches. Cattle extensively use these patches as refuges from heat and in doing so open the patches up, trample the fragile litter layer and introduce savannah grasses. The drying out of the patch allows fires to impact more extensively on the vegetation at the edge of the patches that in turn opens up the patch and increases drying conditions causing a repeated cycle of increased fire impacts over time. Rainforest species sensitive to fire are quickly eliminated from the stand and the ongoing impacts can rapidly cause the loss of the community. It is important that this site is revisited to assess the extent of the damage today as compared to 1987.

Theda Soak rainforest:
This community is categorised as Vulnerable at the State level. In the Kimberley Rainforest Survey it was described as a small patch around a spring-fed soak on a floodplain. It occurs adjacent to an ephemeral creek 0.5 kilometres from a major tributary of the Morgan River. It was described as being a discrete patch of rainforest on a moderate slope. The lithology is Quaternary alluvium, the subsurface soil is a very dark grey sandy loam and a leaf litter depth of 10cm was recorded during the survey. The height of the rainforest canopy is 20 metres. The survey recorded a perennial plant species richness of 17, bird species richness at 12, and a total species richness of 36. Most of the Camaenid land snails recorded in the survey are restricted endemics in the Kimberley (McKenzie *et al.* 1991).

The trees include:

- *Albizia lebbeck* (Indian siris),
- *Antidesma ghaesembilla*,
- *Bombax ceiba* (kapok tree),
- *Garuga floribunda*,
- *Glochidion disparipes*,
- *Ficus opposita* (sandpaper fig),
- *Ficus racemosa* var. *racemosa* (cluster fig),
- *Litsea glutinosa*,
- *Melaleuca leucadendra*,
- *Sesbania formosa* (white dragon tree),
- *Sterculia quadrifida* (redfruit kurrajong),
- *Syzygium nervosus* and
- *Terminalia microcarpa*.

The historical extent of the community is presumed to be similar to its current 0.8 hectares and it is located on the Theda pastoral lease. When surveyed in 1987 cattle impacts on this community were recorded as being widespread and severe. This impact is usually evidenced by the opening up of the patch, trampling and destruction of the leaf litter layer and the increased potential for the introduction of savannah grasses, particularly around the perimeter of the patch. This increases the risk of fire impacting upon the community.

Conservation measures have been implemented with the patch being fenced in 1993. This fencing was undertaken by the station leaseholder with materials being purchased through a Commonwealth grant fund. When visited in 1999 parts of the fence were down and cattle were in the patch, indicating that a regular inspection and maintenance schedule is warranted.

Walcott Inlet swamp rainforest
This community is categorised as Vulnerable at the State level. The Kimberley Rainforest Survey sampled three known occurrences of this community, which, being on swampy terrain adjacent to sandstone ridges,

was described as markedly different from other patches of rainforest surveyed at the time.

One patch was described as a swamp fed by streams from sandstone hills and appearing to be part of a broad watercourse. Water drains from the swamp towards the tidal mud flats. At the time of survey (June 1987) there was free water to at least 30 centimetres deep in the central part of the swamp. Higher ground with a tall *Melaleuca leucadendra* forest occurs in the centre of the swamp area. The soils are generally highly organic and in places composed of layers with different textures. The vegetation comprised closed-canopy rainforest to 30 metres in height, dominated by *Ficus* spp., Leichhardt (*Nauclea orientalis*), and *Celtis philippinensis* over mangrove fern (*Acrostichum speciosum*) one to three metres high. During the survey, the tree species *Cordia subcordata* and the snail species *Torresitrachia* sp., were recorded at a single patch.

The lithology of the three occurrences is Quaternary alluvium and the subsurface soil is black silty clay, black sandy clay loam and a very dark grey sandy loam. Leaf litter depth was seven centimetres at one site and 10 centimetres at the other two. The height of the rainforest canopy was measured at 15, 20 and 27 metres. The survey recorded perennial plant species richness at 31, 96, and 33; bird species richness at 20, 36, and 15; and, total species richness of 59, 142, and 57 (McKenzie *et al.* 1991).

The historical extent of these patches is presumed to be the same as the current extent (one hectare, five hectares and 0.5 hectares). One patch is within a proposed conservation reserve.

The threatening processes have been described as cattle and fire. Cattle impacts were described as 'widespread and severe' (McKenzie *et al.* 1991) at all three locations with trampling and the opening up of the patches through tree death evident. Fire impacts were recorded as severe throughout the stands for two patches and minor on exposed stand edges for one. These patches are at the interface between sandstone savannah and the mudflats of the Walcott Inlet. The upslope side of the patches abuts savannah woodland with an annual grass understorey and the down slope side abuts the mudflat devoid of vegetation. Fires affecting the savannah will impact the patches to differing extents depending on the how dry the patches might be. Fires that occur in the savannah toward the end of the dry season are more likely to have a greater impact because of the patches being much drier at this time of the year.

Conservation through reserves

Appropriate methodologies for reserve system design

Conservation reserve systems are assessed in terms of three criteria: comprehensiveness, adequacy and representativeness (CAR). Our methodology for reserve selection in this study was based on a Geographic Information System (GIS) query. Its aim was to identify and list, in order of their potential contribution to the comprehensiveness, adequacy and representativeness of the entire bioregion's reserve system, unreserved land parcels with as many as possible of the region's 20 unreserved vegetation associations within them. This was done for all unreserved land tenure types, including proposed reserves such as at Walcott Inlet. Output included the following details on each land parcel: land tenure type, vegetation associations (with codes), how many areas of each are present, and contribution to reserve system adequacy and representativeness.

The number of unreserved threatened ecological communities (TECs) is also considered. The methodology includes a manual assessment of TECs that are too small for the 1:250,000 scale GIS assessment to identify. The limitations of each option for acquisition are discussed, as well as the question of urgency of acquisition (e.g. is it degrading fast?).

Three previous reserve system assessments cover the North Kimberley bioregion[1]:

- Conservation Through Reserves Committee: (Environmental Protection Authority 1981) (System 7) and Environmental Protection Authority (1993)
- Kimberley Regional Planning study: Burbidge *et al.* (1991).
- Recommendations from the Kimberley Rainforest survey: McKenzie and Belbin (1991).

A number of the reserves they recommend for the region remain undeclared (refer to Map 2 in the fold out section a the back of this document):

- Cape Londonderry Unallocated Crown Land (UCL)
- King George River UCL
- Mount Agnes - Mount Hann extension to southeast corner of the Prince Regent River Reserve (*ca.* 30 km X 30 km square in the Mount Jameson UCL)
- Bonaparte Archipelago (Prince Regent and Bigge Groups) UCL
- Osborne Islands UCL
- Doubtful Bay UCL

[1] Reserve planning is discussed for the North Kimberley bioregion, rather than for the Mitchell subregion in isolation.

- Isdell River UCL
- Buccaneer Archipelago UCL
- An array of rainforest patches recommended for reservation, some of which are in the UCL areas listed above and others on pastoral leases.

The appraisal uses the vegetation map units defined by Beard (1979) at the 1:250,000 scale, recently updated and digitised (Beard and Hopkins Vegetation Database unpublished). These are used to identify targets (Table 6) and then to reassess the existing reserve system in terms of optional land parcels recognisable in the region (see 'Gap analysis' section). We do not address the issue at the level of the individual Department of Land Administration Pin numbers that comprise many of these parcels, although they are listed under the relevant land parcel name in the 'output' table in Appendix F, and can be treated separately for acquisition purposes.

Table 6: Beard vegetation associations that are not reserved in the North Kimberley bioregion.

Beard Veg Assoc	Description	Area in Bioregion (ha)
12	Medium woodland-tropical; Darwin stringybark (*Eucalyptus tetrodonta*) and woollybutt (*Eucalyptus miniata*).	7,274
43	Low forest; mangroves.	8,657
60	Grasslands, tall bunch grass savannah woodland, Darwin box (*Eucalyptus tectifica*) and cabbage gum (*Eucalyptus* grandifolia*) over ribbon grass (*Chrysopogon* spp).	47,170
61	Grasslands, tall bunch grass savannah woodland, coolibah over ribbon grass (*Chrysopogon* spp).	17,443
75	Grasslands, curly spinifex, low tree savannah woodland; scarlet gum (*Eucalyptus phoenicea*) and *Eucalyptus ferruginea* over *Triodia bitextura*.	1,193
125	Bare areas; salt lakes.	89
589	Mosaic: Hummock grasslands, grass steppe; curly spinifex (*Triodia bitextura*).	26
744	Grasslands, tall bunch grass savannah sparse low tree; *Acacia suberosa* and bauhinia (*Bauhinia cunninghamii*) over Mitchell and ribbon/blue grass (*Astrebla* spp./*Chrysopogon* spp./*Bothriochloa* spp.) on black soil.	4,249
754	Shrublands, pindan; *Acacia tumida* shrubland with woollybutt (*Eucalyptus miniata*) and cabbage gum (*Eucalyptus grandifolia*) medium woodland over ribbon grass (*Chrysopogon* spp) and curly spinifex (*Triodia bitextura*).	9,915
773	Grasslands, high grass savannah low tree, bloodwood (*Eucalyptus* spp.) and Darwin box (*Eucalyptus tectifica*) over whitegrass (*Sehima nervosum*) and/or upland tall grass.	10,672
800	Grasslands, high grass savannah woodland; Darwin stringybark and woollybutt (*Eucalyptus miniata*) over (upland tall grassland) curly spinifex (*Triodia bitextura*).	267,377
807	Grasslands, tall bunch grass savannah sparse low tree; acacia over grass on black soil.	1,346
808	Grasslands, curly spinifex (*Triodia bitextura*), low tree savannah; snappy gum (*Eucalyptus brevifolia*) over curly spinifex (*Triodia bitextura*).	5,255
814	Hummock grasslands, low steppe woodland; silver-leaved box (*Eucalyptus pruinosa*) and *Melaleuca* over *Plectrachne*.	61,579
835	Grasslands, high grass savannah woodland; Darwin box (*Eucalyptus tectifica*) and *Eucalyptus greeniana* over spinifex and whitegrass (*Sehima nervosum*).	59,510
838	Grasslands, high grass savannah woodland; ghost gum (*Eucalyptus bella*) and bloodwood (*Eucalyptus polycarpa*) over spinifex and tall upland grass.	3,579
902	Hummock grasslands, low tree steppe; scattered low rare eucalypts in open curly spinifex (*Triodia bitextura*).	11,322
907	Grasslands, high grass savannah woodland; ghost gum (*Eucalyptus bella*) and bloodwood (*Eucalyptus polycarpa*) over ribbon (*Chrysopogon* spp.) and tall upland grass.	10,954
914	Grasslands, high grass savannah woodland; Darwin box (*Eucalyptus tectifica*) and *Eucalyptus greeniana* over kangaroo (*Themeda australis*) and whitegrass (*Sehima nervosum*).	4,312
8001	Grasslands, curly spinifex (*Triodia bitextura*), low tree savannah; bloodwood (*Eucalyptus* spp.) and woollybutt (*Eucalyptus miniata*) over curly spinifex (*Triodia bitextura*) on islands.	209,565

* For consistency with Beard descriptions the use of *Corymbia* for the bloodwood eucalypts has not been adopted in this table.

Subregional constraints

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

There are three main constraints on reserve acquisition in both Mitchell and Berkeley subregions of the North Kimberley Bioregion. These are:

Competing land uses:
These include pastoral production in the southern and western parts of the bioregion

Economic constraints:
High land prices for pastoral leases.

Other:
Our knowledge of biodiversity patterns across the bioregion's landscape does not have enough resolution to accurately define all acquisition priorities on the ground.

Priority for reserve consolidation

The North Kimberley bioregion has a Preliminary Bioregional National Reserve System (NRS) priority rank of 4 (see Appendix D, and Appendix C, rank 4). However this may need to be 3 due to the continued impact of inappropriate fire regimes and uncontrolled stock grazing. There is a strong bias in the reserve system because most ecosystems are not reserved (see Table 6 and analysis below) and many of these are being grazed, and have been grazed the longest, and are burnt most often at high intensity. There is insufficient data on the condition of the Berkeley subregion to compare this to the Mitchell subregion in terms of prioritising between the two.

Reserve management standard

The North Kimberley Bioregion conservation reserve system comprises three national parks, three conservation parks, one nature reserve and an area of leasehold owned by CALM (Table 7). In terms of their management standard, the bioregion is ranked at poor (i) to fair (ii) (see Appendix C, rank 5). Apart from the donkey control program undertaken by the Department of Agriculture (WA), there are no concerted feral animal control programs in place. There is limited strategic aerial prescribed burning along with some opportunistic hand burns, with the latter being confined to very small areas of the Mitchell subregion. This is aimed at establishing lines of burnt country in an attempt to stop the progress of wildfires. The extent of other threatening processes, for example weeds, are yet to be determined. Due to uncontrolled stock access, changes are occurring within parks particularly in valley systems and noticeably within the Mitchell subregion.

Table 7: Existing conservation estate in the North Kimberley Bioregion, and management issues.

Estate	Area (ha)	IUCN Category	Rank	Issues
Mitchell River National Park	115,325	II	Fair (ii)	Management ability is being developed. Currently one ranger on location during the tourist season. Full extent of threatening processes (fire, weeds, feral animals) need to be documented. Stock impact occurring.
Lawley River National Park	17,572	II	Poor (i)	Remote and inaccessible. Issues have not been identified. Inappropriate fire regimes of note.
Drysdale River National Park	448,264	II	Poor (i)	No documentation of impacts over time. Biological survey undertaken in the 1970's. No knowledge of visitation. Degree of impact of uncontrolled fire is an important consideration but little studied.
Laterite Conservation Park	12,191	II	Fair (ii)	Location makes the park accessible. Small amount of biodiversity assessment being undertaken. Full extent of threatening processes (fire, weeds, feral animals) need to be documented. Stock impact occurring.
Camp Creek Conservation Park	1,267	II	Poor (i)	Rainforest monitoring being undertaken on the impact of stock grazing and fire. Stock impact occurring.
King Leopold Ranges Conservation Park	50,000 approx.	II	Fair (ii)	Accessed for tourism. Stock impact occurring. Qualitative evidence of changes to the vegetation of valleys due to changes in the fire regimes.
Prince Regent Nature Reserve	634,952	IA	Poor (i)	Full extent of threatening processes (fire, weeds, feral animals) need to be documented. Current status of critical weight range mammals unknown. Stock impact occurring.
Charnley River UCL	26,000 approx	--	Poor (i)	Remote and inaccessible. Issues have not been identified. Inappropriate fire regimes of note. Full extent of threatening processes (fire, weeds, feral animals) need to be documented. Stock impact occurring.

See Appendix C (rank 5) for ranking information.

Gap analysis

Lands in the North Kimberley Bioregion occur as discrete parcels, and acquisition options are influenced by their availability. Many parcels are subject to indigenous land claims, already exist as indigenous lands or are owned by indigenous corporations as pastoral leases. Availability is determined by land use and tenure commitments as well as political factors so, in practice, the order in which lands are added to the reserve system is unlikely to be optimal, or even efficient, in the context of improvements to the CAR conservation reserve system. This means that explicit reserve selection processes will be confounded by the eclectic reality of land acquisition in this region.

A second issue is the oversimplified and distorted representation of actual biodiversity patterns provided by maps of vegetation associations, so selection processes that are too finely tuned are probably meaningless. Nevertheless, John Beard's 1:250,000 vegetation maps are still the only systematic representation of biological patterns across the region. In contrast, surface geological and CSIRO land-unit maps are not digitised, and provide even less resolution within most of the major units mapped.

In the context of the North Kimberley, the preferred method for initial reserve selection is a GIS query on the vegetation association layer. The output table (summary in Table 8; whole table in Appendix F) lists each unreserved land parcel in the region in terms of its potential contribution to the bioregional conservation reserve system and shows which, if any, of the 20 unreserved vegetation associations are present. The output table (Table 8) allows priorities to be set for acquisition among all unreserved land parcels, including proposed reserves such as Walcott Inlet. The query and corresponding data-base are archived so that as each parcel is acquired, the GIS query can be re-run to generate a revised table that identifies subsequent needs.

This reserve selection strategy can take into account arrangements in which compatible land tenures are jointly managed for their biodiversity values.

All land parcels in the region are displayed in Map 2 in the fold out section at the back of this document, with labels and legend to indicate tenure and their unique identification numbers. Existing reserves (including lands recently purchased for conservation) are also marked. In the output table shown in Appendix F, these land parcels are listed against headings such as land tenure-type, Beard vegetation associations present (hectares of each), and their contribution to comprehensiveness, adequacy and representativeness. The existing reserve system is included at the top of the table as a single entry. Unreserved TECs have been inserted manually if they were too small to be mapped as vegetation associations in the existing GIS layer.

Pragmatic CAR targets

The current conservation estate in the North Kimberley Bioregion has a comprehensiveness of 37 per cent (11 out of 30 Beard vegetation associations), an adequacy of 13.2 per cent (1,134,781 out of 8,620,134 hectares) and a representativeness of 27 per cent (8 out of 30 Beard vegetation associations).

Non-conservation land-tenures occupy extensive tracts of land in the North Kimberley and include pastoral leases, unallocated Crown lands, Aboriginal lands, Commonwealth Defence Forces lands and (limited) mining tenement. Given that virtually no land has been cleared in the region, that unallocated Crown lands are extensive and that co-vesting is a possibility in relation to defence lands, it may be possible to achieve a conservation reserve system that includes:

- examples of all vegetation associations (C = 100 per cent),
- greater than 10 per cent of the area of all vegetation associations (A = greater than 10 per cent) and
- a fully "representative" reserve system (given that both of the North Kimberley subregions are similar in the extent and type of their alienation/modification, there is still potential for examples of all vegetation associations to be reserved in the subregions in which they occur).

One such scenario is presented in Table 8. For instance, Commonwealth Defence Land (PIN 636961) includes greater than 50 per cent of the total area of eight unreserved vegetation associations (all of three), and is considered a priority for reservation or co-management to protect its biodiversity values. Aboriginal Reserve 13873 includes virtually all of six of the unreserved vegetation associations; clearly a co-management agreement to protect the biodiversity values of the vegetation associations is essential to regional conservation strategies. On the other hand, only a small proportion of the Mount Connor UCL would be required. Appendix F gives the GIS output table in full and shows the Beard Vegetation Associations that would be contributed to the reserve system if various land parcels were acquired to CALM estate.

Table 8: Improvements contributed by the fewest land parcels (that would fill the biggest gaps in the existing conservation reserve system). An asterisk (*) against the Beard vegetation association code in this table indicates that 100 per cent of the CAR criteria have been met for that vegetation association. Under this scenario, only vegetation association 53 (8.4 per cent) would be reserved for less than 10 per cent of its total area in the region. Refer to Appendix F for more detailed information regarding individual land parcels.

Land Parcel	Beard Veg Assoc Codes	% of total area	Representative?
Existing Conservation Estate	53	8.4	1
	717 *	16.5	1
	738 *	100.0	1
	739	4.7	1
	774	4.8	1
	901	9.9	1
	904	4.0	1
	905	4.2	1
Commonwealth Defence Land PIN 636961	60 *	98.4	1
	61 *	98.2	1
	125 *	9.1	1
	744 *	100.0	1
	754 *	99.4	1
	773 *	100.0	1
	808 *	47.9	1
	8001 *	45.7	1
Aboriginal Reserve 13873	43 *	0.3	1
	75 *	98.5	1
	127 *	11.1	1
	814 *	87.9	1
	835 *	99.8	1
	838 *	48.6	1
	904 *	6.6	
	907 *	100.0	1
	914 *	100.0	1
Lease 3114865	12 *	97.1	1
	739 *	10.2	
	774 *	82.5	
	802	6.6	
	901 *	2.1	
	905 *	19.4	
Sir Graham Moore Group UCL	902 *	15.3	1
Lease 3114997	800 *	17.1	1
	802 *	6.6	1
Osborne Islands UCL	589 *	100.0	1
Mount Connor UCL	807 *	25.4	1
TOTAL	30		30

A variety of threatened ecological communities occur in this region. These were too small an area to be mapped for the GIS and so were overlooked by the GIS analysis (Table 9). These need to be reserved with some urgency, in less than a five year timeframe. Due to grazing and burning regimes, savannah rainforest patches in the Kimberley have lost more than 60 per cent of their former areas during the last 30 years (McKenzie *et al.* 1991).

Table 9: Ecosystems subject to some level of threat that were too small to be mapped in the vegetation association GIS and are either not reserved within the North Kimberley or are poorly represented.

Threatened Ecological Communities (TECs)	In Reserve (Y/N)	Notes
Black Spring organic mound spring community	No	Proposed for exclusion from the pastoral lease in 2015.
Theda Soak rainforest – patch 10/5*.	No	Discussions with the pastoral leaseholder for the protection of this site are recommended.
Walcott Inlet swamp rainforest – 18/4, 19/2, 21/4.	No	
Roe River swamp rainforest – patch 16/2	No	See Prince Frederick Harbour UCL in Map 2 in the fold out section at the back of this document.

Threatened Ecological Communities (TECs)	In Reserve (Y/N)	Notes
Organic mound springs of the southern North Kimberley Bioregion.	No	Proposed for exclusion from the pastoral lease in 2015.
Other Ecosystems at Risk		
Savannah communities of which *Callitris intratropica* is a component.	Some	
Rainforest patches of the Kimberley savannah generally.	Some	
Flora and fauna assemblages of upland swamps of the Kimberley. On laterite and sandstone (Airfield Swamp and Beverley Springs Station).	No	
Assemblages of permanent/ephemeral wetlands, damplands, and riparian habitat of the Kimberley region.	Some	
Invertebrate community in creek near Pago Mission.	No	
Eucalyptus tectifica community of the Gibb River and Mt. Barnett areas.	No	
Eucalyptus jensenii woodlands of Gibb River and Mt. Barnett areas.	No	

These numbers were allocated to individual rainforests in the Kimberley Rainforest Survey (McKenzie *et al.* 1991).

In addition to the above recommendations, reservation of the coastal islands (Buccaneer Archipelago, Bonaparte Archipelago, and island groups further north along the coast) remains a priority. They support populations of many critical weight range mammals that are now extinct or have severely declined on the mainland. Elsewhere in Australia, islands are the last manageable refuges for such species. Populations of most of these species could become extinct on the adjacent mainland within 10 years if overt trends continue (a range of the relevant, and apparently unstoppable, threatening processes now pervade the entire North Kimberley mainland), and colonisation by cane toads is imminent. Known populations of several species are now confined to the north-western fringe of the region, a coastal strip of the North Kimberley that is less than 30 kilometres wide.

To achieve comprehensiveness, a total of 15 excisions from pastoral leases would need to be negotiated and purchased: Two areas each of 5,000 hectares in the scenario above (Table 8), and thirteen additional patches of 2,000 hectares each for the threatened ecosystems listed in Table 9. At an average value of $6 per hectare (approx.), this would cost $216,000 (36,000 ha X $6) plus $15,000 for travel and six months of staff time.

Management costs would include fencing to exclude stock and feral donkeys from critical sites within these excisions and the installation of troughs where stock drinking waters were involved. The potential cost is $290,000.

Off reserve conservation

Priority species or groups

Areas of priority include:

- Threatening processes operate from the species to landscape level.
- Little is known of the status of critical weight range mammals in the Mitchell subregion.
- Action is required to identify appropriate fire regimes.
- The effect of fire and cattle on critical weight range mammals, granivorous birds and savannah composition and structure is of concern.
- Changed grassland structures are of concern. There is evidence that changes have occurred, and continue to occur, to the balance between annual and perennial grasses.
- Landscape level threatening processes bring about changes to the organic profile layer in soils, water infiltration rates and surface flow velocity after rain.
- Impacts on rainforest patches of inappropriate fire regimes and, specifically, the impact of the interaction between cattle and fire on rainforests is of concern.
- There have been changes to riparian zones due to the impact of changed fire regimes, grazing and the indirect effects from changed hydrology.
- Action is required to identify what is at risk, identify the components of the biota at most risk, carry out research and recommend appropriate management.
- Little is known of the distribution, status and impact of weed species.

Species recovery planning

A national recovery plan has been completed for the Gouldian finch (Dostine 1998). There is a plan in preparation for turtles and there are national action plans for bats (Duncan *et al.* 1999), birds (Garnett and Crowley 2000), rodents (Lee 1995) and marsupials and monotremes (Maxwell *et al.* 1996) that apply to species in this subregion. The action plans make recommendations on the requirements for the recovery of several species. A Draft Kimberley Region Management Plan (Portlock *et al.* 2001) is currently being prepared and may have relevance for some species.

Some of the critical weight range mammals recovery outlines are listed within the rodent (Lee 1995) and marsupial and monotreme (Maxwell *et al.* 1996) action plans. A limited study to locate extant populations (based on previous records) and to provide material for clarifying the taxonomic status of the Kimberley population has been undertaken for the golden bandicoot (*Isoodon auratus*) (Graham 1995). CALM maintains records of opportunistic sightings of fauna.

A national recovery plan for marine turtles is being prepared but the level of implementation is low to non-existent. CALM has undertaken some survey work (Bob Prince CALM).

Part of the recovery planning process for flora is the requirement to undertake far more extensive survey work to clarify status, identify habitat associations and potential threatening processes. To our knowledge there are no recovery outlines proposed at this stage. An important recovery action for priority flora would be to undertake a BIOCLIM model analysis to identify potential additional sites where a particular species might be found.

The Mitchell subregion is of high conservation significance because of the lack of any recorded species extinctions from the area. This is significant in a national context. There are several endemic mammal species within the critical weight range mammal group, with the loss of this group of mammals elsewhere in Australia being well documented. Likewise there remain good populations of other faunal groups such as granivorous birds. The subregion has the highest rainfall in the Kimberley and the vegetation of this area is unique as a result. The best example of a broad landscape scale vegetation association is the *Livistona eastonii*/Eucalypt forest. Other smaller scale vegetation associations are of great importance such as the various types of rainforest found embedded in the broader landscape. While it is possible to address specific species in terms of the various recovery plans that could be produced, the first necessary step is to prepare a plan for biodiversity conservation of the subregion as a whole to determine priorities.

There are major threatening processes operating unabated at a landscape scale within the subregion. The two most important of these are the impacts resulting from stock and changed fire regimes. The amount of documentation of the impact of these processes is inadequate and mostly anecdotal. Within the area of the Mitchell Plateau, for example, cattle and donkeys continue to spread into new areas and grow in numbers. The level of stock control within the subregion is minimal. In the vicinity of Little Mertens Falls, within a period of 10 years before 2001, sightings of donkeys and cattle went from being occasional (they were not recorded at all for the Mitchell Plateau in the 1970's) to very common. Cattle have been seen on the coastal mudflats as far west as the mouth of the Roe River near the Prince Regent Nature Reserve. There is clearly a need to address the issue of the lack of stock control. Past efforts at stock control in the Mitchell Plateau area have been totally ineffective.

The impact of an increase in the occurrence of late dry season fires is likewise poorly documented. However, the landscape scale effects of repeated large fires are of great concern (see Map 3 in the fold out section at the back of this document). For example there is a perception that the *Livistona eastonii*/Eucalypt vegetation association is highly resistant to fire. While this may be the case under a pre-European burning regime the same may not be true under the current regime. Indigenous elders responsible for the Mitchell Plateau have expressed dismay at what they perceive to be a lack of care for this country.

Associated with these main threatening processes are:

- The impacts from changes to the hydrology across the landscape leading to erosion and changed river dynamics.
- The gradual depletion of the natural resources of the area. The process is a reduction in productivity and seasonal bottlenecks (cf. Gouldian finches at the end of the dry season).
- Changes to the savannah/tree, shrub and grass dynamic and the perennial/annual grass dynamic.
- Cat predation.
- Human impacts, such as the rapid increase is tourist visitation to the area where there in minimal management occurring.

Threats exist from the spread of exotic fauna such as the Pacific rat (*Rattus exulans*) and the cane toad (*Bufo marinus*). The current rate of unchecked spread of the cane toad across northern Australia indicates that this animal will enter the Kimberley within the next five years. Wherever it has been found, the cane toad impacts upon many species of native fauna and is expected to have a significant impact upon the fauna of the Kimberley. In spite of substantial investments that have documented the spread of this species, to date there has been no solution identified that might effectively control its continued invasion of northern Australia. For its part the Federal Government has nominated, as a key threatening process under the

Environmental Protection and Biodiversity Conservation (EPBC) Act (1999) the predation, competition and lethal toxic ingestion caused by cane toads. The most effective course for tackling this problem lies in developing biological control methods.

At present, the subregion is relatively weed free with changes in the level of impact of those species already within the subregion and further introductions likely. No further information is available on weeds.

There is an urgent need to undertake systematic benchmark surveys of the natural resources of the subregion. While many important fauna species are present, there is no information available that quantifies their status and trend. It is highly likely that a systematic biogeographical assessment of the subregion would lead to the identification of undescribed flora and fauna. This data should then be used in the preparation of a natural resource management plan incorporating the high biodiversity conservation needs of the subregion.

Australia's international obligations require particular protection and management of the Prince Regent Nature Reserve, which is listed as a world biosphere reserve. There is an urgent need to establish a planning process for the expenditure of the limited conservation funds currently available for the subregion. This would establish priorities for the expenditure of conservation funds at the State level and an improved integrated planning process both within the subregion and in the wider context of Northern Australia.

Appropriate species recovery actions

Fire management:
There is a need to move towards biodiversity-driven approaches to fire management strategies, such as trying to avoid frequent, broad scale, hot, late dry-season burning in savannah. A mosaic of areas burnt at different frequencies and intensities should be established across its landscape. Refer to Map 3 – Fire scars of the North Kimberley Bioregion, in the fold out section at the back of this document.

Weed control:
Weed priorities need to be defined both in an agricultural resource sense and an environmental sense. Resources are required to implement State and regional weed strategies.

Capacity building:
There is a need for organisational responsibility to coordinate management efforts across tenure, and for management responsibilities to be clearly defined. Local adoption of strategies is needed. Capacity building with the pastoral industry and Aboriginal groups is needed to optimise biodiversity and savannah productivity.

Feral animal control:
There is a need to remove feral stock from conservation estate and for the management of stock on other lands e.g. close order husbandry of cattle herds to prevent overgrazing. Feral animals such as cattle, donkeys and pigs, need to be eradicated.

Ecosystems and appropriate recovery actions

This is a general savannah issue and fire is the main driver in addressing this. The next most important issue (and linked with fire) is grazing. Actions that are required are linked to research, management and better-coordinated efforts between Government agencies, the pastoral grazing industry, traditional owners and the broader community. For example recovery actions for mound springs would be fire management (ix), feral animal control (vii), and weed control (vi). See Appendix B, key h for a full list of recovery actions. A whole of landscape approach is required with complementary actions being developed that assist in biodiversity conservation irrespective of land management goals.

Tropical savannah communities are showing signs of changes in vegetation cover and micro-hydrology under the current fire regimes and with grazing by feral herbivores. This has caused increased erosion that affects the riparian ecosystems through bed load and stream velocity effects. Cattle, fire and the trend toward annual grasses that they induce, are interacting threatening processes pervading the whole region. The scale is so great that the coastal islands have a paramount protection role for the region's biodiversity. The biodiversity conservation importance and management of these islands along the length of this coastline as intact fragments representing the West Australian tropical biodiversity must take priority.

The rapid decrease in productivity associated with the stripping of the organic A soil horizon through erosion is associated with the weed colonisation problem. In savannah areas the decrease in productivity is also due to fire and/or oxidation of soil organics. These changes affect the carrying capacity of the environment, essentially the standing biomass of the indigenous flora and fauna, for critical weight range mammals and savannah birds. This then leads to increased exposure to predation and a shortened growing season.

Mainland rainforest ecosystems throughout the region are contracting in area and density, as they become more fire prone (McKenzie *et al.* 1991). A monitoring study carried out by CALM indicates that exclusion of stock needs to be accompanied by fire control if the process is to be reversed. The priority is management of patches that are set in a tall grass matrix and in areas where cattle are numerous. Patches in rugged sandstone country, on mudflats and abutting

mangroves can often be protected from fire and cattle as a result of the rugged landscape surrounding them. A two-kilometre fence across the neck of Cape Bougainville protects a substantial area of rainforest.

A priority for reserve management within the subregion is to implement more effective control of stock (donkeys, cattle, horses, pigs) to allow for ecosystem recovery and protect the biodiversity that remains.

Ecosystem recovery planning

There are no existing recovery plans for ecosystems at risk in the Mitchell subregion. A Draft Kimberley Region Management Plan (Portlock *et al.* 2001) is currently being prepared and may have relevance for management of some ecosystems at risk. Research into the status and recovery of the following ecosystems is being carried out:

- *Callitris intratropica* communities (Graham 2000),
- rainforest communities (McKenzie *et al.* 1991 and Gordon Graham CALM) and
- riparian habitats (Tony Start CALM).

These are being conducted under a variety of joint Commonwealth and State programs.

In the context of the savannah threatening processes, including the volcanic and sandstone country off-reserves, the task is too great for existing CALM resources to reverse. The approach has to be facilitated through natural resource management policy at the level of the tenure holders such as Government departments (e.g. Department of Land Administration, Department of Agriculture, Water and Rivers Commission) pastoral leaseholders, Land Conservation District Committees, Aboriginal groups and the broader community. The NRM management strategy needs to be across all tenures as the two main threatening processes are operating at landscape level. The timeframe to initiate these processes needs to be one to five years. The necessary changes are feral animal control, close husbandry of stock, improved fire management programs, and disease control programs. Some of these are already happening but need support and encouragement to maintain and accelerate the cultural change in the one to five year timeframe. Processes ensuring a perpetual commitment must be developed.

Subregion priority for off-reserve conservation

The priority for off park conservation in the Mitchell subregion is good (iii), indicating that limited off park measures will result in significant conservation gains (See Appendix C, rank 6).

Cost

Some individual species action plans identify an overall expenditure figure for the species across its distribution. The important level of planning required for the protection of the biodiversity values of the subregion is at the subregion scale. Further work is required to identify the costs of preparation of an action plan for the subregion (incorporating individual species, groups of species and ecosystems at risk) and for the components of systematic baseline study, plan preparation and plan implementation. A figure of around $750,000 would not be unwarranted in terms of study, plan preparation and some targeted on-ground operations.

Recovery priority

The preparation of a subregion natural resource management plan is a priority within the next one to five years.

Revegetation

Revegetation strategies are not applicable to this subregion.

Protected area initiatives

Remnants and small occurrences of important vegetation exist within the broader savannah landscape. There are a number of management options to achieve biodiversity conservation on non-park tenures. Aboriginal people hold large areas of the subregion under State legislation. Apart from the declaration of Indigenous Protected Areas, there are opportunities for the development of joint management arrangements between a conservation agency such as CALM and Aboriginal groups. These joint management arrangements should also be developed for the conservation estate. The conservation estate should be treated as a tenure component within the continuous landscape and not separate from it. Apart from the need to engage all stakeholders, the development of involvement of the traditional owners in the management of this subregion is the primary constructive step that can be taken in moving toward better management of the natural resources. Other programs that might be engaged include Section 16 agreements under the *Conservation And Land Management (CALM) Act (1984)* and covenanting.

There is no fragmentation of the landscape as occurs elsewhere (e.g. land clearing), and as such the conservation estate is embedded in a continuum of the landscape. The meeting of biodiversity conservation

objectives is at the landscape scale in concert with all land managers and the community. 'On-reserve' and 'off-reserve' conservation initiatives can often be the same, or immediately complementary, in addressing similar major issues of concern.

Impediments, land holder capacity and resource requirements

A major impediment to conservation in the North Kimberley is that for many areas the landholder is often identified or perceived to be the State, and the State must allocate limited resources across a wide range of expenditures in trying to meet public expectations. This applies to conservation reserves, unallocated Crown lands and pastoral leases. Aboriginal lands have no monies allocated to manage components of conservation or a source of funds to achieve this. Management capacity is also constrained by a very low resident human population able to get involved in management activities and associated with this is the lack of adequately trained personnel. Resource requirements to establish an integrated level of capacity are significant. This once again emphasizes the need for focussed, planned issues management that networks with all stakeholders and interested parties. An open approach to defining management options is to be encouraged where an integration of different strategies occurs.

Reserve consolidation initiatives required and limitations

More pastoral leases are being managed or purchased for reasons other than cattle production, including tourism and the protection of cultural sites. This results in an elevated purchase price above values that might be set by the valuer general. However, this does present opportunities for agreements between Government and leaseholders to achieve conservation objectives.

As Native title claim issues are resolved, agreements to protect conservation issues on those lands may become more common. This applies across all land tenures and particularly current Aboriginal lands such as reserves and pastoral leases. It is highly likely and necessary that this will involve co-management (joint management), but recognition needs to be given to the substantial costs of achieving this.

There are a number of CTRC reserve recommendations (such as Walcott Inlet and many of the islands) that are State Cabinet endorsed but are yet to be declared.

Natural Resource Management (NRM)

Existing actions

Refer to Appendix B, rank i for a full list of Natural Resource Management actions.

Legislation:
Pastoral lease inspections are undertaken by the Department of Agriculture and leaseholders notified of any problems via the Pastoral Lands Board. The final scenario is that the Commissioner for Soil Conservation can institute formal proceedings if issues are not being addressed. The last step is rarely undertaken.

Threat abatement planning as part of NRM:
There is a concerted and coordinated effort by the Department of Agriculture in the control of donkeys.

Capacity:
A Land Conservation District Committee has been established and provides a venue for discussion of conservation matters.

Integration with property management planning, catchment planning and Landcare:
Land Conservation District Committees provide an opportunity for integration of land management activities.

Opportunities

Refer to Appendix B, rank i for a full list of Natural Resource Management actions.

Environmental management systems:
Research is needed on the mechanism and impacts of threatening processes. Outputs of this should assess potential cost/effective solutions. There has been some development in the co-ordination of multiple research initiatives and communication of this, such as environmental planning across tenure (weeds, fire and feral animals) coordinated through the Land Conservation District Committee.

Legislation:
Improved understanding and implementation of existing legislation.

Capacity building:
Improved communication is required between all stakeholders, and an acknowledgment of differing land management objectives.

Other planning opportunities:
State level planning for land use and management of the North West Kimberley coast is required. A shire plan incorporating biodiversity objectives and an

acknowledgment of the worth of the natural environment (e.g. tourism, including the cost of management) is required to make national parks accessible.

Integration with property management planning, catchment planning and land care:
Catchment and regional plans involving all stakeholders need to be developed.

Impediments or constraints

A limited financial resource is a major constraint. The number of people available to implement strategies is also a constraint. There is a need to increase awareness of conservation values throughout the community.

Priority between subregions

A more coordinated approach to land management would be a priority for the Mitchell subregion. This is because of differing and potentially competing land uses, the increase in multiple land uses and the landscape scale of threats. Although the Berkeley subregion has fewer stakeholders, research into issue identification may change the priority. The rank for both subregions is (ii), indicating that there are significant constraints to integrate conservation as part of the existing production and development systems (See Appendix C, rank 7).

Data gaps

Refer to Appendix B, key A for a full list of data gap categories:

Vegetation and regional ecosystem mapping:
Much finer scale (at 1:100,000 or better) vegetation/regional ecosystem mapping is required. This needs to align with soil maps and environmental geology maps. Unfortunately, these do not yet exist at better than 1:250,000 scale.

Systematic fauna survey:
There has been no systematic quadrat based fauna sampling program across the subregion to provide a basis for modelling species distribution and status. Monitoring structures are non-existent.

Floristic data:
Significant gaps exist in any flora database and monitoring structures are non-existent.

Ecological and life history data:
Information is lacking on the habitat requirements of many fauna species.

Other priority data gaps include:
Further research is required on the conservation status of many fauna and flora taxa as well as the effects of threatening processes such as exotic predators (cats), stock (cattle, donkeys and pigs), fire and weeds.

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 species have been added to the most recent (2003) version of Western Australian Fauna Gazette's (all are Camaenid land snails). While the 25 additions are species of eastern and southern Kimberley subregions, they indicate the likely status of many land snail species that are confined to contracting rainforest patches in the Mitchell subregion. Further changes to species at risk are expected when the 2004 versions of the Fauna Gazette and Declared Rare Flora are produced.

Cristilabrum bubulum
Cristilabrum buryillum
Cristilabrum grossum
Cristilabrum isolatum
Cristilabrum monodon
Cristilabrum primum
Cristilabrum rectum
Cristilabrum simplex
Cristilabrum solitudum
Cristilabrum spectaculum
Ningbingia australis australis
Ningbingia australis elongata
Ningbingia bulla
Ningbinga dentiens
Ningbingia laurina
Ningbingia octava
Ningbingia res
Ordtrachia elegans
Turgenitubulus christenseni
Turgenitubulus costus
Turgenitubulus depressus
Turgenitubulus foramenus
Turgenitubulus opiranus
Turgenitubulus pagodula
Turgenitubulus tanmurrana

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:

Organic mound spring sedgeland community of the North Kimberley Bioregion

No further recovery plans have been written regarding species or communities in the subregion.

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Appendix A – Terms of reference and structure

The structure and the categorisations used in the case studies are detailed below.

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 that 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 for fauna

Extent and specific nature of threatening processes for fauna species at risk, including information such as known distribution and range contractions, and some life history information.

Threatening processes for flora

Extent and specific nature of threatening processes for flora species at risk (DRF and Priority), including information such as known distribution and range contractions, and some life history information.

Threatening processes for ecological communities

Extent and specific nature of threatening processes for Threatened Ecological Communities (but not other ecosystems at risk) including survey information and known occurrences of that community.

Conservation through reserves

Appropriate methodologies for reserve system design

Identify an appropriate method then carry out a gap analysis to list un-reserved Threatened Ecological Communities, other ecosystems at risk, and vegetation associations. Next, identify appropriate method to identify parcels of land for their reservation.

Although more detailed vegetation mapping is available for some WA regions, 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).

Gap analysis

Define for current gaps in conservation reserve system CAR values and select suitable land parcels to close those gaps.

Pragmatic CAR targets

Consider appropriate CAR thresholds for the North Kimberley, then assess the reality of reaching those targets, associated costs for land purchase and lessons from management and any current negotiations.

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 and community capacity for species and groups of species at risk.

Appropriate species recovery actions

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

Ecosystems and appropriate recovery actions

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

While these actions have been recommended for the recovery of the particular species or ecosystem, further research may reveal more effective alternatives in some cases. The listing should not be interpreted as an intent by CALM to undertake all these actions.

Existing ecosystem recovery plans

Identify specific threatened ecosystems found off CALM reserve and any relevant recovery plans.

Subregion priority for off-reserve conservation

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

Cost

Analysis of cost for producing action plan for the subregion as a whole rather than individual species.

Recovery priority

Desirable timeline for production of a natural resource management plan for the subregion.

Revegetation

Desirability and effectiveness of revegetation as a potential recovery action.

Protected area initiatives

Possible methods for protecting biodiversity outside the CAR reserve system.

Impediments, land holder capacity and resource requirements

Impediments, land holder capacity and resource requirements for off reserve conservation.

Reserve consolidation initiatives required and limitations

Current initiatives to add land to the reserve system as well as explanation as to why this may not be possible.

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

Identify feasible opportunities for NRM actions to specifically address biodiversity (Key i of Appendix B) and describe type of action and effectiveness.

Impediments and constraints

Explain any impediments or constraints to operation of NRM (Key g of Appendix B).

Priority between subregions

Note if there is a prioritisation between subregions within the bioregions and reasons for this (rank 7 of Appendix C).

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.

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
BIOCLIM	A species distribution model that depends on biological and climatic data
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
CTRC	Conservation Through Reserves Committee
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
EA	Environment Australia
GIS	Geographic Information Systems
IBRA	Interim Biogeographic Regionalisation for Australia (version 5.1 is used for this document)
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
NLWRA	National Land and Water Resources Audit
NRM	Natural Resource Management
NRS	National Reserve System
NVIS	National Vegetation Inventory System
TEC	Threatened Ecological Community
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

Appendix F - Land parcels in the North Kimberley

Output table from GIS query showing land parcels from Map 2 (fold out section at the back of this document) assessed in terms of additions they would make to the existing conservation reserve network. Comprehensiveness is a measure of how many, and which, Beard vegetation Associations are added to the reserve system by each land parcel; Adequacy is the percentage of vegetation association's total extent in the region (see Table 8, page 22) that occurs in each land parcel and would be added if parcel was conserved; Representativeness is achieved when a vegetation association is reserved in the North Kimberley subregions that it occurs in. Beard Vegetation Associations added are indicated in bold font. UCL = unallocated crown land; Lease = Government land leased out for pastoral purposes; Non-CALM managed reserve = reserves vested in other Government Departments for purposes other than conservation (e.g. townsites, water reserves).

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	**Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22**	**Adequacy**	**Representativeness**
CALM managed reserves and other lands purchased for conservation (see Charnley River Lease on Map 2)	Total = 11 of 30 NK veg-types	%	Total = 8
	43	23.9	0
	53	8.4	1
	127	3.7	0
	717	16.5	1
	738	100.0	1
	739	4.7	1
	774	4.8	1
	802	0.7	0
	901	9.9	1
	904	4.0	1
	905	4.2	1
Lease 3114 648	Added = 0	Added %	Added = 0
	901	0.1	0
Lease 3114 723	Added = 0	Added %	Added = 0
	53	0.1	0
	127	1.4	0
	739	0.8	0
	802	49.3	0
	901	1.4	0
	905	7.9	0
Lease 3114 786	Added = 1	Added %	Added = 1
	12	1.7	1
	53	0.1	0
	739	1.2	0
	901	0.6	0
Lease 3114 865	Added = 1	Added %	Added = 1
	12	97.1	1
	53	1.3	0
	739	10.2	0
	774	82.5	0
	802	6.6	0
	901	2.1	0
	905	19.4	0

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Lease 3114 918	Added = 0	Added %	Added = 0
	901	0.1	0
Lease 3114 962	Added = 1	Added %	Added = 1
	53	0.9	0
	814	11.0	**1**
	901	2.8	0
	904	1.4	0
Lease 3114 980	Added = 0	Added %	Added = 0
	901	0.2	0
Lease 3114 997	1	Added %	Added = 2
	53	0.4	0
	739	0.1	0
	800	17.1	**1**
	802	6.6	**1**
	901	0.3	0
Lease 3114 1056	Added = 0	Added %	Added = 0
	43	0.4	0
	53	1.6	0
	127	0.0	0
	739	12.0	0
	901	1.0	0
	904	4.1	0
	905	11.1	0
Lease 3114 1174	Added = 0	Added %	Added = 0
	53	2.0	0
	739	10.1	0
	901	0.9	0
	904	14.3	0
	905	12.2	0
Lease 3114 1190	Added = 0	Added %	Added = 1
	53	17.7	0
	739	0.0	0
	802	1.7	**1**
	901	3.5	0
	905	4.6	0
Lease 3114 1204	Added = 1	Added %	Added = 1
	53	1.2	0
	739	1.7	0
	800	58.3	**1**
	802	2.3	0
	901	0.1	0
Lease 3116 10869	Added = 1	Added %	Added = 1
	12	1.3	**1**
	739	0.1	0
	774	1.0	0
	901	0.0	0

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Lease 3116 11277	Added = 0	Added %	Added = 0
	53	0.0	0
	901	0.0	0
Lease 398 446	Added = 1	Added %	Added = 1
	53	3.8	0
	739	4.2	0
	800	8.8	**1**
	802	0.3	0
	901	1.2	0
	904	3.0	0
	905	3.7	0
Lease 398 836	Added = 0	Added %	Added = 0
	739	1.3	0
	774	3.1	0
	901	0.0	0
Lease 398 844	Added = 0	Added %	Added = 0
	53	3.5	0
	739	0.4	0
	901	1.9	0
	905	0.4	0
Lease GE H324273	Added = 1	Added %	Added = 1
	8001	0.1	**1**
Lease GE H716576	Added = 1	Added %	Added = 1
	53	6.7	0
	739	6.5	0
	807	74.6	**1**
	901	2.8	0
	904	5.0	0
	905	1.9	0
Non- CALM managed reserve 1011	Added = 2	Added %	Added = 2
	43	0.4	0
	127	0.0	0
	800	0.2	**1**
	739	2.5	0
	901	0.1	0
	8001	1.6	**1**
Non- CALM managed reserve 8222	Added = 0	Added %	Added = 0
	739	0.1	0
Non- CALM managed reserve 8223	Added = 0	Added %	Added = 0
	739	0.2	0
Non- CALM managed reserve 8247	Added = 0	Added %	Added = 0
	739	0.1	0
Non- CALM managed reserve 8248	Added = 0	Added %	Added = 0
	739	0.0	0
	901	0.0	0

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Non- CALM managed reserve 8254	Added = 0	Added %	Added = 0
	802	0.5	0
	905	0.5	0
Non- CALM managed reserve 8255	Added = 0	Added %	Added = 0
	739	0.1	0
	901	0.0	0
Non- CALM managed reserve 8256	Added = 0	Added %	Added = 0
	739	0.1	0
Non- CALM managed reserve 8258	Added = 0	Added %	Added = 0
	53	0.0	0
	901	0.0	0
Non- CALM managed reserve 8260	Added = 0	Added %	Added = 0
	739	0.1	0
Non- CALM managed reserve 8263	Added = 0	Added %	Added = 0
	53	0.0	0
	901	0.0	0
Non- CALM managed reserve 22054	Added = 1	Added %	Added = 1
	8001	0.0	**1**
Non- CALM managed reserve 33706	Added = 0	Added %	Added = 0
	53	0.3	0
	739	0.2	0
Stock Route PIN 639631	Added = 0	Added %	Added = 0
	53	1.1	0
	739	0.4	0
	802	0.6	0
	901	0.1	0
	905	0.9	0
Stock Route PIN 640114	Added = 0	Added %	Added = 0
	53	0.5	0
	739	1.0	0
	901	0.4	0
	904	1.8	0
	905	1.0	0
Stock Route PIN 640151	Added = 0	Added %	Added = 0
	53	0.1	0
	739	0.6	0
	901	0.0	0
	904	1.2	0
	905	6.7	0
Commonwealth PIN 636795	Added = 1	Added %	Added = 1
	808	6.0	**1**

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Commonwealth PIN 636961	Added = 8	Added %	Added = 8
	43	5.0	0
	60	98.4	**1**
	61	98.2	**1**
	125	9.1	**1**
	127	3.5	0
	739	1.7	0
	744	100.0	**1**
	754	99.4	**1**
	773	100.0	**1**
	774	3.7	0
	808	47.9	**1**
	901	0.2	0
	8001	45.7	**1**
Aboriginal Reserve 3960	Added = 2	Added %	Added = 4
	43	0.2	**1**
	127	7.6	**1**
	814	1.1	**1**
	838	33.1	**1**
	901	0.7	0
Aboriginal Reserve 13873	Added = 6	Added %	Added = 7
	43	0.3	**1**
	53	3.5	0
	75	98.5	**1**
	127	11.1	**1**
	739	1.1	0
	814	87.9	**1**
	835	99.8	**1**
	838	48.6	**1**
	901	8.5	0
	904	6.6	0
	907	100.0	**1**
	914	100.0	**1**
Aboriginal Reserve 15530	Added = 0	Added %	Added = 0
	43	0.5	0
	127	0.7	0
	717	1.0	0
	739	3.7	0
	901	0.7	0
	904	0.1	0
Aboriginal Reserve 19751	Added = 0	Added %	Added = 0
	127	0.3	0
	802	1.1	0
	901	0.1	0

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Aboriginal Reserve 21327	Added = 0	Added %	Added = 0
	53	0.0	0
	739	0.2	0
	901	0.1	0
	905	0.1	0
Aboriginal Reserve 21328	Added = 0	Added %	Added = 0
	739	0.2	0
	901	0.1	0
Aboriginal Reserve 21675	Added = 0	Added %	Added = 0
	43	1.5	0
	53	4.6	0
	739	3.6	0
	901	1.4	0
	904	1.8	0
Aboriginal Reserve 23079	Added = 0	Added %	Added = 1
	43	11.8	0
	53	0.3	0
	127	1.9	0
	717	2.7	0
	739	5.1	0
	802	0.8	0
	901	7.2	0
	904	0.0	0
	905	0.0	0
	8001	0.1	**1**
Aboriginal Reserve 24705	Added = 1	Added %	Added = 1
	43	2.2	0
	53	2.9	0
	717	52.6	0
	739	1.7	0
	901	0.9	0
	902	84.4	**1**
	904	0.4	0
Aboriginal Reserve 30643	Added = 0	Added %	Added = 0
	43	3.0	0
	53	1.9	0
	717	1.7	0
	739	1.3	0
	901	3.9	0
	904	0.0	0
Aboriginal Reserve 30674	Added = 3	Added %	Added = 3
	43	2.9	0
	60	0.9	1
	739	1.0	0
	808	36.0	**1**
	8001	40.1	**1**

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Aboriginal Reserve 41886	Added = 0	Added %	Added = 0
	739	0.0	0
	901	0.0	0
Aboriginal Reserve 41921	Added = 0	Added %	Added = 0
	802	0.4	0
	901	0.0	0
Aboriginal Reserve 42512	Added = 0	Added %	Added = 0
	53	0.0	0
	717	2.6	0
	739	0.2	0
	901	0.0	0
	904	0.4	0
Aboriginal Reserve 42513	Added = 0	Added %	Added = 0
	43	0.0	0
	739	0.0	0
	901	0.0	0
Aboriginal Reserve 42514	Added = 0	Added %	Added = 0
	739	0.0	0
Aboriginal Reserve 42999	Added = 1	Added %	Added = 1
	800	0.1	1
Adolphus Island UCL PIN 639772	Added = 0	Added %	Added = 2
	43	0.8	1
	127	3.3	1
	901	0.1	0
Banjo Creek UCL PINs 1115829, 1065739	Added = 0	Added %	Added = 0
	53	1.9	0
	901	2.8	0
Barlee Impediment UCL PINs 272463, 1272464, 1285713, 1285729 - 1285733, 1285738 - 1285741	Added = 0	Added %	Added = 0
	43	3.5	0
	127	3.3	0
	739	0.0	0
	901	0.0	0
	904	0.2	0
Beta Creek UCL PIN 639687	Added = 0	Added %	Added = 0
	53	3.3	0
	739	0.0	0
	901	0.8	0
Bonaparte Archipelago UCL PINs 1259586 - 1259595, 1259598 - 1259603, 1259606, 1264639, 1264671, 1265775, 636051, 636099, 636109, 636164, 636403, 636405, 636472, 636482, 636483	Added = 1	Added %	Added = 0
	43	0.6	0
	53	0.1	0
	717	2.8	0
	739	0.3	0
	901	0.5	0
	904	0.1	0

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Buccaneer Archipelago UCL PINs 1145407, 1252879, 1253353, 1253354, 636762, 636835, 636905, 636927, 636933, 637006, 637011, 637015, 637044 - 637047, 637051, 637055, 637057, 637058	Added = 1	Added %	Added = 1
	43	0.4	0
	8001	3.6	**1**
Cape Londonderry UCL PIN 639688	Added = 0	Added %	Added = 0
	43	0.3	0
	53	1.3	0
	127	0.2	0
	739	1.1	0
	901	0.5	0
	904	12.1	0
Doubtful Bay UCL PINs 1278067, 1278068, 1278077, 1278078, 1278079, 636426	Added = 2	Added %	Added = 2
	43	10.1	0
	127	6.4	0
	800	8.6	**1**
	802	9.4	0
	901	1.7	0
	8001	0.2	**1**
Hunch Hill UCL PINs 640172, 640170, 1248086, 1248087	Added = 0	Added %	Added = 2
	43	2.8	**1**
	127	3.0	**1**
	901	0.3	0
Isdell River UCL PINs 1278071, 636623	Added = 1	Added %	Added = 1
	127	7.7	0
	739	0.2	0
	774	4.9	0
	800	0.0	**1**
	901	1.0	0
Junction Hill UCL PIN 636602	Added = 0	Added %	Added = 0
	739	0.1	0
	901	0.0	0
King Creek UCL PINs 1264206 - 1264212, 1264214 - 1264217, 1264441 - 1264455, 1264463 - 1264468	Added = 1	Added %	Added = 1
	43	3.8	0
	127	3.3	0
	739	0.0	0
	8001	0.0	**1**
King George River UCL PIN 639698	Added = 0	Added %	Added = 0
	53	0.0	0
	739	0.1	0
	901	0.1	0
	904	0.1	0

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Mitchell Plateau UCL PIN 636180	Added = 0	Added %	Added = 0
	43	0.5	0
	53	0.8	0
	127	0.5	0
	717	14.0	0
	739	6.4	0
	901	0.3	0
	904	26.4	0
Mitchell River UCL PINs 1268915, 1268916, 1268917	Added = 0	Added %	Added = 0
	43	2.6	0
	901	0.0	0
Mount Connor UCL PINs 1268929, 1268930, 640107	Added = 1	Added %	Added = 1
	43	2.1	0
	53	5.1	0
	739	2.4	0
	807	25.4	**1**
	901	3.5	0
	904	3.4	0
Mount Jameson UCL PINs 640122, 636419	Added = 1	Added %	Added = 1
	53	4.7	0
	717	0.3	0
	739	6.6	0
	800	4.4	**1**
	802	12.9	0
	901	12.1	0
	904	2.2	0
	905	5.1	0
Osborne Islands UCL PINs 636145, 636147, 636148, 639649, 639650	Added = 1	Added %	Added = 1
	589	100.0	**1**
	717	4.9	0
	739	0.2	0
	901	0.0	0
Pickering Point UCL PIN 1268921	Added = 0	Added %	Added = 0
	43	0.2	0
	901	0.0	0
Prince Frederick Harbour UCL PINs 1265779 - 1265781, 1274683, 1274685, 1274781 – 1274783, 1274785, 1274786, 1274788 - 1274803	Added = 0	Added %	Added = 0
	43	1.2	0
	739	0.0	0
	901	0.0	0
	904	0.0	0
Saint George Basin UCL PIN 1272410	Added = 0	Added %	Added = 0
	43	2.0	0
	739	0.0	0
Secure Bay UCL PINs 1264183 - 1264205, 1264218, 1264456, 1264457	Added = 1	Added %	Added = 1
	43	1.7	0
	739	0.0	0
	8001	0.2	**1**

Land Parcel (refer to PINs listed in Map 2 in the fold out section at the back of this document)	Comprehensiveness – Beard Vegetation Associations, refer also to Table 8, page 22	Adequacy	Representativeness
Sir Graham Moore Group UCL PINs 639659, 639661, 639662, 639663, 639667	Added = 1	Added %	Added = 1
	739	0.0	0
	901	0.0	0
	902	15.3	**1**
Steere Hills UCL PIN 639766	Added = 0	Added %	Added = 2
	43	1.7	**1**
	127	21.6	**1**
	901	0.4	0
Stokes Bay UCL PINs 1257120 - 1257123, 1257127, 1257130 - 1257141, 1257185 - 1257187	Added = 5	Added %	Added = 5
	43	5.1	0
	60	0.1	**1**
	61	1.8	**1**
	125	90.9	**1**
	127	10.9	0
	754	0.6	**1**
	8001	0.2	**1**
Thompson River UCL PIN 640177	Added = 2	Added %	Added = 4
	43	1.3	**1**
	127	7.7	**1**
	835	0.2	**1**
	838	12.2	**1**
	901	0.7	0
Walmesly Bay UCL PINs 1268842, 1268845, 1268908 - 1268914, 1268937 - 1268939, 636274, 636278	Added = 0	Added %	Added = 0
	43	1.0	0
	53	0.0	0
	901	0.0	0

Index

Map 1 Landuse in North Kimberley 1 (Mitchell Subregion)

LEGEND

Secondary Land Use

- Livestock grazing
- Managed resource protection
- Nature conservation
- Other minimum intervention use

- Locality
- North Kimberley 1 IBRA Subregion
- IBRA Regions

THEME	CUSTODIAN	DATE
Secondary Land Use	Agriculture Western Australia	2001

OORARO HILL

WARRENDER

BOBS CAMP

MUNJA

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

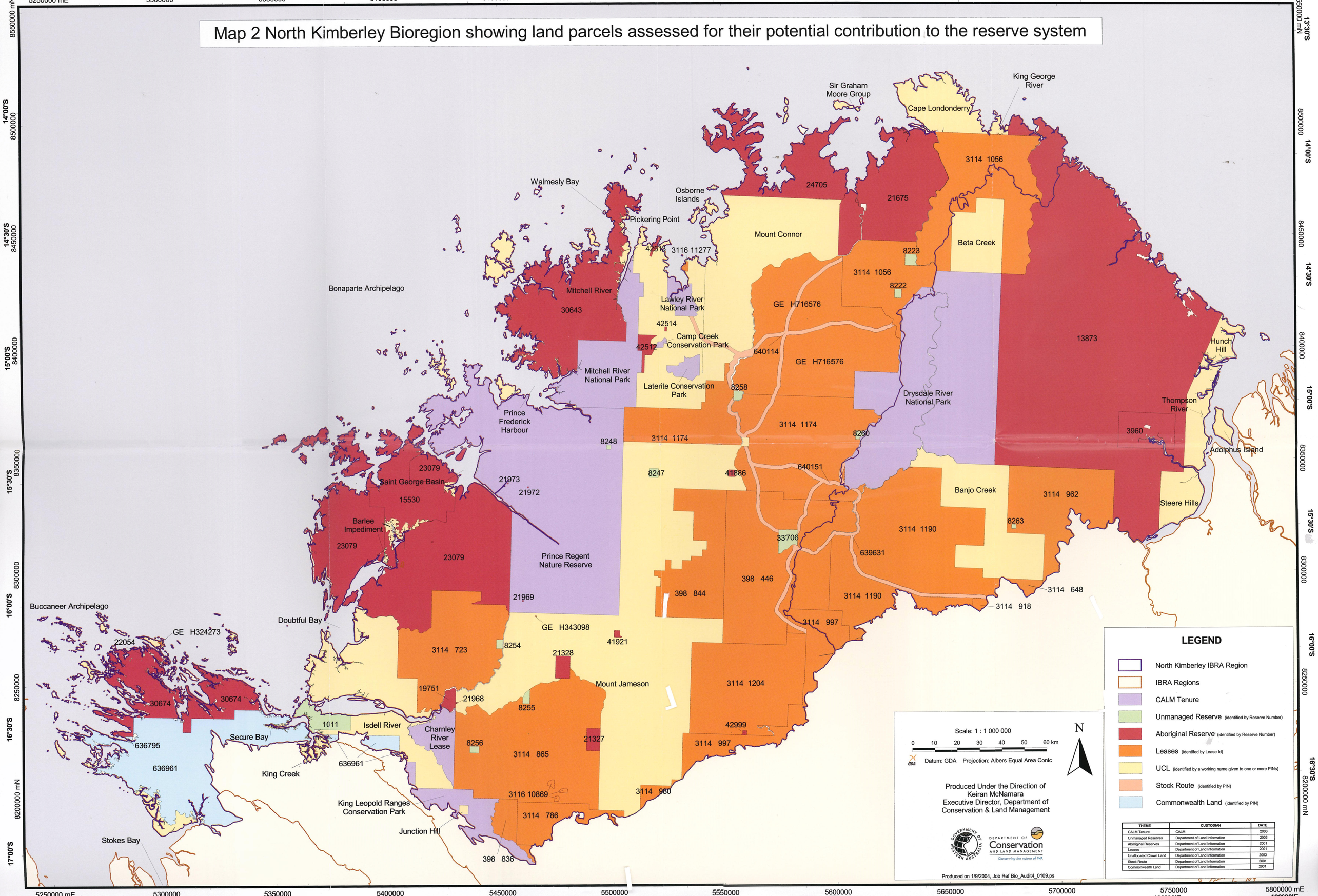
Government of Western Australia
Department of Conservation and Land Management
Conserving the nature of WA

Produced on 1/9/2004, Job Ref Bio_Audit3_0109.ps

123°00'E 5200000 mE
123°30'E 5250000
124°00'E 5300000
124°30'E 5350000
125°00'E 5400000
125°30'E 5450000
126°00'E 5500000
126°30'E 5550000
127°00'E 5600000
127°30'E 5650000
128°00'E 5700000
5750000 mE

14°00'S 8500000 mN
14°30'S 8450000
15°00'S 8400000
15°30'S 8350000
16°00'S 8300000
16°30'S 8250000
17°00'S 8200000
8150000 mN

Map 2 North Kimberley Bioregion showing land parcels assessed for their potential contribution to the reserve system



LEGEND

- North Kimberley IBRA Region
- IBRA Regions
- CALM Tenure
- Unmanaged Reserve (identified by Reserve Number)
- Aboriginal Reserve (identified by Reserve Number)
- Leases (identifed by Lease Id)
- UCL (identified by a working name given to one or more PINs)
- Stock Route (identified by PIN)
- Commonwealth Land (identified by PIN)

Scale: 1 : 1 000 000

0 10 20 30 40 50 60 km

Datum: GDA Projection: Albers Equal Area Conic

N

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Executive Director, Department of
Conservation & Land Management

THEME	CUSTODIAN	DATE
CALM Tenure	CALM	2003
Unmanaged Reserves	Department of Land Information	2003
Aboriginal Reserves	Department of Land Information	2001
Leases	Department of Land Information	2001
Unallocated Crown Land	Department of Land Information	2003
Stock Route	Department of Land Information	2001
Commonwealth Land	Department of Land Information	2001

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Map 3 Fire scars of the North Kimberley Bioregion

LEGEND

- Locality
- Northern Kimberley 1 IBRA Subregion
- IBRA Regions

Fire Scar Frequency

- Not Burnt since 1993
- Burnt once since 1993
- Burnt twice since 1993
- Burnt 3 times since 1993
- Burnt 4 times since 1993
- Burnt 5 times since 1993
- Burnt 6 times since 1993
- Burnt 7 times since 1993
- Burnt 8 times since 1993
- Burnt 9 times since 1993
- Burnt 10 times since 1993
- Burnt every year since 1993

THEME	CUSTODIAN	DATE
Fire Scar Frequency	Department of Land Information	2003

Scale: 1 : 1 000 000

0 10 20 30 40 50 60 km

GDA Datum: GDA Projection: Albers Equal Area Conic

N

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OORARO HILL

WARRENDER

BOBS CAMP

MUNJA

123°00'E 123°30'E 124°00'E 124°30'E 125°00'E 125°30'E 126°00'E 126°30'E 127°00'E 127°30'E

5200000 mE 5250000 5300000 5350000 5400000 5450000 5500000 5550000 5600000 5650000 5700000 5750000 mE

8500000 mN 8450000 8400000 8350000 8300000 8250000 8200000 8150000 mN

14°00'S 14°30'S 15°00'S 15°30'S 16°00'S 16°30'S 17°00'S

128°00'E