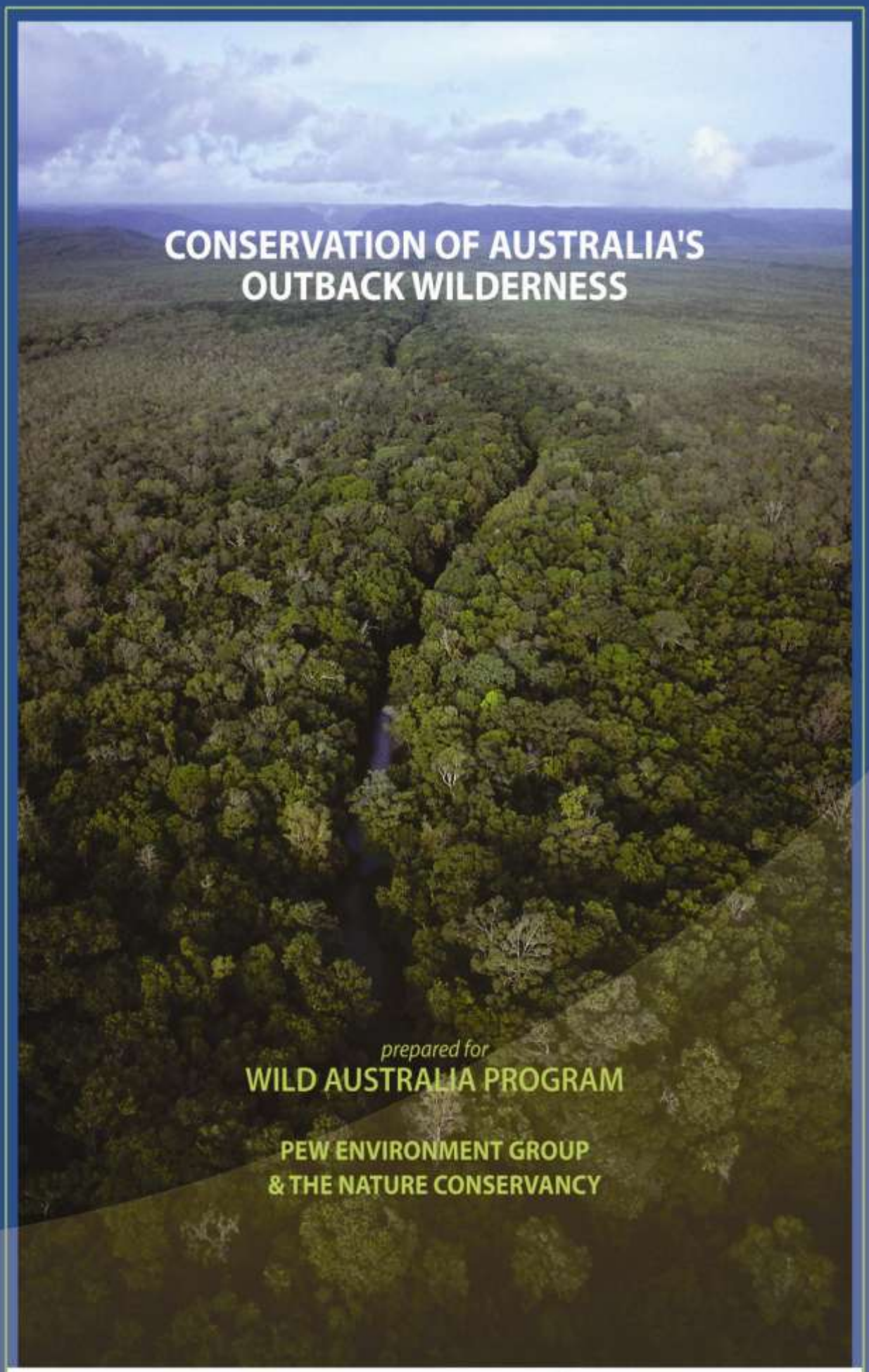

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CONTENTS

INTRODUCTION

AIMS OF THIS PAPER

In this paper we identify potential focus areas for the Wild Australia program in terrestrial Australia. This paper is one of two: one on marine priorities and this one on terrestrial priorities. This paper does not attempt to create new datasets or generate other primary data. It is a desk-top study using information from the excellent datasets and published information already available in Australia. Information from available information sources was collated and analysed. Here we identify those large intact areas that are in relatively good condition which constitute the pool of areas in which the Wild Australia program may work. We then provide a conservation snapshot of these areas, describing their natural values, the ecological processes that maintain those values, and threats. We also provide an overview of the current capacity of different conservation and on-ground community groups, in the region.

We do not attempt here to identify a list of regions in which the program will definitely work or a definitive hierarchical list of priority areas. To determine specific areas of work discussions will be held with conservation organisations and community groups in the described areas to determine specific projects that will be supported by the Pew-TNC Wild Australia Program.

ORIGINS & AIMS OF THE WILD AUSTRALIA PROGRAM

With the world-wide decimation and degradation of nature, Australia stands out in having huge areas where native vegetation still stands and rivers still run freely. Australia harbours a substantial proportion of the 17% of the global land surface, excluding Antarctica, still relatively free of human influence (CIESIN 2002) (see Figure 1.1). In fact, in the three global biomes considered in this paper—(i) tropical/subtropical grasslands, shrublands and savannas, (ii) deserts and xeric shrublands, and (iii) Mediterranean forests, woodlands & scrub—Australia has the largest remaining wild areas of any country (CIESIN & WCS 2003).

These large natural areas support some of the richest concentrations of flora and fauna found anywhere on Earth. Australia ranks first among all nations in the number of endemic mammal and reptile species, and among the top five in numbers of endemic plants, birds and amphibians.[1]

However, these areas face threats. Already, Australia has one of the worst records of extinctions, particularly of mammals and vascular plants, and many species are threatened, including about 20% of mammals. The extinction process is ongoing, including in areas with high wilderness qualities (eg. Johnson

Pew Environment Group (Pew) works on four continents to strengthen environmental policy and produced concrete, measurable conservation gains in both terrestrial and marine ecosystems worldwide. Pew's staff of scientists, economists, lawyers and public policy experts focuses on reducing the scope and severity of three major global environmental problems:

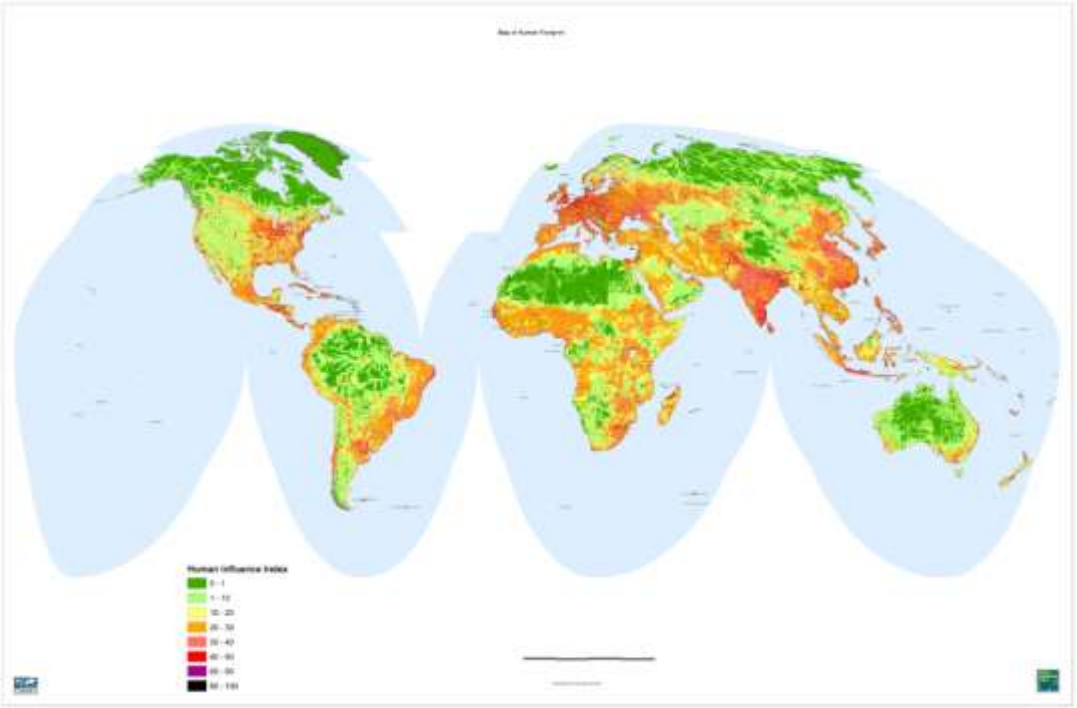
* Human induced climate change.
* The loss of large wilderness ecosystems.
* The destruction of the world's oceans.

The Nature Conservancy (TNC) is a leading conservation organisation working around the world to protect ecologically important lands and waters for nature and people. To date, the Conservancy and its more than one million members have been responsible for protection of more than 6 million hectares in the United States and have helped conserve more than 40 million hectares in Canada, Latin America, the Caribbean, Asia and the Pacific. The TNC has worked directly in Australia since 1999. See http://www.nature.org for further information.

[1] Based on various sources, summarised at URL <http://www.wilderness.org.au/au/campaigns/policy/biodivsum/>.

2006, Robinson & Traill 1996, Woinarski et al. 2001).

FIGURE I.1 WILDERNESS AREAS OF THE WORLD



Source: Center for International Earth Science Information Network (CIESIN), available at <http://www.ciesin.columbia.edu/wild_areas/#>. Nine data layers—in the themes human population pressure, human land use and infrastructure and human access—were used to create this global 'human footprint' map. Darker green areas indicate least human impact.

Australians now recognize the need to address their local biodiversity crisis. However, with only 20 million citizens responsible for stewardship of an entire continent, they need and seek assistance from conservationists in other nations.

After studying the situation, two international non-government organisations, The Nature Conservancy (TNC), and The Pew Charitable Trusts (Pew) have agreed to collaborate on a new conservation program in Australia. This program will provide major strategic and financial support to bolster efforts by Australians to protect their globally significant flora and fauna.

The Pew-TNC Australia Program will provide assistance to Australian organisations to secure long-term protection, via conservation tenure and good land management, of large natural areas, both terrestrial and marine. Three years of funding is currently available for the program.

Partnerships with Indigenous landowners and private land conservation groups, and advocacy approaches will all be used. Projects will be sought with partners to get on-ground/on-water results within the 3 year period.

PROTECTION OF LARGE NATURAL AREAS

There has been considerable debate in conservation about whether efforts should be focused primarily on protecting large wilderness areas or biodiversity 'hotspots', which tend to be smaller areas, often degraded by human activities, with particularly high species richness and endemicity. The difference is exemplified by Mittermeier et al. (2003) in their comparison of the relative richness and endemicity of 24 wilderness areas (which includes the Australian savannas and the Australian deserts). They found that, overall, the wilderness areas are not highly species-rich on a global scale and that only 18% of plants and 10% of terrestrial vertebrates are endemic to individual wilderness areas. They suggested that with the exception of 5 of the 24 wilderness areas identified, "the targets of biodiversity conservation and of wilderness conservation are generally different".

In contrast, papers by Soule and others (eg. Mackey et al. 1998, Soule et al. 2004) emphasise the importance of protecting large natural areas in order to maintain the full suite of ecosystems and ecological processes they maintain. While efforts to protect biodiversity hotspots and large natural areas are both important and complementary, they often require different approaches and different resources. One of the differences frequently encountered is highlighted in The Nature Conservancy's distinction between 'crisis' ecoregions, where ecosystems have been largely modified and face ongoing degradation, and 'opportunity' ecoregions, which remain largely intact. Neither should be neglected: it is important not only to protect the highly threatened high-value areas but also those areas where conservation of large areas in the short term is cost-effective and will mitigate the need for longer term restoration work. In Australia and internationally, The Nature Conservancy has worked in both types of ecoregions. In its terrestrial environment programs in the United States and Canada, Pew Environment Group has focused largely on the protection of large natural areas. It has also sought protection of very large marine sanctuary zones globally. Until recently in Australia, conservation advocacy and private land conservation work have concentrated disproportionately on the 'crisis' bioregions of the more populated south and east of the continent. Although the balance has been shifting in recent years, there has been relatively less conservation work in the very large natural areas in the arid zone and the monsoonal tropics of Northern Australia.

In Australia there is also increasing knowledge of the need to ensure the maintenance of ecological processes and connectivity which may work over huge distances on the continent (Soule et al. 2004). Protection of these natural processes is vital for the long term conservation of many species and ecosystems. Larger and more intact natural areas are also likely to be more robust in the face of rapid, human-induced climate change. Taking into account these factors—ie. the need to secure long-term protection of conservation values and ecological processes, the relative lack of conservation focus in large natural areas in Australia, and the looming impacts of climate change—TNC and Pew have decided that their combined Wild Australia Program will focus on conservation of large natural areas. This focus on large natural areas will complement existing conservation programs in Australia, in particular by providing resources in regions that have received disproportionately less conservation focus.

The Wild Australia Program will contribute to TNC's global biodiversity goal "to work with others to ensure, by 2015, the effective conservation of places that represent at least 10 percent of each major habitat type on Earth" (TNC 2006). Currently, eight of 13 terrestrial major habitat types do not meet this goal, including the three habitat types that include the large natural areas considered in this paper.

GAPS AND OMMISSIONS

This is a desk-top study using available datasets and literature, and working at a continental scale. We may therefore have missed specific information held by local people and local groups. We are also conscious that we have not obtained much detail on the capacity of some regional groups. We therefore apologise in advance if we have not acknowledged current conservation efforts in some areas. TNC and Pew look forward to learning more about specific projects and opportunities during consultation on work in specific regions.

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of the following people:

- Steve Morton, Hugh Possingham and Paul Sattler for scientifically reviewing the paper
- Simon Kennedy for GIS work
- Janet Stein for data on river disturbance
- Carissa Klein and the UQ Ecology Centre for information and maps
- James Watson for information about the Great Western Woodlands
- Brendan Mackey, Michael Looker, and Hank Cauley for discussion and advice on different aspects of the study.

METHODOLOGY

SELECTION OF FOCUS AREAS

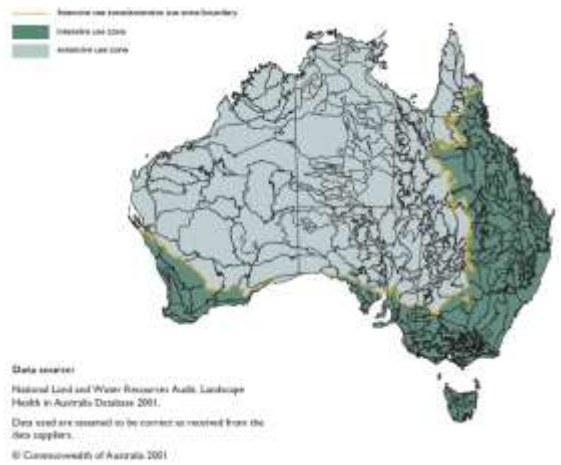
The selection is designed to nominate areas of interest for the Pew-TNC Wild Australia Program—the 'focus areas' for this paper. Focus area are large (>1 million hectares) semi-natural to natural areas in relatively good condition. Condition is assessed in terms of extent of native vegetation cover, quality of vegetation condition and landscape health. In the selection process we exclude the more fragmented and degraded areas in which the program will not focus.

BIOGEOGRAPHIC UNITS FOR SELECTION

Only areas in the 'extensive zone' as defined by the National Land and Water Resources Audit and shown in Figure M.1 are considered for selection. This is because (a) the 'intensive zone' as delineated by the audit has very few large natural areas left, and (b) with the great majority of the Australian population living in the intensive zone there tends to be a much greater conservation focus on natural areas within that zone than on areas within the extensive zone, which are remote from population centres.

A typology of four biogeographic levels are used or referred to in the selection process: biomes, ecoregions, bioregions and subregions. Biomes are global-scale broad habitat types, and ecoregions are finer regional-scale patterns of ecological organisation shaped by local geography and climate. Biomes and ecoregions were delineated by WWF (Olson et al. 2001) and endorsed by TNC (Hoekstra et al. 2005). In Australia, the ecoregions are delineated as one or more bioregions derived from the Interim Bioregionalisation of Australia (IBRA), as developed originally by Thackway and Cresswell (1995) and refined by Environment Australia (2000). Bioregions are delineated according to factors associated with climate, soils, geology, landforms and vegetation. Subregions are finer-scale delineations based on these same factors. The Australian extensive zone contains four (of 13) global terrestrial biomes, 21 ecoregions, 48 IBRA (version 5.1/6.1) bioregions and 172 subregions.

FIGURE M.1: EXTENSIVE/INTENSIVE LAND USE ZONE BOUNDARY



The initial units for selection are IBRA (version 5.1) bioregions in the extensive zone.[2] Assessment forming the basis of the 'landscape health' criteria is at the subregional scale. Those bioregions which meet the selection criteria defined below are then clumped into ecoregions (excluding the bioregions not meeting the selection criteria). The regions thus designated are our 'focus areas' and are described in subsequent sections, according to their global biome category.

[2] For the extensive zone, we understand IBRA versions 5.1 and 6.1 (the latest version) to be the same. As most of the available databases refer to IBRA 5.1 bioregions, we have maintained the reference to that version.

SELECTION CRITERIA

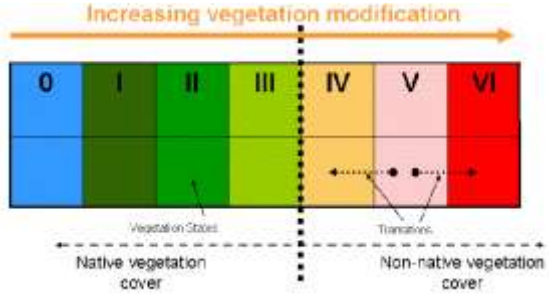
The criteria have been designed to select for bioregions in comparatively good land condition, based on assessments of vegetation cover and condition, and a measure of environmental stress. Any bioregion which meets criteria (1) AND EITHER criteria (2) OR criteria (3) is selected. The three criteria are:

(1) *Native vegetation cover*, as reported by the National Land and Water Resources Audit (NLWRA 2001), is >90%

(2) *'high quality vegetation',* as assessed using the 'Vegetation Assets, States, and Transitions' (VAST) framework (Thackway & Lesslie 2005), covers >50% of the bioregion. Note that 'high quality vegetation' is equivalent to VAST classes 0 and 1, referred to by Thackway and Lesslie as 'residual'.

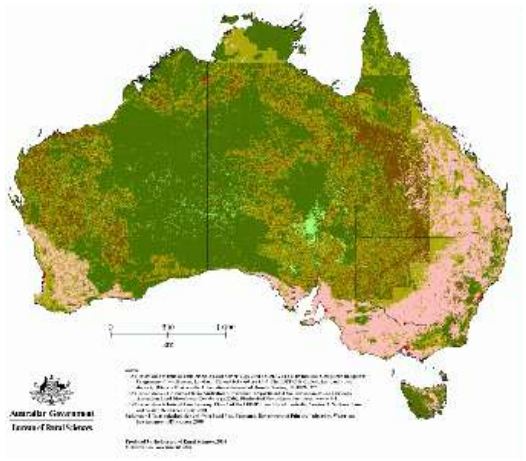
(3) Median subregional 'Continental Stress Class', a measure of *landscape health*, as assessed in the National Land & Water Resources Audit by Morgan (2001), is at least 5 (5 is the second lowest stress class). This means that at least half of the subregions in the bioregion selected are rated in the two best landscape health categories.

FIGURE M.2: VAST CONCEPTUAL FRAMEWORK



Source: Thackway & Lesslie (2005)

FIGURE M.3: DRAFT VAST CLASSIFICATION FOR AUSTRALIA



Source: Thackway & Lesslie (2005)

Note the 2 colours indicative of 'high quality':

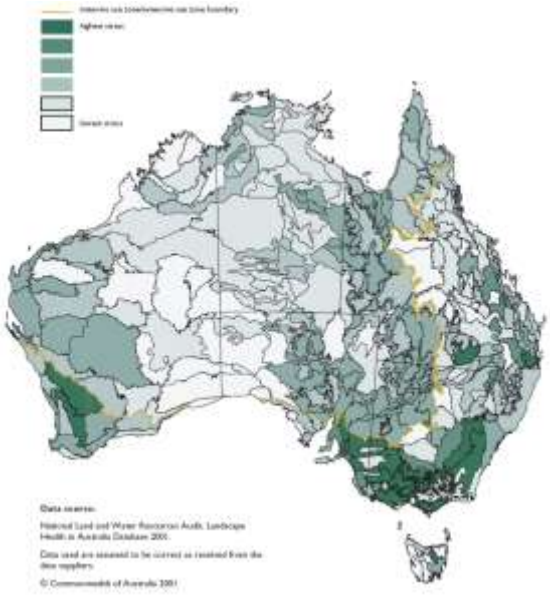
Vegetation condition: The VAST classification framework is "a means of ordering native vegetation by degree of anthropogenic modification as a series of states, from a residual or base-line condition through to total removal" (Thackway & Lesslie 2005).

The 'high quality' vegetation condition states (referred to as 'residual' by Thackway and Lesslie) are defined as either areas where "native vegetation does not naturally persist" naturally (for example the beds of inland salt lakes) or where "native vegetation community structure, composition, and regenerative capacity are intact – no significant perturbation from land use/land management practice" (ibid). In the draft national VAST assessment we use here, Thackway and Lesslie used four sources of data to assess vegetation states: (a) Biophysical Naturalness layer within the Australian Land Disturbance Database held by the Australian Government Department of Environment and Heritage, (b) the 1996/97 (National) Land Use of Australia, Version 2, (c) catchment scale land use mapping produced through the Australian Collaborative Land Use Mapping Program, and (d) MODIS satellite imagery (bare ground). See the resulting classification map in Figure M.3.

Using the VAST dataset, obtained from the Bureau of Rural Sciences, we assessed whether the proportion of 'high quality' vegetation condition (states I or 0) was at least 50%.

Landscape health: As part of the National Land and Water Resources Audit, Morgan (2001) assessed the health of each of 354 Australian subregions according to defined attributes. For the extensive zone, these attributes (which differed for the intensive zone) were:

FIGURE M.4: CONTINENTAL LANDSCAPE STRESS



Source: Morgan (2001). Note the darkest colours indicate greatest landscape stress.

- Percent of subregion with least impacts from total grazing pressures
- Percent of native vegetation in land tenures associated with conservation land use practices
- Density of weeds (mainly Weeds of National Significance)
- Density of feral animals
- Number of threatened species.

The decision table used to determine landscape stress for the extensive zone is shown in Morgan (2001, Figure 82). The resulting map of stress classes is shown here in Figure M.4. The lighter-coloured areas are those subregions in the highest stress classes (suffering least stress). A stress class rating of 5 or 6 (the two used in the selection criteria) are taken to indicate the subregion is in "relatively good health" (ibid).

DESCRIPTION OF FOCUS AREAS

The aim is to provide a comprehensive snapshot of each selected focus area, as the basis for future evaluation of program opportunities and priorities.

DESCRIPTION OF BIOMES

The focus areas are described in biome categories (as defined above). The characteristics of each relevant biome in Australia is described in an introductory section, with a particular focus on their biological history and ecological processes as defined by Soule et al. (2004).

GENERAL DESCRIPTION

Each focus area is described in terms of location and biogeographic categories, biophysical attributes, land tenure, land use and information about people and institutions. Information about Aboriginal language groups is derived primarily from a map provided by AIATSIS (2005). This map is based on published resources available up to 1994, and indicates only the general location of larger groupings of people, which may include smaller groups such as clans, dialects or individual languages in a group. It does not reflect native title claims or rights. Information about native title claims was derived primarily from the National Native Title Tribunal website (NNTT 2006). Because of native title resolutions, the information in the land tenure maps may be out of date. It is likely that much of the area designated 'unassigned crown land' has either been resolved as native title or is under native title claim.

CONSERVATION VALUES

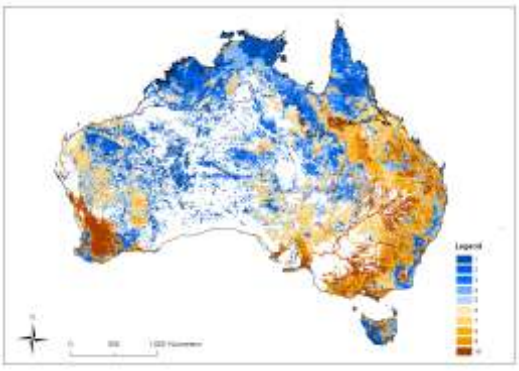
Conservation values are described in terms of land condition, biodiversity values, and refugia and significant landscape features. A key source of information for many attributes are the databases for the National Land and Water Resources Audit Australian Terrestrial Biodiversity Assessment, obtained from the Australian Natural Resources Atlas (NLWRA 2002).

Land condition: Five categories of land condition attributes are considered.

Landscape health indices are derived from Morgan (2001), an NLWRA-conducted assessment of continental stress in each subregion, described above.

Vegetation condition is derived from Thackway and Lesslie's (2005) VAST assessment, described above.

FIGURE M.5 RIVER DISTURBANCE INDEX

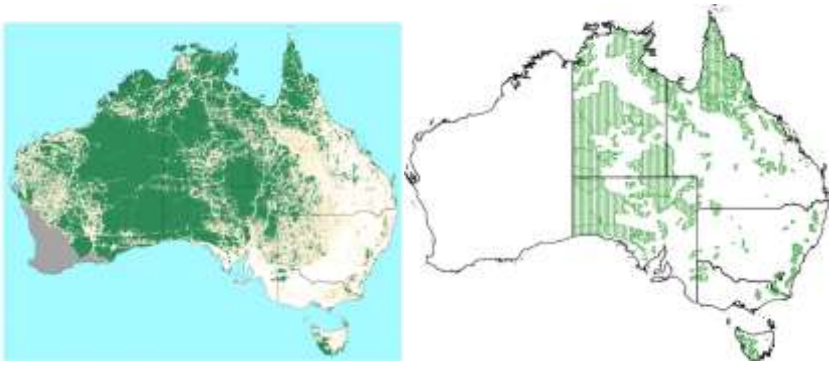


Source: Stein et al. (2002), Stein (2006)

Note: Class 1 (dark blue) indicates rivers of least disturbance

River condition is derived from the River Disturbance Index by Stein et al. (2002) updated by Stein (2006) and based on the methodology described in Stein et al. (1998). Figure M.5 shows the River Disturbance Index as applied Australia-wide. The methodology is based on the "assumption that (a) the intensity and extent of human activities within the catchment and (b) in-stream structures that alter the flow regime, provide surrogate indicators of the extent of disturbance of natural river processes." Each stream section or link was scored on four indices of catchment disturbance—(1) land use activity; (2) settlements and structures; (3) infrastructure; and (4) extractive industries and other point sources of pollution—as well as indices reflecting direct alterations to the flow regime from impoundments, flow diversions or discharges and levee banks (Stein et al. 2002).

FIGURE M.6: AUSTRALIAN WILDERNESS AREAS



National Wilderness Inventory **Commonwealth Wilderness Delineation Project**

Source: Australian Land Disturbance Database, available at <http://www.heritage.gov.au/anlr/code/ald.html>

Wetland condition and riparian condition are derived from the NLWRA (2002) biodiversity audit database.

Scores (1-4) for each were generated by expert opinion.

Wilderness quality is derived from the National Wilderness Inventory (NWI) (Lesslie & Maslen 1995). This Inventory was based on four attributes: (a) biophysical naturalness, (b) remoteness from settlement, (c) remoteness from access, (d) apparent (or aesthetic) naturalness. A more recent Commonwealth Wilderness Delineation Project was undertaken by the federal government, but because Western Australia was not

included in this assessment, we have used the earlier NWI assessment for the sake of consistency. Both maps (shown in Figure M.6) are similar, although some areas of high quality wilderness in the NWI assessment are no longer classified as such in the delineation project.

Biodiversity values: Values considered include biodiversity richness, endemism, and threatened ecosystems and species. They are documented from a variety of sources, in particular the NLWRA (2002) biodiversity database, and assessments by state conservation agencies. We note various limitations to this data:

- Endemism is a matter of scale – the larger the area considered the higher is likely to be the level of endemism.
- Threatened species listings are far from comprehensive and often out of date. They have significant biases in the types and locations of species included. Changes in status often result from better knowledge rather than actual status change. Thus, "bulked indices of numbers of threatened entities per site or region [can be] ambiguous as indicators of biodiversity status" (Landsberg & Crowley 2004).
- There is very poor information about biodiversity in many of the areas considered; typically, the more intensively surveyed an area the greater is its richness (How & Cowan 2006)—and presumably the causal relationship operates in both directions. Some states provide much more information about biodiversity than others, also biasing the data.
- There has not been consistent ecosystem mapping across Australia.

Refugia/landscape features*:* Refugia are identified in categories defined by Morton et al. (1995). *Evolutionary* refugia are where species persist in a fraction of their original ranges, typically such sites as islands, mound springs, caves, gorges, and mountain ranges. *Ecological* refugia are where particular environments provide dependable resources allowing the persistence of populations during periods of time that are short relative to those implied by evolutionary refugia (i.e. periods close to the generation time of the organisms concerned). For example, in arid environments, this is likely to be places where water and plant nutrients tend to accumulate, such as wetlands, gorges, mountain ranges. *Human-induced* refugia are where species occur because elsewhere in their ranges anthropogenic impacts prevent them from persisting. Examples include refuges from exotic animals and refuges from land clearing.

We also identify wetlands of national significance (those listed in the Directory of Important Wetlands) and other significant landscape features.

ECOLOGICAL PROCESSES

The status of seven ecological processes is briefly assessed. These processes have been identified by Soule et al. (2004) as most relevant to the conservation of biodiversity in Australia. A brief qualitative judgment is made about the relative intactness of each process and examples given where processes are considered to be compromised.

MAJOR THREATS

Information about threatening processes in each focus area is derived primarily from the NLWRA (2002) biodiversity audit, assessments by state government agencies, and the scientific literature.

EXISTING CONSERVATION ACTIVITIES

Protected areas: Information about the status of protected areas in each bioregion is derived primarily from Sattler and Glanznig (2006). This in turn is based upon 'Comprehensive, Adequate and Representative' criteria and other principles within a bioregional framework used by the federal Department of Environment to assess

the adequacy and priorities of the National Reserve System (Commonwealth of Australia 1999).[3] In information presented, 'adequacy' is defined in terms of the extensiveness of the area reserved in each bioregion (hectares & %), in IUCN categories I-IV, and V-VI; and 'comprehensiveness' is defined as the degree to which regional ecosystems are represented in the reserve system across each bioregion (% reserved).

Policies, plans and programs: Various area-specific policies, plans and programs in each focus area are identified to provide an indication of existing conservation effort. There is also a wide range of state and federal policies and programs that influence conservation activity in each of the focus areas, which cannot be summarised here—policies affecting the capacity of Aboriginal people to manage country, and those regulating pastoralism, for example.

CONSERVATION CAPACITY

A brief assessment is made of the capacity of community groups and institutions to undertake conservation activities in the focus areas. In addition, there is a brief assessment of the adequacy of information about each focus area.

[3] For example, there is a target to have 80% of regional ecosystems represented in the NRS by 2010-2015.

SELECTION OF FOCUS AREAS

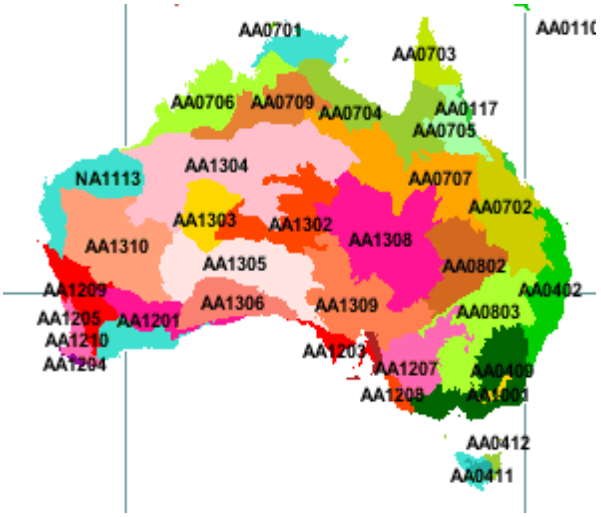
In brief, as described in the methodology, we have selected bioregions in the extensive zone which:

(a) have >90% native vegetation cover, AND
(b) have >50% 'high quality' vegetation cover (according to the VAST classification by Thackway and Lesslie 2005) OR
(c) are rated as relatively healthy, with at least half their subregions in stress class 5 or 6 (according to the landscape health assessment by Morgan 2001).

We clumped the bioregions that met these criteria into the ecoregions delineated by WWF (Olson et al. 2001) and shown in Figure S.1. These ecoregions or partial ecoregions were designated our 'focus areas' (in some cases with different names from the WWF ecoregions). The focus areas are grouped according to the biome they represent, as shown in Figure S.2.

Table S.1 shows the results of the selection process, which yielded 12 focus areas in 3 biomes: (i) 5 focus areas in the Tropical and Subtropical Grasslands, Savannas, and Shrublands biome, (ii) 6 focus areas in the Desert and Xeric Shrublands biome, and (iii) 1 focus area in the Mediterranean Forests, Woodland, and Scrub biome. There were none in the Temperate Grasslands Savannas and Shrublands biome.

FIGURE S.1: AUSTRALIAN ECOREGIONS



Source: WWF (2001), available from URL <http://www.worldwildlife.org/science/ecoregions/australasia.cfm

FIGURE S.2: AUSTRALIAN BIOMES

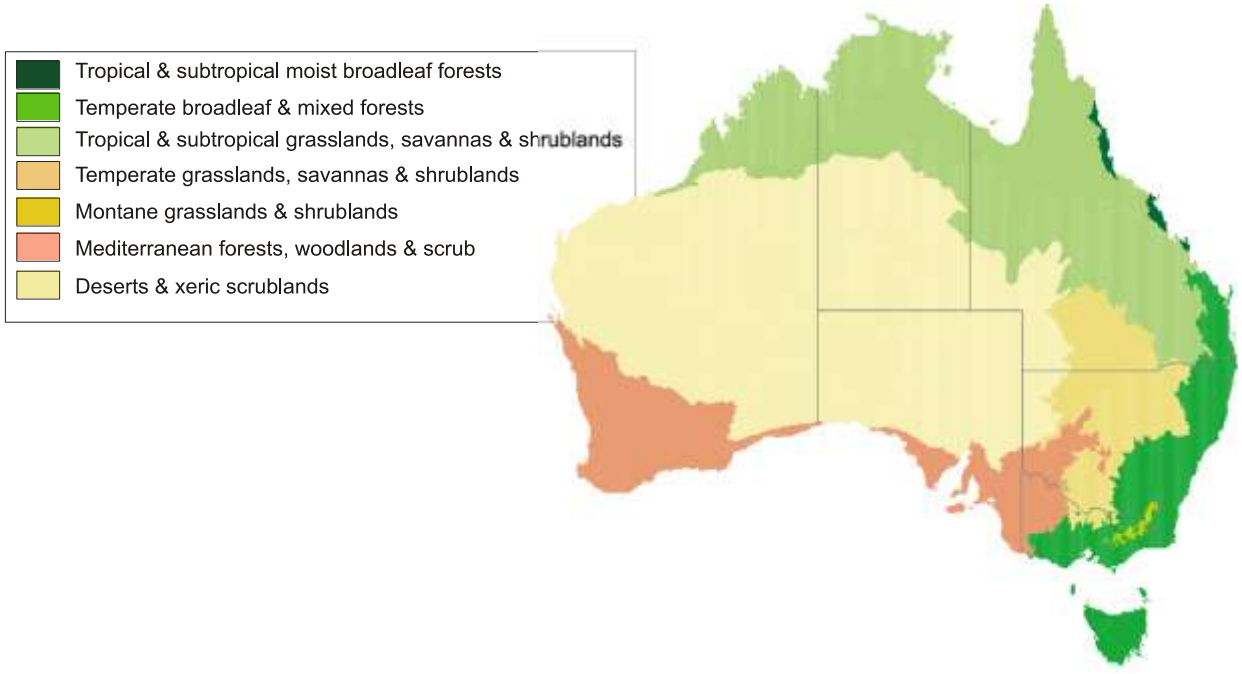


TABLE S.1: SELECTION OF LARGE NATURAL FOCUS AREAS

Biome	Ecoregion	IBRA Bioregion	Native vegetation >90% cover	Vegetation condition >50% high quality	Median Subregional Continental Stress Class 5or 6	Selected Large Natural Focus Areas
Tropical and Subtropical Grasslands Savannas, & Shrublands	Victoria Plains Tropical Savanna **AA0709**	Sturt Plateau	✓	✓	✓	**VICTORIA PLAINS TROPICAL SAVANNA**
		Ord Victoria Plain	✓	✗	✓	
	Kimberley Tropical Savanna **AA0706**	Dampierland	✓	✓	✓	**KIMBERLEY TROPICAL SAVANNA**
		Northern Kimberley	✓	✓	✓	
		Central Kimberley	✓	✓	✓	
		Victoria Bonaparte	✓	✗	✗	
	Carpentaria Tropical Savanna **AA0704**	Gulf Fall and Uplands	✓	✗	✓	**CARPENTARIA TROPICAL SAVANNA**
		Gulf Coastal	✓	✗	✓	
		Gulf Plains	✓	✗	✗	
	Cape York Peninsula Tropical Savanna **AA0703**	Cape York Peninsula	✓	✓	✗	**CAPE YORK PENINSULA TROPICAL SAVANNA**
	Arnhem Land Tropical Savanna **AA0701**	Arnhem Coast	✓	✓	✓	**DALY BASIN - ARNHEM LAND TROPICAL SAVANNA**
		Darwin Coastal	✓	✓	✗	
		Tiwi-Cobourg	✓	✓	✓	
		Central Arnhem	✓	✓	✓	
		Arnhem Plateau	✓	✓	✓	
		Daly Basin	✓	✗	✓	
		Pine Creek	✓	✗	✗	

Biome	Ecoregion	IBRA Bioregion	Native vegetation >90% cover	Vegetation condition >50% high quality	Median Subregional Continental Stress Class 5or 6	Selected Large Natural Focus Areas
	Mitchell Grass Downs **AA0707**	Mitchell Grass Downs	✓	✗	✗	
		Mount Isa Inlier	✓	✗	✗	
Deserts & Xeric Shrublands	Simpson Desert **AA1308**	Simpson-Strzelecki Dunefields	✓	✓	✓	**SIMPSON-STRZELECKI DESERT**
		Channel Country	✓	✗	✗	
	Western Australian Mulga Shrublands **AA1310**	Gascoyne	✓	✗	✗	
		Murchison	✓	✗	✗	
	Tirari-Sturt Stony Desert **AA1309**	Stony Plains	✓	✗	✗	
		Gawler	✓	✗	✗	
		Flinders Lofty Block	✗	✗	✗	
		Broken Hill Complex	✓	✗	✗	
	Pilbara Shrublands **AA1307**	Pilbara	✓	✗	✗	
	Nullarbor Plains xeric shrublands **AA1306**	Nullarbor	✓	✓	✓	**NULLARBOR PLAINS**
	Great Victoria Desert **AA1305**	Great Victoria Desert	✓	✓	✓	**GREAT VICTORIA DESERT**
	Great Sandy-Tanami Desert **AA1304**	Little Sandy Desert	✓	✓	✓	**GREAT SANDY-TANAMI DESERT**
		Great Sandy Desert	✓	✓	✓	
		Tanami	✓	✓	✓	
		Davenport Murchison Ranges	✓	✓	✓	

Biome	Ecoregion	IBRA Bioregion	Native vegetation >90% cover	Vegetation condition >50% high quality	Median Subregional Continental Stress Class 5or 6	Selected Large Natural Focus Areas
	Gibson Desert **AA1303**	Gibson Desert	✓	✓	✓	**GIBSON DESERT**
	Central Ranges Xeric Scrub **AA1302**	Burt Plain	✓	✗	✗	
		MacDonnell Ranges	✓	✓	✓	**CENTRAL RANGES**
		Finke	✓	✗	✓	
		Central Ranges	✓	✓	✓	
	Carnarvon Xeric Shrublands **AA1301**	Carnarvon	✓	✗	✗	
Mediterranean Forests, Woodland, & Scrub	The Coolgardie Woodlands **AA1201**	Coolgardie	✓	✓	✓	**GREAT WESTERN WOODLANDS**
		Hampton	✓	✓	✓	
	Murray-Darling Woodlands and Mallee **AA1207**	Murray-Darling Depression	✗	✗	✗	
	Southwest Australia savanna **AA1209**	Yalgoo	✓	✗	✗	
		Geraldton Sandplains	✗	✗	✗	
Temperate Grasslands Savannas & Shrublands	Eastern Australia Mulgalands **AA802**	Mulgalands	✗	✗	✗	
	Southeast Australia Temperate Savanna **AA0803**	Cobar Peneplain	✗	✗	✗	
		Darling River Plains	✗	✗	✗	

BIOME INTRODUCTION: TROPICAL SAVANNAS

Savannas are one of the world's major terrestrial biomes, covering 33 million km^2 globally (Beerling & Osborne 2006). In Australia the top third of the continent is dominated by savanna, an area of >1.5 million km^2. With much of the world's savannas subject to intense human exploitation, Australia now has by far the largest continuous expanse of intact savanna woodlands in the world (Woinarski et al. *in press*). This was also recognised in a global assessment identifying 569 large wild areas left on earth, excluding Antarctica. Australia was identified as the country having the largest proportion of the tropical/subtropical savanna grasslands, shrublands and savannas in a wild state (CIESIN & WCS 2003). In addition, Mittermeier et al. (2003) identified Australian savannas (585,000km^2 in the Top End, Cape York Peninsula and the Kimberley) as one of 24 'global wilderness areas' (defined as areas >1 million hectares, > 70% intact and with human densities <5 people/km^2).

Thus far, Australian tropical savannas have largely been spared the intense development pressures that have transformed most of the temperate Australian biomes. However, there is currently a major push to expand clearing for agricultural development into northern Australia. Furthermore, despite the thus-far limited extent of clearing there are ongoing regional extinctions of some species due to changed fire management, grazing by introduced stock, and the effects of invasive species (Woinarski et al. in press). Granivorous birds and small mammals have been especially affected (Franklin 1999, Woinarski et al. 2001).

Australian tropical savannas are biologically rich. For example, north-western Australia, covering 15% of the Australian land area, is habitat for about 40% of Australian mammal and terrestrial reptile fauna and more than 50% of land birds (Woinarski 1992).

The biota is poorly understood and, in many cases, only recently recognised. Thus, Woinarksi (1992) remarks of the northwest that 101 reptile species (38% of the known total) and 17 mammal species (18% of the known total) had only been described in the previous 20 years or were still being described. More species have been discovered since then. Beyond species cataloguing there is still much to understand about ecological interactions and processes.

In their comparison of global wilderness areas, Mittermeier et al. (2003) found that Australian savannas do not stand out for overall species richness or endemicity (particularly compared with the speciose, and larger, tropical forests such as Amazonia). However, they do stand out for mammal species richness (top 5) and reptile species richness (top 6) and, less prominently, for plant species richness (top 9) and bird species richness (top 12).

Due to remoteness, small human populations and a sense that the physical intactness of the savanna vegetation implies conservation security, there has been limited conservation focus in the north.

In this paper we consider conservation values, threats and opportunities in a large proportion of the tropical savannas, in five focus areas: Cape York Peninsula, Daly Basin-Arnhem Land, Kimberley, Carpentaria and Victoria Plains tropical savannas. In this introduction, we consider the biological history and ecological processes common to these areas.

BIOLOGICAL HISTORY

Globally, the savanna biome has arisen in relatively recent times, originating about 8 million years ago in the late Miocene, after the evolution of C_4 grasses (Cerling et al. 1997). In hot conditions or when concentrations of carbon dioxide are low the C_4 grasses have a more efficient photosynthetic pathway than the C_3 trees they largely replaced. It has been hypothesised that their increasing dominance and

the development of savannas occurred in many places due to a network of positive feedbacks between fire, climate and the C_4 grasses—fire accelerates grassland expansion through multiple feedback loops that promote drought and more fire (Beerling & Osborne 2006).

However, although fire is a key ecological driver in Australia's tropical savannas it was probably not the critical factor in the origin of savannas. In the sparse archaeological record, there is no strong correspondence between vegetation alterations and charcoal peaks, or else charcoal peaks occur after vegetation change, suggesting that fire was the result, rather than the cause, of vegetation change (Kershaw et al. 2002).

Since at least the end of the Tertiary, the climate in northern Australia has been tropical and seasonal, with a long dry season (Williams et al. 2002). Increasing aridity and seasonality from 10-15 million years ago caused a major contraction of rainforest across northern Australia (Russell-Smith & Stanton 2002). The development of the Australian savannas is thought to have occurred primarily due to climate change rather than the burning of rainforest. Nonetheless, fire impact on rainforests was particular strong just prior to the Holocene and has played a significant role in ongoing structuring of savannas (Williams et al. 2002). Charcoal records indicate a widespread and abrupt increase in burning about 30-45,000 years ago, in conjunction with an increase in more open vegetation, which is interpreted as the onset of Aboriginal burning (Kershaw et al. 2002). This increased burning probably accelerated an existing trend.

Geologically, the northern Australia tropical savannas are a combination of new and old landscapes. Having endured recent climatic and sea-level oscillations, the top strata of the coastal lowlands are relatively young. Until recently, there were connections between these areas, between the mainland and offshore islands, and between Australia and New Guinea. In contrast to the instability of the lowlands, the sandstone and limestone ranges are ancient, and have persisted through deep time. Because of their stable presence and altitude they have served as

BRIEF BIOPHYSICAL DESCRIPTION[#]

The Australian tropical savannas consist of three broad types of landform: flat lowland plains of sands and loams (with surfaces of Tertiary age); rocky escarpments, slopes and plateaus (often with pre-Cambrian bedrock) with shallow rudisols; and black-soil plains, with predominantly cracking clays.

Most of the vegetation types are dominated by Eucalypts (*Eucalyptus* and *Corymbia*). In the upper-mid storeys are often broad-leaf, pan-tropical trees and shrubs. The ground cover is typically tussock or hummock grasses. The structure varies from open forest in wetter coastal and subcoastal regions to woodlands and low open woodlands in more arid areas. On heavier soils or where drainage is limited, there may be treeless grasslands. There are also many small patches of rainforest and heath.

Although structurally simple, Australian tropical savannas have high species richness in plants and animals. The composition and structure of the biota are primarily determined by variations in moisture and nutrients, fire and herbivory.

There is marked climatic seasonality, with about 90% of the annual rainfall falling in summer. The amount of rain varies from about 400 mm to >2000 mm a year, in a roughly south-north gradient. While the seasonality is predictable, there is considerable inter-annual and regional variability in the timing and duration of the wet season. Temperatures are high, with daily maxima generally >25^{0}C year-round.

Fire is a key feature of the savannas, due to the large fuel load created by climatic seasonality—large amounts of grass biomass are produced and then cured during the long hot dry season. Most ignition is anthropogenic, rather than by lightning. Savanna fires release a significant proportion of Australia's greenhouse gas emissions.

[#]Source: predominantly Williams et al. (2002)

evolutionary refugia, demonstrated by their concentration of endemic and relictual species. Now, they often also serve as human-induced refugia because their ruggedness and complexity have excluded some of the anthropogenic impacts being felt elsewhere (Morton et al. 1995).

ECOLOGICAL PROCESSES

Soule and colleagues (2004) highlight the importance for conservation of understanding and accommodating large-scale and long-term ecological processes that sustain natural systems. They review seven categories of ecological phenomena that:

> require landscape permeability and that must be considered when planning for the maintenance of biological diversity and ecological resilience in Australia: (1) trophic relations at regional scales; (2) animal migration, dispersal, and other large scale movements of individuals and propagules; (3) fire and other forms of disturbance at regional scales; (4) climatic variability in space and time and human forced rapid climate change; (5) hydroecological relations and flows at all scales; (6) coastal zone fluxes of organisms, matter, and energy; and (7) spatially dependent evolutionary processes at all scales.

The conservation virtue of most of the tropical savannas in Australia is that landscape permeability—necessary for exchanges of energy, water and nutrients, and plant and animal interchange, between both contiguous and distant locations at diverse scales—are still largely intact.

Here we briefly consider aspects of these seven categories of ecological processes to demonstrate their relevance to designing conservation approaches for the tropical savanna focus areas.

CRITICAL SPECIES

'Critical species' are those major ecological players, also known as 'keystone' or 'strongly interacting' species, which have a major impact on the habitat in which they live. Their decline or disappearance is often felt in the ecosystem at large, and may initiate ecological chain reactions or trophic cascades (Soule et al. 2004).

Some of the critical species in the tropical savannas are:

- Pollinators, such as honeyeaters and flying-foxes
- Seed dispersers, such as fruit pigeons, flying-foxes and ants
- Predators, such as goannas and dingoes
- Cavity creators, such as termites
- Termites and ants for energy flow and nutrient recycling
- Plants that provide food—nectar, fruit and seeds—during resource bottlenecks, such as grass species providing early seed after rain

LONG DISTANCE BIOLOGICAL MOVEMENT

It is important to conserve the capacity in tropical savannas for large-scale biological movements. Because of the (often extreme) variability in productivity of most Australian biomes, a large proportion of fauna must migrate or disperse during at least part of their life-cycle. For example, many birds disperse seasonally within the region or between the region and elsewhere, tracking seasonal changes in food abundance. The conservation of such species requires protection of each of their major habitats as well as the patches that serve as 'stepping stones' for long-distance movements (Soule et al. 2004). It is also critical to protect refugia that provide resources for mobile species during times of stress, such as unusually extended dry seasons (Morton et al. 1995).

Some of the long distance biological movements that occur in the tropical savannas are those by:

- Nectarivorous, granivorous, and frugivorous birds and bats seeking food
- Waterbirds seeking wetlands in both Wet and Dry seasons
- Seabirds and turtles to islands, and shorebirds to the northern hemisphere for breeding

DISTURBANCE

Disturbance is natural and inevitable, and important for maintaining species diversity in tropical savannas. However, anthropogenic disturbance is often damaging because it "exceeds the historic range of variability and intensity of natural disturbance regimes" (Soule et al. 2004). For example, in the tropical savannas, there have been extensive changes in fire regimes—the most critical of disturbance regimes—which has disrupted landscape permeability, and caused local and regional extinctions (see Fire box).

Significant natural disturbances in the tropical savannas which are important in maintaining species richness and diversity include:

- Cyclones which provide major flooding events (which may intensify in response to climate change)
- Fire regimes, which have significantly altered since European settlement.

FIRE IN THE TROPICAL SAVANNAS

Prior to Aboriginal arrival, fire probably occurred mostly during the transition from dry to wet season when there was an abundance of dry, combustible fuel and lightning (Williams et al. 2002). Although knowledge of Aboriginal burning regimes, which undoubtedly varied from place to place, has been lost to a large extent since traditional owners were displaced, it is clear that frequent burning occurred for many reasons: for example, to reduce wildfire risk to important resources, aid hunting, facilitate travel, regenerate senescent vegetation, and ceremony (Bowman 1998). The result was a fine-scaled mosaic of patches (typically 1-10 ha) with different burning histories. "There is evidence that the integrated effect, and probably unintended consequence, of skilful Aboriginal landscape burning was the maintenance of habitats for numerous small mammals and birds species that are now under the threat of extinction in arid rangelands and tropical and sub-tropical savannas" (Bowman 2003).

Extensive and intensive burning now occurs over a large proportion of the focus area, and is considered a key threatening process. In the five years to 2003, about 77% of the area north of 21^0S was burnt annually (Cork et al. 2006).

Reduced heterogeneity of fire patterns has been linked to broad-scale decline of savanna fauna (Woinarski et al. 2005). Besides the damage caused to particular fire-sensitive biota, the resulting extensive uniformity of the landscape exacerbates the challenges of extreme resource fluctuations for wildlife by destroying discontinuities that provide different resources or resources out of phase with changes elsewhere (ibid). Fire is the most obvious way of manipulating landscape heterogeneity to maintain resources for species with diverse needs.

In contrast to the damage caused by too much burning, there is also damage to some biota caused by too little burning. In the absence of hot fires, grasslands in some places, particularly Cape York Peninsula, are being transformed by the invasion of shrubs and trees (Crowley & Garnett 1998). Pastoralism is implicated for reduction of fuels for burning and attempted fire exclusion. The loss of grasslands compromises resources for some wildlife, such as the endangered golden-shouldered parrot.

CLIMATE CHANGE & VARIABILITY

Natural and human induced climate variability and change affects species, their distributions, and their habitats. Annual climate seasonality is probably more extreme in the Australian tropical savannas than anywhere else in the monsoonal tropics (Cook & Mordelet 1997, cited by Woinarski et al. 2005). On the coast at Darwin, for example, >95% of rain falls from December to April (Bowman 2002). The contrast between the wet and dry seasons is as Bowman (2002) says, "arguably the most important environmental feature of northern Australia, driving biological process operating at annual to evolutionary time-scales." Summer flooding since at least the late Holocene has facilitated the development of massive floodplains.

Global warming will exert considerable pressure on all biomes, and many species are likely to go extinct, particularly when climate change is combined with other anthropogenic pressures, such as those caused by invasive species, fire and grazing, and due to the loss or degradation of climate refugia. Some of the potential detrimental impacts of human-induced climate change in the tropical savannas include:

- Range contractions for some native species
- Range expansions for some invasive species and diseases
- Destructive fire regimes and more intense cyclones
- Sea level rise and salt-water intrusion into wetlands
- Reduced nutrition in leaves used by herbivores
- Disruption of key relationships such as pollination

PASTORALISM IN THE TROPICAL SAVANNAS

A large proportion (about 80%) of the savannas has been subjected to grazing, mostly cattle, for more than a century. Pastoralism was established in north Queensland in the 1860s and expanded westward over the next few decades (Woinarski & Ash 2002, citing Holmes 1963). Grazing occupies more than 99% of some grassland types and dominates elsewhere apart from the most rugged and least fertile areas, and some fertile areas used instead for horticulture (Woinarski & Ash 2002).

Pastoralism has been responsible for major changes in the tropical savannas, with changed fire regimes, vegetation changes, introduction/facilitation of weeds and pests, and degradation of riparian and other vegetation communities. In some areas, such as the Victorian River floodplain, there has been transformation of grasslands to dense woodlands, due to overgrazing and loss of flammable vegetation (Sharp & Whittaker 2003).

Pastoralism has also had significant impacts on fauna, and the change from Aboriginal land management to pastoralism over most of the area is implicated in regional losses of mammals and birds. In one study, Woinarski and Ash (2002) found that vertebrate assemblages were significantly different in grazed from ungrazed sites, probably due to the effects of "fire regime, alteration of floristics or vegetation structure, or direct impacts of trampling." Their study complemented studies in arid and semi-arid areas, which found that a significant proportion of plants and animals decline with increasing grazing pressure (Landsberg et al. 1997). The effects of grazing may be particularly pronounced for some wildlife, such as rodents, if cattle concentrate on the restricted relatively fertile areas within a low-productive environment that serve as population sources or refuges (Woinarski 2000).

HYDROECOLOGY

Hydroecology refers to the links between water, vegetation and wildlife, including water flows below and above the ground. Because of the long dry season, permanent or semi-permanent surface water, often maintained by groundwater, is highly significant, allowing various fauna and flora to persist. Land clearing in northern Australia can affect water flows into the underground aquifers that maintain water holes in rivers during the Dry, thus affecting wildlife a long distance from the actual area of clearing.

Douglas et al. (2005) have identified five general principles which characterize tropical rivers in northern Australia and have implications for conservation:

1. Seasonal hydrology—flooding in the Wet and then an extended Dry—is the primary driver of aquatic food-web structure and ecological processes.
2. Hydrological connectivity underpins food web 'subsidies' between terrestrial and aquatic ecosystems, and between productive floodplains and less productive river habitats.
3. River and wetland food webs are strongly dependent on algal production.
4. A few common macroconsumer species, such as fish and shrimp, have a strong influence on benthic food webs.
5. Omnivory is widespread and food webs are short.

COASTAL ZONE FLUXES

The fluxes of water, biota and nutrients between land and sea are vital for many terrestrial, freshwater and marine ecosystems and species. Northern Australia has a long and complex coastline, with considerable biotic and abiotic transfers between land and see. Mangrove forests and other estuarine systems are extensive and productive across Northern Australia. Marine influences reach a long way upstream into the large rivers. In a study of tropical estuaries adjacent to the GBR, Ley (2005) found that "a substantial amount of the variation in fish assemblages (42.9%) was related to catchment hydrology, configuration of the estuary mouth, substrate and mangrove area."

SPATIALLY DEPENDENT EVOLUTIONARY PROCESSES

Effective conservation must protect landscapes to allow for long term changes in the range of species, and the movement of genes across land and seascapes.

In tropical savanna maintaining permeability requires protecting, for example:

- Habitat heterogeneity at different scales
- Fire refugia in gorges and on escarpments for rainforest and other biota sensitive to fire.
- Geologically stable regions which have been less affected by climatic changes over deep time.

DECLINES IN MAMMALS & BIRDS

Although largely intact, the tropical savannas of northern Australia are showing signs of compromised ecological processes with substantial declines in both the mammal and bird fauna (Franklin 1999, Woinarski et al. 2001).

A large proportion of the Australian mammal fauna has already been lost from arid and semi-arid areas. There is evidence that this has extended north, particularly in areas used for pastoralism in the Kimberley and Gulf areas, with contraction of many mammals to the wetter more coastal parts of their range. Even in these wetter regions, however, some species that were once common, eg. the brush-tailed rabbit-rat, are now rare (Woinarski et al. 2001). A recent study in Kakadu National Park (ibid) has found that even in what was thought to be a secure area for wildlife significant declines are occurring. It was concluded that the "spate of declines that devastated the arid mammal fauna, mostly between the 1920s and 1960s …appears to have extended to the lower rainfall fringe of the monsoon tropics (at an uncertain period between the 1890s and now) and thence, possibly much more recently, to the higher rainfall areas of northern Australia".

With no foxes in northern Australia, and drought not the issue, the most feasible explanations are feral cat predation, exotic diseases and/or environmental change due to weeds, livestock and feral stock, or to changes in fire regime. Woinarski et al. (2001) consider the most likely cause to be subtle environment change due to loss of traditional Aboriginal land management, particularly fire management, and its replacement by pastoral management.

The same factors are likely to be implicated in the decline of granivorous birds (pigeons, finches, parrots), analysed by Franklin (1999). Twelve species (about one-quarter of the granivores), seven endemic to the northern savannas, have significantly declined in abundance—one is extinct, two are critically endangered. As Franklin says, "the ability of granivorous birds [and other wildlife] to coexist with widespread patterns of land-use and management, including in particular grazing and fire regimes, is a key conservation and sustainability issue for northern Australia."

CAPE YORK PENSINSULA TROPICAL SAVANNA

GENERAL DESCRIPTION

The Cape York Peninsula Tropical Savanna focus area covers 121 000 km^2 in far north Queensland, separated from New Guinea by Torres Strait, a 100 km gap at its narrowest. The focus area is equivalent to the IBRA bioregion Cape York Peninsula (CYP), as well as the ecoregion of the same name delineated by WWF and described by Mockrin (2001).

FIGURE CYP.1: LOCATION OF CAPE YORK PENINSULA TROPICAL SAVANNA

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[4]

Cape York Peninsula consists predominantly of undulating plains, sloping gently east and west from a ridge of low mountains and hills running parallel to the east coast. This backbone of ancient (Precambrian and Paleozoic) rock, which also constitutes the islands in Torres Strait and off the east coast, reaches just over 800m height. The western slopes and plains are also ancient and highly weathered. Part of western CYP overlies the Great Artesian Basin, a multilayered aquifer system. The focus area includes most of the islands in the Torres Strait, and off the eastern coast is the Great Barrier Reef.

About two-thirds of the vegetation is eucalypt woodlands, with a grass understorey. There are also large areas of Melaleuca-dominated woodlands (15%), and other vegetation types include grasslands (6%), rainforest (6%), and heathland (3%). Extensive mangrove forests line both coastlines. See Table CYP.1 for dominant vegetation types.

CYP.1: DOMINANT VEGETATION GROUPS (KM^2)

Eucalypt woodlands	Melaleuca forests & woodlands	Tropical eucalypt woodlands/ grasslands	Tussock grasslands	Rainforest & vine thickets
66,508	15,446	13,828	5,260	3,870

Source: NLWRA (2001)

The climate is monsoonal with about 80% of rainfall falling December to March. Rainfall ranges from about 800 mm in the south to 2400 mm in the east and north. Summers are hot and humid (32-37°C mean daily temperatures) and winters mild (17-23°C).

[4] Sources: NLWRA (2002) database, Mockrin (2001)

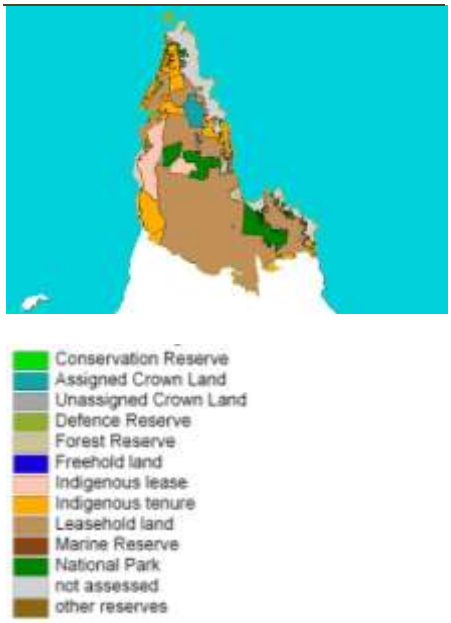
LAND USES, PEOPLE & INSTITUTIONS[5]

The dominant land use (about 60%) is pastoralism, on pastoral leases (see Figure CYP.1). Aboriginal lands (Deed of Grant in Trust) comprise about 15%, and national parks about 10%. Other land uses include mining, tourism and fishing. There are 12 small urban centres.

Mining (mainly of bauxite, silica, and kaolin) produces about half of the Gross Regional Product (GRP) and employs 12% of the workforce. The public sector accounts for about 20% GRP and 40% of the workforce, while pastoralism, cropping and fishing together account for 5% GRP and 6% of the workforce.

There is a small human population of about 18,000, 60% of whom are Indigenous (Aboriginal and Torres Strait Islander). About 70% of the CYP population lives in towns, and 700 people live on pastoral properties. There are at least 30 Indigenous language groups in the focus area. Their representative bodies are the Cape York Land Council and the Torres Strait Regional Authority.

FIGURE CYP.2: LAND TENURE



CONSERVATION VALUES

Having escaped the intense development pressure of southern Australia, this focus area has a largely intact natural landscape with functioning ecological processes and highly significant biodiversity values. In fact, these values have been assessed as sufficiently high to qualify much of Cape York Peninsula for world heritage listing (Mackey et al. 2001). However, the condition of CYP is deteriorating due to pervasive threatening processes such as grazing, invasive species and inappropriate fire regimes.

LANDSCAPE CONDITION

TABLE CYP.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE AND RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best)
CYP 1/2/3	4/4/4		3/3/3
CYP 4/5/6	4/4/4	0	3/3/3
CYP 7/8/9	3/4/5		3/2/2

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

In the assessment of landscape health by Morgan (2001), CYP rated only moderately well, with an average stress rating of 4 out of 6 (see Table CYP.2). The Weipa Plateau (CYP7), rating only 3, is the site of large-scale bauxite mining operations. The relatively low health ratings are a function of problems with invasive species and grazing. Note that the assessment did not include the effects of fire, one of the threatening processes in the focus area.

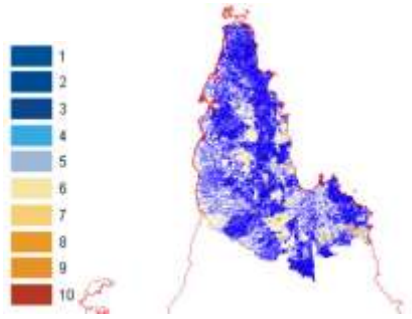
Minimal vegetation has been cleared in CYP. Vegetation condition (again without reference to fire), however, is variable, with a substantial proportion rated as 'modified', due to grazing pressure (see Figure CYP.2).

[5] Sources: Mackey et al. (2001), Woinarski et al. (2000), AIATSIS (2005)

FIGURE CYP.3: VEGETATION CONDITION (VAST)

Source: Thackway & Lesslie (2005)

FIGURE CYP.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE CYP.5: WILDERNESS QUALITY (NWI)

Source: Lesslie & Masslen (1995)

Rivers are mostly in good condition with high natural integrity (see Figure CYP.3). This has been recognised in the proposal to declare a number of CYP rivers under the Queensland Wild Rivers legislation. Nationally important wetlands in CYP are also in good to near pristine condition (NLWRA 2002, 32). The average subregional condition of riparian zones is considered good except for two

subregions where condition is considered 'fair (recovery requires significant intervention)' (see Table CYP.2).

Finally, in the National Wilderness Inventory, most of the focus area was assessed as having high wilderness quality (see Figure CYP.4). This is also the case in the more recent Wilderness Delineation.

BIODIVERSITY VALUES

Cape York Peninsula has been assessed as having regional, national and global significance for "outstanding biodiversity, and as a largely intact land and biological bridge retaining valuable evidence of the bio-evolution and ongoing 'fragmentation' of the biomes of the Australian Wet Tropics region and the island of New Guinea" (Mackey et al. 2001). These values qualify much of the area for world heritage listing.

There are very ancient landscapes in Cape York Peninsula. Its low mountainous backbone and islands are constituted of 1.5 billion year old Precambrian rock, 400 million-year-old granite and 270-300 million-old volcanic rock (ibid). Its western side, the catchment for the former Lake Carpentaria, is also old and weathered. Despite the major tectonic events occurring as Australia drifted north and collided with the Pacific plate, CYP appears to have been geologically stable over tens of millions of years, and there is possibly "no match globally for evidence of very long-term stability of a tropical landscape" (ibid).

For much of the past 3 million years Australia and New Guinea (the southern half is part of the Australian tectonic plate) have been linked through CYP (and also through Arnhem Land when sea levels were especially low). The last time Australia and New Guinea were land-linked was just 6,000-8,000 years ago. Not surprisingly, there are strong biological affinities between CYP and New Guinea, primarily in the lowland biota (with the land-bridge having been low and relatively dry). Thus, CYP "holds an amalgam of the megadiverse Australian biota and the megadiverse New Guinea biota in a dynamic matrix that is of global significance" (ibid).

CYP has diverse vegetation communities, with 30 broad vegetation types (Neldner & Clarkson 1995) and 211 regional ecosystems (Sattler & Williams 1999), of which 87 are threatened (Sattler & Glanznig 2006). An estimated 20% of the national extent of rainforest occurs in the focus area, mostly on the east coast. It is highly significant as a habitat for endemic species. One of the world's most species-rich mangrove systems (>30 species) lines both coasts of the Peninsula (Abrahams et al. 1995).

At the species level, CYP has high levels of plant richness and endemicity. Crisp and colleagues (2001) found that Cape York Peninsula was one of eight Australian centres of plant richness and one of 11 centres of plant endemism. The flora is a combination of Gondwanan relicts (at least 104 species), plants that evolved after the breakup of Gondwana, Indo-Malay plants that arrived since Australia collided with the Sundaland plate 15 million years ago (at least 103 species), and New Guinea species which made their way across the Torres Strait (at least 21 species) (Abrahams et al. 1995). The Gondwanan relicts include Austral conifers, proteas and orchids, mostly in rainforest (ibid). In total 3,338 plant species have been recorded, of which 264 species[6] and three genera are endemic, mostly occurring in the McIlwraith-Iron Ranges (Neldner & Clarkson 1995). There is globally significant diversity of orchids, with 62 genera occurring in CYP (Abrahams et al. 1995).

The more than 500 terrestrial vertebrates on CYP include one-quarter of Australia's frogs, one-quarter of the reptiles, a third of mammals, and half of its birds (CYRAG 1996). Wenlock River has the highest diversity of freshwater fish of rivers in Australia (Abrahams et al 1995). Forty vertebrate species are endemic to CYP, including more than 20% of its frogs, reptiles and non-flying mammals, and more than 10% of its passerine land birds, flying mammals, and freshwater fish (Mackey et al 2001).[7] CYP is an important component of the Eastern Australian Bird Migration System (ibid)—it functions as a transit site for birds to and from New Guinea, as overwintering habitat for species coming from the south, as breeding habitat for species coming from New Guinea and as part of a network in the seasonal movements of wetland birds. In significant contrast to other rangeland areas, there have been no published reports of declining mammal fauna in CYP, although it is reported that some larger rodent and dasyurid species, possums, bandicoots and small macropods are declining (Morrick 2001, citing J. Winter).

CYP is appears to be rich in invertebrates (not that there have been systematic surveys). About 60% (223 species) of all Australian butterfly species have been recorded in CYP, about 20% of which are endemic (Abrahams et al. 1995). In addition, 86 species of drosophilid (vinegar) flies (out of an Australian recorded total of 279) have been recorded in the Iron Range; 2000 species of moths and butterflies were collected on one 7 km length of track in the McIlwraith Range;

[6] An additional 40 to 100 undescribed taxa are also likely to be endemic (Abrahams et al. 1995).

[7] Furthermore, for many of the non-endemic species CYP is their "most important, remaining relatively undisturbed habitat" (Mackey et al 2001). The non-endemics tend to be (a) species with a range across the monsoonal savannas, (b) rainforest species that are also in the Wet Tropics to the south (c) species with seasonal movements into or through CYP or (d) wide-ranging seabirds, waders, aerial feeders.

and 106 species of ant were collected in the Iron Range area (ibid). See Table CYP.3 for further information about significant species in the focus area.

TABLE CYP.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	264 spp. 3 genera	71 6 endangered 51 vulnerable	Threatened plants include 17 orchids, 5 palms, 4 grasses, 3 cycads, 2 wattles. The endemics also contain a large proportion of orchids. There are also 39 vegetation types unique to tropical Australia.
Birds	20	15 5 endangered 4 vulnerable	Bird fauna is considered 'highly diverse' (in top 10 bioregions) & the number of range limited birds, is the highest in Australia. Threatened birds include 3 parrots, 3 seabirds, 2 finches, 2 owls, 1 stone-curlew, cassowary, 1 raptor, 1 button-quail. Endemics include 3 parrots, 3 honeyeaters, 3 robins, 2 monarchs, 2 birds of paradise, 1 bowerbird, 1 cockatoo, 1 kingfisher, 1 pitta, 1 gerygone, 1 silvereye.
Reptiles	33	6 1 endangered 4 vulnerable	Threatened reptiles include 4 marine turtles, 1 skink, 1 crocodile. Endemics include 17 skinks, 6 geckos, 2 monitors, 7 snakes, 1 freshwater turtle.
Mammals	13	7 3 endangered 1 vulnerable	Threatened mammals include 6 bats, 1 quoll. Endemics include 5 bats, 2 dasyurids, 2 possums, 2 rodents, 1 bandicoot, 1 macropod.
Freshwater fish	10	-	Endemics include 3 gudgeons, 2 gobies, 2 garfish, 1 rainbowfish, 1 catfish, 1 grunter.
Amphibians	7	-	Endemics include 4 Hylids, 3 Microhylids.
Invertebrates	50 butterflies	7 -	All threatened invertebrates are butterflies. Endemics include 21 blues, 17 eggflies, 6 whites, 6 skippers.
Richness & endemism statistics	3338 plants / 509 vertebrates / 362 birds / 397 endemics		

Sources: NLWRA (2002) database, Mackey et al. (2001), Birds Australia (2002) database

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Evolutionary refugia include the Iron and McIlwraith Ranges and the rainforests, evidenced by the large number of relict and endemic species; as well as the numerous islands, microcosms of what used to be much more extensive landscapes prior to inundation.

Ecological refugia include the ranges, which provide diverse microclimates and stable refuge areas for fire-sensitive species; the rainforests, which provide dry season refuges; riparian zones; mangroves; springs and wetlands.

Human-induced refugia include the islands and the ranges. With CYP providing the last undisturbed large areas of habitat for many species, the whole area can be regarded as refugial.

Significant wetlands: CYP has > 20 wetlands listed in the Australian Directory of Important Wetlands (NLWRA 2002 database).

Other features: Mackey et al. (2001) nominate four significant geological features as exemplifying CYP's geological diversity: the extensive and aesthetically dramatic white sands of the Eastern Dunefields; the Mitchell Palmer Limestone Belt for the karst surface formations; the Black Mountain and Cape Grenville Boulder landscapes for their massive ancient black boulders (blackened by algae); and the Chenier Plains of Princess Charlotte Bay.

ECOLOGICAL PROCESSES

Key ecological processes for the tropical savannas have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes in Cape York Peninsula, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and probably also by declines in frugivorous seed dispersers such as cassowaries and flying-foxes.

Long distance movement: Compromised where productive 'stepping stone' patches (such as riparian habitats) or refugia have been degraded by grazing or fire.

Hydroecology: Largely intact, but potentially compromised due to proposed groundwater extractions for mining.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Coastal fluxes: Largely intact—mangrove areas support large fish populations.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

Although there has been little gross disturbance of Cape York Peninsula, there has been gradual deterioration in conservation values, particularly due to the insidious and synergistic impacts of grazing, fire, and invasive species (see Table CYP.4).

TABLE CYP.4: THREATS

Threatening process	Impacts—observed, likely or future	Comments
Grazing	▪ Changes in vegetation, eg. composition of perennial grasses (Crowley & Garnett 1998) ▪ Reduced productivity for some wildlife, eg. golden-shouldered parrots ▪ Woody thickening & loss of grasslands (ibid) ▪ Introduction & spread of weeds ▪ Degradation of riparian & wetland habitats	Future intensification and establishment of new pasture plants is of major concern.
Altered fire regimes	Change from Aboriginal mosaic burning to attempted exclusion (on pastoral properties) and extensive wildfires: • Burning homogeneity across large areas & thus reduced diversity of resources for wildlife & declines in some fauna, eg. granivorous birds (Franklin 1999) ▪ Destruction of fire-sensitive vegetation, eg. rainforests & heaths (Crowley & Garnett 1998) ▪ Reduced numbers of hollow-bearing trees—may be the most serious threat to palm cockatoos (Garnett & Crowley 2000) ▪ Invasion of melaleucas into grasslands & grassy woodlands due to lack of fire, contributing to decline of golden-shouldered parrots (Crowley et al. 2003)	Over much of CYP, there is extensive & frequent burning: from 1999-2003, an average 57% of 5 million ha burnt (Felderhof & Gilieson 2006); >70% of CYP burnt in 2002 (Landsberg & Crowley 2003). But in some areas there is exclusion of fire (deliberate or as a result of grazing).
Feral animals	▪ Pigs degrade wetlands, rainforests & woodlands; spread weeds; damage termite nests; compete with golden-shouldered parrots, magpie geese, brolgas and cassowaries for food; predate eggs of marine turtles (Norris & Low 2005) ▪ Feral cattle degrade national parks, riparian habitats, change composition of perennial plants, spread weeds (ibid) ▪ Rusa deer have caused degradation on Torres Strait Islands (ibid).	Ferals include pigs, cane toads, cattle, horses, deer. An emerging threat is other types of feral grazers: rusa deer, buffalo, blackbuck antelope. They have been released onto unfenced land by big game hunting enterprises (Norris & Low 2005).
Weeds	▪ Displacement of native species & degradation of wildlife habitats ▪ Exacerbation of fire impacts by gamba grass ▪ Smothering of wetland vegetation by olive hymenachne ▪ Smothering of riparian trees by rubber vine	37 'significant' environmental weeds documented (Anon 2003). Major concern is spread of fire-intensifying exotic pasture grasses (eg. gamba grass)
Other	▪ Bauxite mining has caused localised destruction	Future threats include mining, agriculture & other developments.

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

By comparison with most areas, the CYP focus area is well reserved with 13% in protected areas. It is thus considered a low NRS priority. Management of the 11 national parks and 3 resource reserves is poor, with highly inadequate resources provided. Table CYP.5 summarises some of the attributes of the reserve system. There is one Indigenous Protected Area in CYP: Warul Kawa island in the Torres Strait, an IPA of 3500 ha which protects important turtle rookeries (DEW 2007). Under development are two other IPA projects in CYP: Pulu Islet in the Torres Strait and Kaanju (Chuula) on the east coast of the mainland.

TABLE CYP.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehensiveness I-IV (%)	Comprehensiveness V-VI (%)	Manag't Standard	NRS priority (1-5, with 5 lowest)
1,414,783 (12%)	166,641 (1%)	80	2	Poor	4

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

There has been significant planning and policy focus on CYP, in recognition of its great environmental and cultural significance (see Table CYP.6). Cape York Peninsula Heads of Agreement, signed in 1996, was an agreement between Traditional Owners, pastoralists and environmental NGOs about principles to guide the future development of CYP. The CYP Land Use Strategy (CYPLUS) was the result of extensive community planning from 1994-97, resulting in an agreed vision for the region based on principles of ESD, self-determination, the continuation of multiple cultures and voluntary partnership approaches. There was a $40 million NHT program for conservation and sustainable land use initiatives. As part of the implementation of CYPLUS, there was an assessment of the natural heritage values of CYP by Mackey et al. (2001). The Cape York Peninsula 2010 Action Plan was developed to advance the recommendations of CYPLUS. The Cape York Partnerships initiative of 2000 focuses on addressing Indigenous social and economic well-being through whole of government negotiated approaches.

TABLE CYP.6: PLANS, POLICIES & PROGRAMS

Plan/policy/program
Bioregional plans & strategies: CYP Land Use Strategy / CYP Heads of Agreement
Sustainable development: Cape York 2010 / Cape York Farm Forestry Landcare Demonstration and Assistance Program / Strategic Plan for Cook Shire / Alau Bushtucker and Rainforest Project
Land management: Cape York Natural Heritage Trust Plan / CYP Property Management Planning project
Conservation: Assessment of the Natural Heritage Significance of Cape York by Mackey et al. (2001) / Recovery plans – eg. for golden shouldered parrot, gouldian finch / Declaration of CYP Fish Habitat Areas / Cape York Weeds & Feral Animal Project

At the time of writing there is an active land tenure resolution and land conservation process involving the Queensland Government, Cape York Land Council, environment groups and pastoralists. The land in question includes 17 properties which are currently owned by the Queensland Government, encompassing >1.3 million hectares, most on the east coast of Cape York. Much of it is of high conservation value. The intent of the process is to determine the tenure as national parks (potentially under Indigenous ownership) or as Aboriginal freehold with conservation agreements over parts of the lands.

CONSERVATION CAPACITY

Indigenous Conservation: Balkanu Cape York Development Corporation (an offshoot of the Cape York Land Council) has a Caring for Country program which has a number of active projects including the well established Traditional Knowledge Recording Project. However, for many of these funding is patchy and short-term.

Many Aboriginal landowners are seeking ways to make a living on country and various options, including conservation land management, are being canvassed. For example, the Chuluungan Aboriginal Corporation on the Northern Kaanju lands of the Upper Wenlock is seeking support for long-term land management work in that area and the Wuthathi people on the sand country and heathlands at Shelburne Bay are seeking long-term support for land and sea management on their country.

There is the potential for the establishment of Indigenous Protected Areas by conservation-minded landowners seeking further support for land management.

Cape York Land Council is a member of the Northern Indigenous Land and Sea Management Alliance, which supports land management across Northern Australia.

Advocacy conservation groups: Advocacy groups are active on a range of conservation issues on Cape York Peninsula. The groups currently active are:

- Cairns and Far North Environment Centre is the regional conservation council based in Cairns and works on a wide range of nature conservation issues in the region and throughout Far North Queensland. It is part of the tenure resolution process seeking finalisation of the land tenure process.
- The Wilderness Society is campaigning for the protection of CYP's rivers through their designation as 'Wild rivers' and is seeking finalisation of the land tenure process. It has several staff working on these campaigns in Cairns, Brisbane and Sydney. It also works on a range of other conservation issues throughout the Cape.
- The Australian Conservation Foundation works on Cape York Peninsula as part of its pan-Northern program work. It has a Cairns office and is part of the tenure resolution process seeking finalisation of the land tenure process. It also works on a range of Indigenous conservation issues through the Cape.

Private land conservation groups: The Australian Wildlife Conservancy owns Brooklyn Station, a large pastoral property in the Mitchell River catchment just to the south of the Cape. It also has two other properties further south in the Wet Tropics region.

There is potential for strategic purchases of pastoral leases by the Australian Wildlife Conservancy, Bush Heritage Australia or other conservation focused purchasers.

Other institutional capacity: Each CYP subregion was assessed as having an 'identified capacity to integrate conservation' through existing natural resource management processes (NLWRA 2002 database).

ADEQUACY OF INFORMATION

Due to CYPLUS and other studies, the natural values of CYP are well known in comparison to other focus areas. The NLWRA (2002) database notes the following data inadequacies: little up-to-date information on riparian or wetland condition and trend and monitoring undertaken by Landcare and other community groups is not collated.

DALY BASIN-ARNHEM LAND TROPICAL SAVANNA

GENERAL DESCRIPTION

The Daly Basin-Arnhem Land focus area covers 150 000 km^2 in the far north of the Northern Territory, known as the Top End. It encompasses six IBRA bioregions—Arnhem Coast (ARC), Arnhem Plateau (ARP), Central Arnhem (CA), Daly Basin (DAB), Darwin Coastal (DAC), and Tiwi-Cobourg (TIW). The focus area is equivalent to the ecoregion of the same name delineated by WWF and described by Woinarski (2001a), except that Pine Creek bioregion has been excluded (for an explanation, see 'Selection of focus areas' section).

FIGURE AL.1: LOCATION OF DALY BASIN - ARNHEM LAND TROPICAL SAVANNA

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[8]

The Daly Basin-Arnhem Land focus area comprises three major landforms: a rugged, eroded (Middle Proterozoic) sandstone escarpment/plateau (the 'stone country'), rising no more than about 400 m ASL; vast flat or undulating (Cainozoic) lowland plains; and coastal/subcoastal (Holocene) floodplains associated with the lower reaches of multiple river systems. While much of the floodplain dries out during the long dry season, there are also numerous permanently wet billabongs and swamps. The focus area includes three of Australia's six largest islands—Bathurst and Melville Islands, and Groote Eylandt.

The vegetation is mostly open eucalypt forest, with a grassy understory, as well as various midstorey species (see Table AL.1 for dominant vegetation types). This is interspersed with thousands of small patches of rainforest. On the escarpment, there are also diverse heath communities and spinifex grasses; extensive mangrove forests grow along the tidal reaches of rivers; and on the floodplain there are sedgelands, grasslands and Melaleuca-dominated wetland forests.

TABLE AL.1 DOMINANT VEGETATION GROUPS (KM^2)

Bioregion	Eucalypt open forests	Tropical eucalypt woodlands/ Grasslands	Eucalypt woodlands	Eucalypt open woodlands	Grassland group
ARC	18,646	8,455	153	76	1,060
ARP	1,822	7	10,522	9,795	36
CA	11,483	19,968	272	2	1,060
DAB	4,178	13,998	651	15	-
DAC	11,574	4,084	43	1	6,217
TIW	8,151	223	19	-	26
Total	**55,854**	**46,735**	**11,700**	**9,889**	**7,339**

Source: NLWRA (2001)

[8] Sources: Woinarski (2001), Woinarski et al. (2000), NLWRA (2002) database.

The climate is markedly seasonal—there is a short wet season with monsoonal rains from about November to March, delivering about 90 percent of annual rainfall. Total rainfall ranges from about 800mm in the south to up to 2000mm on the Tiwi Islands in the north. The climate is hot, with monthly average maxima ranging from 27^{o} to 33^{o}C.

LAND USES, PEOPLE & INSTITUTIONS[9]

The majority of this focus area is vested in Aboriginal Land Trusts, and used for traditional purposes. Other extensive uses include conservation and pastoralism. About 60% of the Daly Basin is pastoral leasehold. Small areas, particularly around Darwin, are used intensively, mostly for urban uses, horticulture, plantations and mining. Tourism is also a significant land use, focused around national parks and urban areas. Figure AL.2 shows land tenures across the focus area.

The total population in the focus area is less than 130,000, most of it in Darwin. Outside urban centres, population density is very low: eg. 0.03 people/km^2 in Central Arnhem and 0.55 people/km^2 in Daly Basin.

There are at least 40 different Indigenous major language groups in the focus area. There is a diverse range of Aboriginal institutions with land management responsibilities, including clan-governing bodies, natural resource management groups, and management boards of national parks (Kakadu and Garig Gunak Barlu National Parks). The Northern Land Council is the peak body for most Aboriginal groups in the focus area, with the exception of the Tiwi Islands, represented by the Tiwi Land Council, and Groote Eylandt, represented by the Anindilyakwa Land Council.

FIGURE AL.2: LAND TENURE

While some Aboriginal people still live on their traditional country and carry out some traditional practices, there has been an aggregation of most of the population to a few permanent settlements. This and a less immediate reliance upon bush tucker has led to an inevitable decay of knowledge about traditional land management. However, there has also been a back-to-country movement, which has seen some dispersal of the population to outstations on traditional lands, either permanently or seasonally. There has also been the development of Aboriginal ranger programs to carry out land management.

Pastoral activity has been based historically on relatively low management operations on large properties using native pastures. In recent years there has been some intensification by tree clearing and introduction of foreign pasture grasses, particularly in the Daly Basin. There has also been a push for increased irrigated agriculture in the Daly Basin over the last decade.

[9] Sources: Woinarski et al. (2000); Baker et al. (2005), AIATSIS (2005).

CONSERVATION VALUES

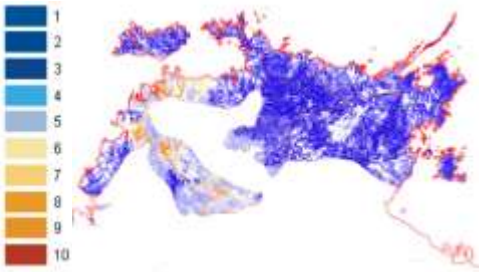
Having escaped the intense development pressure of southern Australia, the Daly Basin-Arnhem Land focus area has a largely natural landscape with ecological processes functioning over extensive areas, and highly significant biodiversity values. However, in many areas condition is deteriorating due to pervasive threatening processes such as fire, invasive species and grazing.

LANDSCAPE CONDITION

FIGURE AL.3: VEGETATION CONDITION (VAST)

Source: Thackway and Lesslie (2005)

FIGURE AL.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE AL.5: WILDERNESS QUALITY (NWI)

High quality wilderness

Source: Lesslie & Masslen (1995)

In the assessment of landscape health by Morgan (2001), the Daly Basin-Arnhem Land focus area rated well with relatively low landscape stress. All subregions apart from Darwin Coastal ranked in the two highest health categories (see Table AL.2). However, the stress assessment did not include fire, one of the major threatening processes in the focus area.

TABLE AL.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE & RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native veg.	Riparian condition (1-4, with 4 near pristine)
ARC /2/3/4/5	5/5/5/5/5	2	3/4/4/3/4
ARP 1/2	6/5	0	4/4
CA 1/2	5/5	0	3/3
DAB	5	8	3
DAC	3	3	3
TIW 1/2	5/6	2	3/3

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

Very little vegetation has been cleared—with 8% cleared, the Daly Basin has suffered the greatest loss (see Table AL.2). There is also some clearing for urban and agricultural development on the fringes of Darwin. Vegetation condition, again without reference to fire, is mostly rated 'high quality', except in the Daly Basin (see Figure AL.3).

Rivers are mostly in good condition with low levels of disturbance (see Figure AL.4) and the average subregional condition of riparian zones is good or near pristine (see Table AL.2), although declining in the majority of subregions (NLWRA 2002 database).

A large proportion of the focus area is considered to have high wilderness quality, particularly in the Central Arnhem, Arnhem Plateau, Arnhem Coast and Tiwi-Cobourg bioregions (see Figure AL.5). This remains the case with the more recent Wilderness Delineation.

BIODIVERSITY VALUES

There are specific conservation values associated with particular ecosystems, such as the monsoon rainforests and escarpment heaths, but also pervasive and refugial values due to the relative lack of landscape modification. The escarpment ecosystems are significant for the endemics they harbour; the wetlands for their productivity for vast numbers of birds and aquatic organisms; and the extensive eucalypt savannas for their intactness allowing long distance ecological processes such as bird migration to function.

In recent history (the past 20,000 years or so) the region has been subject to rapid climate oscillations, which would have wiped out much of the region's biota (Woinarski 2001). The floodplains were formed only in the past 5000 years with the most recent rise of sea levels. Until only a few thousand years ago, the Tiwi islands and the mainland were connected, and at times there have been connections with New Guinea and Cape York Peninsula (ibid). In contrast to the young lowlands, the escarpments are old, formed more than 100 million years ago. As a constant presence in the landscape they have functioned as relictual sites (ibid).

Heath and rainforest communities are the major sources of endemic plants. Both ecosystem types are threatened by current land management practices (or lack of it), and are considered threatened (NLWRA 2002 database). Sandstone heath ecosystems, harbouring many fire-sensitive species, are under threat from changed fire regimes. Monsoon rainforests are also threatened by fire, as well as degradation caused by feral animals and weed invasion. These rainforests occur in more than 10,000 patches across the focus area, relicts from times past when rainforest was dominant, now surviving in gullies and other moist areas (Russell-Smith & Bowman 1992). The patches contain relictual plants but are too small to support endemic rainforest vertebrates (Woinarski 2001). They are challenging to conserve, because of their patchiness, small size and the "highly idiosyncratic species composition of individual patches" (Woinarski & Baker 2002). They can be characterised as "components of a disjunct habitat" for many mobile species, such as fruit pigeons, "such that the loss of any patch may affect the maintenance of individuals or species within the remaining patches" (ibid).

The Arnhem Plateau bioregion is a major centre of endemism, in particular for plants in heath and rainforest communities, and less so for reptiles and aquatic invertebrates. There is also some endemism associated with the larger islands (Woinarski et al. 2000a), although this is mainly at the subspecies level because their isolation is relatively recent. Crisp et al. (2001) designated western Arnhem Land (in the Kakadu and Alligator River areas, an area of about 32 000km^2) one of eight centres of plant species richness in Australia. Woinarski et al. (2006) tallied more than 200 endemic plant species.[10] If a larger area is taken, north of 16^{o}S (roughly equivalent in size to other areas of recognised endemicity, Cape York Peninsula and the Northern Province of Western Australia) the level of plant endemicity at 438 species is comparable (ibid).[11]

In contrast to most other areas, the Daly Basin-Arnhem Land focus area has suffered no known extinctions in the 200 years since European colonization, although the range of many vertebrates has contracted and there is evidence of substantial declines in some bird and mammal assemblages (Franklin 1999, Woinarski et al. 2001).

[10] Woinarski et al. (2006) documented 172 plant species entirely restricted to the plateau area (with a 30-km buffer); 25 species with at least 90 percent of their range within this plateau area and about 20 other species largely confined to the plateau but extending out also along sandy creeklines, and/or as disjunct populations in smaller sandstone isolates elsewhere in the monsoonal tropics of the NT. Endemicity is high on the plateau probably because (1) deep gorges restrict gene flow between species with limited dispersal ability, promoting speciation; (2) there are diverse microclimatic settings and environments due to the complex topography and geomorphology; (3) there are refuge areas for fire-sensitive or climate-sensitive species; (4) the plateau has existed for >100 million years in contrast to the plains which were inundated during the Pleistocene; and (5) the plateau is surrounded by extensive lowlands, constraining broad-scale dispersal (ibid, 636-37).

[11] But, as Woinarski et al. (2006) point out, this level of endemicity does not rival that of South-West Western Australia with its 4500 endemic plants.

TABLE AL.3: SIGNIFICANT SPECIES

Group	Bioregionally endemic taxa (species & subspecies)	Threatened taxa: federal & territory / federal listings	Comments
Plants	>200 ARP 10 TIW	56 5 vulnerable	High levels of endemicity and threat on the western escarpment. Many threatened species are fire sensitive.
Birds	3 ARP 8 TIW 1 DAC	10 2 endangered 5 vulnerable	Threatened taxa include 1 pigeon, 1 finch, 1 grass-wren, 1 goshawk, 1 shrike-tit, 1 chat, 2 owls, emu, bustard. Bird fauna in DAC is considered highly diverse, in other bioregions moderately diverse.
Reptiles	12 total: 7 ARP	8 2 endangered 4 vulnerable	Threatened reptiles include 6 marine turtles, 1 gecko, 1 python.
Mammals	5 total: 2 ARP 2 TIW	9 6 vulnerable	Threatened species include 4 rats/mice, 2 bats, 1 macropod, 1 dunnart, 1 bandicoot.
Fish	3	2 2 vulnerable	Threatened species include 1 sawfish, 1 shark. 3 endemics include 2 grunters, 1 hardy head.
Amphibians	3	- -	Considered to be an area of high amphibian diversity.
Invertebrates	Numerous	1 -	Eg, an endemic family of shrimps, Kakaducarididae & an endemic genus of isopods, *Eophreatoicus.* The threatened species is the Oenpelli Whip-scorpion, listed as endangered in the NT.
Regionally extinct species	Golden bandicoot (*Isoodon auratus*) from CA, ARC Brush-tailed Rabbit-rat (*Conilurus penicillatus*) from DAB		
Richness & endemism statistics	ARC: 1721 plants / 486 vertebrates / 266 birds / 262 NT endemics / 67 bioregion endemics ARP: 1649 plants / 427 vertebrates / 212 birds / 410 NT endemics / 74 bioregion endemics CA: 1273 plants / 325 vertebrates / 161 birds / 183 NT endemics / 10 bioregion endemics DAB: 1334 plants / 434 vertebrates / 235 birds / 177 NT endemics / 5 bioregion endemics DAC: 1795 plants / 561 vertebrates / 317 birds / 350 NT endemics / 52 bioregion endemics TIW: 1193 plants / 411 vertebrates / 192 birds / 152 NT endemics / 39 bioregion endemics		

Sources: NLWRA (2002) database, Woinarski et al. (2006), Woinarski & Baker (2002), Finlayson et al (2006); Baker et al. (2005), Birds Australia (2002) database.

Note: bioregion endemics are those endemic in the NT, so may exist outside the NT.

Arnhem Land wetlands are highly productive. They support vast numbers of waterbirds, including the world's largest breeding colonies of magpie geese, with up to half a million in some swamps (DIWA 1996). There are high densities of fish, freshwater turtles, crocodiles and other aquatic wildlife.

The area's coastline is internationally significant for seabird colonies and turtle breeding sites. Seabird colonies are numerous and large, for example Seagull Island supports the world's largest breeding colony known for crested tern, and the area also contains Australia's largest colonies of black-naped tern (Chatto 2001). The area may have Australia's largest breeding populations of endangered Olive ridley turtles (Chatto 1998, cited by Woinarski & Baker 2002).

The invertebrates are poorly known, but this area may contain one of the richest ant faunas in the world, (only about one-quarter of the ant species have been described) In sites of only 500 m^2 more than 100 species were reported (Andersen 1992). Table AL.3 provides further information about significant species in this focus area.

SIGNIFICANT REFUGIA & LANDSCAPE FEATURES

Evolutionary refugia include the ancient sandstone escarpment, evidenced by the large number of endemic species; the islands, which have persisted during sea-level rise and support a number of endemic taxa, at least at subspecies level; and rainforest patches. Such patches have probably been refuges during periods of drier climate (Russell-Smith 1991; Woinarski et al. 2001). The Daly Basin supports the most extensive stands of riparian rainforest in the NT (NLWRA 2002 database).

Ecological refugia include the escarpment, wetlands and rainforests. The topographic complexity of the escarpment provides diverse microclimates and protection for fire-sensitive species (Woinarski et al. 2006). Wetlands and rainforests are critical areas for sustaining some fauna during the long annual Dry.

Human-induced refugia include the islands and the escarpment. For example, Tiwi Islands retain healthy populations of many species which have been eliminated or diminished across their former mainland range (Woinarski & Baker 2002). Wildlife considered at risk from cane toads have been moved to two islands in the English Company group. The escarpment areas exclude some threats because of their rugged terrain, deep clefts and chasms, waterfalls, caves and cliffs (NLWRA 2002 database).

Significant wetlands: Wetlands within Kakadu National Park and on the Cobourg Peninsula are recognised as internationally significant (listed as Ramsar sites), and several other wetlands are listed in the Directory of Important Wetlands (NLWRA 2002 database).

Other features: The large and seasonally variable Top End rivers are significant landscape features. The Daly River has by far the largest annual discharge and perennial flow of any system in the Northern Territory, and possibly in northern Australian (NLWRA 2002 database).

ECOLOGICAL PROCESSES

Key ecological processes for the tropical savannas have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes in Daly Basin-Arnhem Land, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches or refugia have been degraded by grazing or fire.

Hydroecology: Largely intact, but compromised in some areas with salt water intrusion into wetlands and other forms of degradation, and with potential for significant compromise if proposals to dam rivers and divert water go ahead.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Coastal fluxes: Largely intact.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

Although there has been little gross disturbance of Daly Basin-Arnhem Land, there has been gradual deterioration in conservation values and evidence is emerging of chronic and insidious threats. Fire, invasive species and grazing (in some areas) are the most significant threats; clearing and climate change are significant emerging threats. In particular, current fire regimes are considered highly threatening to some biota. Woinarski and colleagues (2006) warn that the "conservation status of the entire sandstone plateau of western Daly Basin-Arnhem Land may now be threatened by prevailing fire regimes". See Table AL.4 for further information about threats.

TABLE AL.4: MAJOR THREATS

Threats	Impacts	Comments
Altered fire regimes	Change from Aboriginal regime to destructive burning across large areas & fire exclusion elsewhere • Destruction of fire-sensitive vegetation, eg. northern cypress-pine (Bowman & Panton 1993), sandstone monsoon rainforests (Price & Bowman 1994) • In eucalypt woodlands, change in structure & phenology, reduced numbers of hollow-bearing trees (Williams et al. 1999) • Vegetation thickening (Bowman et al. 2001), eg. in Litchfield NP grasslands reduced from 7%-2.5%. • Associated with fauna declines: granivorous birds (Franklin 1999), small mammals (Woinarski et al. 2001), frilled lizard (Griffiths & Christian 1996)	Traditional Aboriginal burning is thought to have caused a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. Now, the regime is much more extensive & destructive, & "it appears to have triggered a positive feedback cycle between fire frequency and flammable grass fuels" (Bowman et al. 2004). In other areas, fire exclusion (eg. by grazing) has caused transformation of grasslands.
Feral animals	• 'Severe disturbance' of rainforests & damage of wetlands by buffalo, cattle, pigs (Finlayson et al. 2006, Russell-Smith & Bowman 1992). • Predation by cats (may be implicated in mammal decline) & pigs (eg. high pressure on Northern snake-nosed turtles) (Fordham et al. 2006, Woinarski et al. 2001). • Habitat damage by banteng, goats & sambar deer (Woinarski 2001a). • Probable declines in carnivorous mammals, fish, reptiles due to recent arrival of cane toad (NLC 2004). • Elimination of native ant fauna in rainforest patch by Big-headed ant (Reichel & Andersen 1996).	Ferals include cats, buffalo, cattle, pigs, banteng, goats, sambar deer, horses, cane toads, big-headed ants & crazy ants. Invasive ants are rated a significant threat to the ecological integrity of rainforests & wildlife. Cane toads are a risk for 59% of agamids, 85% of varanids, 30% snakes, crocodiles & turtles in their range (Smith & Phillips 2006), as well as quolls.
Weeds	• Fire threats greatly exacerbated by spread of mission & gamba grasses into large areas of eucalypt open forest. • *Mimosa pigra* has transformed >10,000 km^2 of floodplain grasslands into woody monocultures (Cook et al. 1996) • Para grass, olive hymenachne and salvinia have also transformed wetlands.	Gamba grass & mission grass greatly increase fuel loads & cause later-season fires, leading to hotter and more destructive fires. With culling of buffalo, hymenachne has spread to dominate many wetlands (Finlayson et al. 2006).
Grazing	Implicated in widespread fauna declines (Wonarski et al. 2002, Franklin 1999): ▪ Changes in vegetation, eg. composition of perennial grasses, & reduced productivity for some wildlife, eg. granivores ▪ Introduction & spread of weeds ▪ Degradation of riparian & wetland habitats, & rainforest patches	Pastoral leases cover about 60% of the Daly Basin.
Land clearing	Large-scale plantation development on Tiwi Islands threatens tallest eucalypt forest environments, favoured by some threatened species (Firth et al. 2006). Potential further loss of productive habitats with clearing for urban expansion, agriculture around Darwin & the Daly Basin.	Plantation development will compromise the refugial qualities of the Tiwi Islands. There are proposals to move agriculture into the north in response to climate change & other factors.

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

The focus area has some significant conservation reserves in place—particularly with Kakadu National Park, which covers about 2 million hectares—but there remain very large major gaps in the protected area estate. In total about 10% of the area is protected, but two bioregions have no reserves at all (see Table AL.5).

In addition, there are three declared Indigenous Protected Areas—Dhimurru, Laynhapuy, and Anindilyakwa—and one in development—Bawinanga, all in the Arnhem Coast bioregion (DEW 2007).

Apart from the Arnhem Plateau and Darwin Coastal bioregions, the focus area is considered a high priority for the National Reserve System program, in particular Daly Basin. The Daly Basin conservation plan has proposed three additional conservation reserves to achieve a CAR system in that bioregion (Sattler & Glanznig 2006). For the Arnhem Plateau bioregion, Sattler and Glanznig note that despite the existence of Kakadu National Park, there is "a compelling conservation case to enhance the existing reservation extent, in order to include the entire western Arnhem Land massif".

TABLE AL.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Bioregion	Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehens-iveness I-IV (%)	Comprehens-iveness V-VI (%)	Manag't Standard	NRS priority (1-5, 1 highest)
ARC	0	0	0	0	--	2
ARP	484,825 (21%)	0	62	0	Very good	4
CA	0	0	0	0	--	2
DAB	30,296 (1%)	18,023 (1%)	31	6	Very good	1
DAC	785,691 (28%)	26,426 (1%)	68	0	Fair	4
TIW	203,375 (20%)	0	44	0	Good	2
Focus area	1,504,187 (10%)	44,449 (<1%)	--	--	--	--

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

There have been only limited conservation planning and management in the focus area, as shown in Table AL.6.

For the Tiwi-Cobourg bioregion, Woinarski and Baker (2002) estimated that there was an annual input to conservation management of about $134,000, or $13/km^2.[12] This figure excludes the unpaid efforts of Aboriginal landowners practising traditional management activities.

[12] This would have increased with the development of the plantation on Melville Island, which required the employment of an environmental officer.

TABLE AL.6: PLANS, POLICIES & PROGRAMS

Plan/policy/program
Oil Spill Response Atlas for coastal areas
Water plans: Daly Basin Water Allocation Plan / Mary River Catchment Plan / West Arnhem Lands Water Study
Land clearing: clearing guidelines for Darwin rural area / clearing policy for Daly Basin
Conservation plans: Kakadu Plan of Management / Arafura Swamp conservation plan / Daly Basin Conservation Plan
NRM: NLC Caring for Country strategy & caring for Country guidelines/ Tiwi Islands Regional Natural Resource Management Strategy / various local land use & management plans
Pastoralism: Landcare groups / monitoring programs have been established on all pastoral leaseholds.
Fire: TSCRC FIREPLAN projects – community-based fire management projects. Some management, monitoring, control through regional offices of the Bushfires Council

CONSERVATION CAPACITY

Indigenous Conservation: The Northern Land Council has a long-standing and extensive Land and Sea Management program. There are a number of ranger programs, (eg. 7 programs in the west Arnhem area). However, these function under short-term and inadequate funding arrangements (NLC 2004). These include some very active programs such as projects of the Dhimurru Land Management Aboriginal Corporation, including fauna surveys and marine turtle management. NLC has developed a Caring for Country strategy, which sets out short-term (1-10 years) and long-term targets (10 years+) (ibid). Many Aboriginal groups are seeking ways to make a living on country and various options, such as use of native or exotic wildlife, are being canvassed (eg. Morse 2005). A number of large Indigenous Protected Areas have been established in the region, especially in Arnhem Land. There are prospects for others including in areas of the western Arnhem Land with very high conservation values. The Northern Land Council is a member of the Northern Indigenous Land and Sea Management Alliance, which supports land management across Northern Australia.

Advocacy conservation groups: Advocacy groups are active on a range of issues in this focus area. Most of the current work involves campaigning to stop or ameliorate particular threats to nature in the region. The two key active groups currently are:

- The Environment Centre of the Northern Territory has 6 staff and works on a wide range of nature conservation issues in the region and throughout the Northern Territory. Major campaigns include campaigning for the cessation of large scale clearing in the Daly Basin and Tiwi Islands and planned industrial developments around Darwin Harbour.

- WWF Australia has an active Darwin office and works on a range of nature conservation issues throughout the Northern Territory. This includes work on land clearing in the Daly Basin, development of river protection legislation and on-ground work with Traditional Owners.

Other national groups (Australian Conservation Foundation and The Wilderness Society) have assisted with campaigning on particular issues. The Northern Australian Environment Alliance acts as a coordinating body for these and other advocacy groups.

Private land conservation groups: The Australian Wildlife Conservancy has recently purchased Wongalarra, a large pastoral property in the Roper River catchment bordering the south-eastern edge of the Arnhem Land Aboriginal freehold lands.

There is potential for further strategic purchases by the Australian Wildlife Conservancy, Bush Heritage Australia or potentially other conservation minded purchasers.

Other institutional capacity: There is variable capacity for natural resource management through existing processes, with some subregions having no processes and significant constraints, and others having NRM instruments in place with some outcomes (NLWRA 2002 database). The Tropical Savannas Cooperative Research Centre has conducted considerable conservation-focused research, and produced a range of assessments and plans. However, CRC funding will not be continued past 2007. The NT department responsible for conservation undertakes management in national parks, and also in non-reserve areas in cooperation with indigenous land owners. They conduct surveys and some monitoring.

ADEQUACY OF INFORMATION

Generally, there is poor knowledge of biota, including basic distribution data. Many areas have not been systematically surveyed for flora and fauna, and there is little baseline information, making assessments of biodiversity change difficult (Woinarksi et al. 2000). Recent discoveries of new vertebrate species indicates how much there is yet to know (Woinarski 2001). Even in the relatively well-known Kakadu National Park, many new plant species have been discovered in recent times. The numbers of plant species recorded there have increased from 954 (in 1973) to 1346 (1986) 1682 (1990) and 1899 (1996) (Woinarski 2001, citing Brennan 1996). Vegetation mapping has generally been done only at very coarse scales (NLWRA 2002 database). With the recent research effort of the CRC, there is now a much better understanding of landscape disturbance by fire and exotic species.

KIMBERLEY TROPICAL SAVANNA

GENERAL DESCRIPTION

The Kimberley focus area covers an area of 244 000 km^2 in the northwest of Western Australia. It encompasses three IBRA bioregions—Central Kimberley (CK), North Kimberley (NK) and Dampierland (DL). It is equivalent to the ecoregion of the same name delineated by WWF and described by Woinarski (2001b), except that the Victoria-Bonaparte bioregion has been excluded (see Selection of Focus Areas section for justification), and the Daly Basin bioregion is included in the Daly Basin-Arnhem Land focus area.[13]

FIGURE K.1: LOCATION OF KIMBERLEY TROPICAL SAVANNA

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[14]

The Kimberley focus area has great topographical and geological complexity. There are ancient (Proterozoic) and rugged sandstone and limestone ranges, with gorges, escarpments, and deeply dissected plateaus, as well as extensive (Quaternary) sandplains and alluvial plains extending to the southwest. The coastline ranges from sheer cliffs to sandy beaches and extensive mudflats, and there are numerous islands dotting the north Kimberley coast. Preserved in the Canning Basin are old (Devonian) limestone barrier reef structures. One of Australia's largest rivers, the Fitzroy, drains the south-west and centre of the region.

K.1 DOMINANT VEGETATION GROUPS (KM^2)

Bioregion	Tropical eucalypt woodlands/ Grasslands	Acacia shrublands	Hummock grasslands	Tussock grasslands	Mangrove group
CK	36,111	83	33,917	6,546	69
DL	1	56,781	7,135	16,854	2,140
NK	79,197	98	1,355	718	1,714
Total	**115,309**	**56,962**	**42,407**	**24,118**	**3,923**

Source: NLWRA (2001)

[13] The Daly Basin bioregion was included in the WWF descriptions of both Kimberley and Arnhem Land Tropical Savannas. As a focus for conservation it makes more sense to include the Daly Basin within Arnhem Land (same state government), which is what we have done.

[14] Sources: Woinarski (2001b), Woinarski et al. (2000), NLWRA (2002) database.

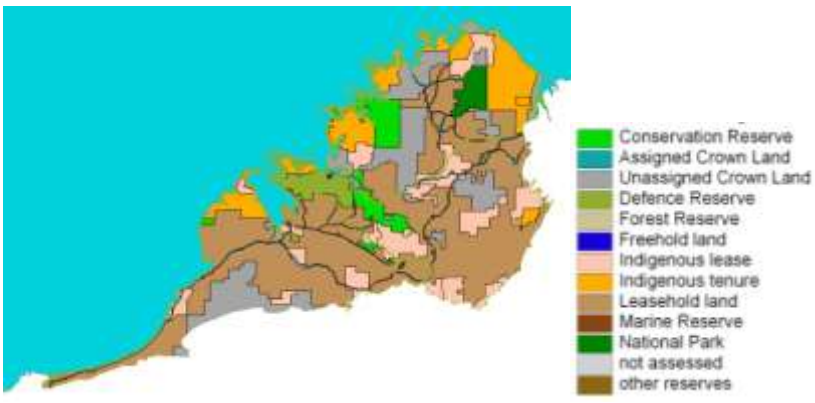
The most extensive vegetation is eucalypt-dominated woodland with a tall grassy understorey (see Table K.1 for dominant vegetation groups). The subcanopy in some parts of the North Kimberley consists of sand palms. In the skeletal sandy soils of the ranges grow spinifex and scattered trees, and in the valleys are ribbon grasses with scattered trees. On red sandy soils in the southwest (DL) is a sparsely grassed vegetation type dominated by a range of wattles, known as Pindan. The coastal plains support mangroves, saline grasslands and herblands, and low melaleuca forests. Along drainage lines grow river red gums, melaleucas, figs and pandanus; and in hundreds of scattered patches is monsoonal rainforest.

The climate is markedly seasonal—there is a short wet season from about November to March, delivering almost all of the annual rainfall, often in cyclone-associated storms. Average rainfall ranges from about 1400 mm in the far north to about 600 mm in the southwest. The climate is hot, with monthly average maxima ranging from 25°C to 35°C.

LAND USES, PEOPLE & INSTITUTIONS[15]

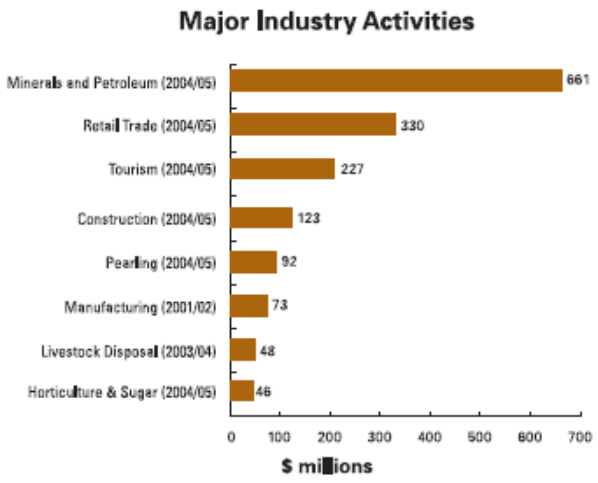
The dominant land use is cattle grazing on pastoral leases, some run by Aboriginal owners. Much of the pastoral area is of relatively poor quality grazing land. Other large areas are Aboriginal freehold lands, national parks and unallocated crown land (see Figure K.2 for tenure). There is urban use focused around Broome in the southwest, as well as booming tourism activity (the second highest value industry in the Kimberley area and the employer of 14% of Broome's population). Some large areas are designated for mining, the highest value industry in the Kimberley (see Figure K.3). Major oil and gas projects are proposed for the Kimberley coast and offshore. In the Ord River valley (outside the defined focus area) the Ord was dammed with a major impoundment and an irrigated agricultural area developed. Various proposals have been floated in recent years to extract large volumes of water from the Fitzroy River for regional irrigation, or to pipe to Perth.

FIGURE K.2: LAND TENURE



[15] Sources: Woinarski et al. (2000), McKenzie et al. (2002); Fargher et al. (2003); LGRD & KDC (2001), AIATSIS (2005), NNTT (2006).

FIGURE K.3: COMPARATIVE INDUSTRY ECONOMIC RETURNS



Source: DLGRD & KDC (2006)

This focus area is very sparsely populated, with the majority of people living in Broome. Central Kimberley is largely uninhabited. Fewer than 1000 people reside permanently in North Kimberley, and there is a density of <.04 people/km^2. About half the population is Aboriginal.

There are at least 20 major Indigenous language groups in the focus area. They are represented by the Kimberley Land Council. A large proportion of the focus area is under native title claim. Members of the Wanjina-Wunggurr Community have had title recognised over parts of their country in the North Kimberley.

CONSERVATION VALUES

Having escaped the intense development pressure of southern Australia, this focus area has a largely natural landscape with ecological processes functioning over landscape-scales, and highly significant biodiversity values. However, its condition is deteriorating due to the pervasive threats of altered fire regimes and grazing.

LANDSCAPE CONDITION

In the assessment of landscape health by Morgan (2001), the Kimberley focus area rated well with relatively low landscape stress. All subregions apart from the Fitzroy Trough (DL1) ranked in the two lowest stress categories (see Table K.2). However, the stress assessment did not include fire, one of the major threatening processes in the focus area. McKenzie et al. (2002) recommend that some of the stress rankings be reviewed in the light of degrading processes underway; in particular, those for Pindanland (DL2) and Northern Kimberley (NK1 & NK2) because of fire and grazing. They concluded that the health of all or most of the Kimberley bioregions was declining.

TABLE K.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE & RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best)
CK 1/2/3	5/5/6	0	3/3/3
DL 1/2	4/6	1	3/3
NK 1/2	6/6	1	3/3

Sources: Morgan (2001), NLWRA (2001); NLWRA (2002) database

Minimal vegetation has been cleared, and vegetation condition (again without reference to fire) is relatively high, most of it 'high quality', although a substantial proportion of the Fitzroy Trough subregion, where more intensive grazing by cattle has occurred, is rated 'transformed' (see Figure K.4). Rivers are mostly in good condition with high natural integrity, although not in the lower Fitzroy River and Lennard River basins (see Figure K.5). Likewise, the average condition of riparian zones is considered good (see Table K.2), although the condition of all is declining (NLWRA 2002 database). Finally, in the National Wilderness Inventory a large proportion of the focus area was considered to have high wilderness quality, apart from the Fitzroy Trough subregion, the Dampierland coast, and parts of the Central Kimberley (see Figure K.6).

BIODIVERSITY VALUES

The Kimberley, particularly the rugged sandstone complex of North Kimberley, is a centre of plant richness (Boden & Given 1995), and endemicity (Woinarski 2001b, citing Wheeler 1992). There are also significant numbers of vertebrate and invertebrate endemics.

Rainforests have special ecological values in the focus area for not only the vegetation associations, but for the resources they provide for rainforest fauna or more widely ranging species that depend on them (NLWRA 2002 database). While rainforest vegetation comprises <0.5% of the land area of the Kimberley (in >1500 patches), it contains 24% of the known flowering species there (Kenneally et al. 1991, Solem 1991). Although most of the plants are widespread in northern Australia and there is just one endemic shrub, all rainforest patches studied have endemic earthworm and Camaenid land snail species (Mckenzie & Dyne 1991, Solem 1991). Cape Bougainville rainforest is singled out as having special value as the largest single patch of rainforest in the Kimberley and for being free of hoofed animals (NLWRA 2002 database).

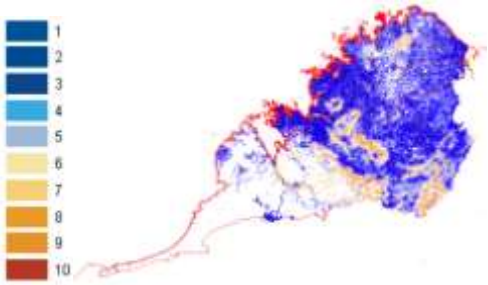
A large proportion of the Kimberley endemics are sandstone species. The north-western margin of the Mitchell sub-region (NK1) has particularly high value as it has retained an intact fauna and has a range of endemic and/or threatened species. The limestone features of the Oscar and Napier Ranges also support endemic plants and invertebrates, include at least 22 snail species and many cave species.

Globally, there are just 12 huge tidal flats rich in shorebirds. Two of these are in the Kimberley: Roebuck Bay and Eighty Mile Beach (both in Dampierland bioregion). These sites are of international significance as habitat for migratory shorebirds. Roebuck Bay supports >300,000 and Eighty Mile Beach about 500,000 of at least 20 species of migratory shorebird (DCLM 2003).

FIGURE K.4: VEGETATION CONDITION (VAST)

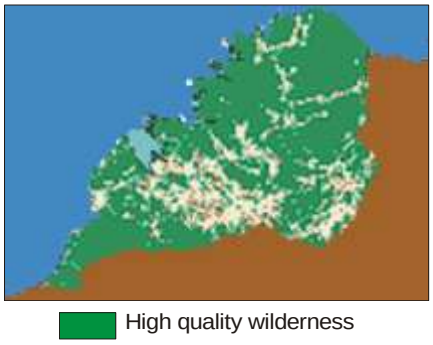
Source: Thackway & Lesslie (2005)

FIGURE K.5: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE K.6: WILDERNESS QUALITY (NWI)



Source: Lesslie & Masslen (1995)

Some Kimberley ecosystems have been listed as threatened under state legislation, most due to grazing, weeds and changed fire regimes (McKenzie et al. 2002). Threatened ecosystems include monsoon thickets, various woodland communities, an intertidal mudflat community and various mound spring communities. Many more communities are considered at risk (ibid).

Much of the distinctive Kimberley biota is most closely related to that of the geologically similar western Arnhem Land sandstone massif, which also has high plant endemism. There are about 230 Kimberley endemic

plant species, a very large number of invertebrate endemics (although invertebrates are poorly known), and also a variety of endemic vertebrates, including 31 reptiles and 16 fish (see Table K.3).

TABLE K.3: SIGNIFICANT SPECIES

Group	Bioregional endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	~230	4 1 endangered 2 vulnerable	Threatened plants include 2 eucalypts, 1 sterculiaceae, 1 pandanus.
Birds	2	7 3 endangered 4 vulnerable	Threatened birds include 2 finches, 1 pigeon, 1 parrot, 1 fairy-wren, 1 shrike-tit, 1 goshawk. The 2 endemics are a pigeon & a grass-wren. NK is considered highly diverse in bird fauna with a high rate of local endemism (in top 15 bioregions for number of limited range species), CK is considered moderately diverse. DL is the first Australian landfall for many migratory waders, and considered highly significant for waders and seabirds.
Reptiles	31	9 2 endangered 5 vulnerable	Threatened reptiles include 6 marine turtles, 2 skinks, 1 crocodile. The endemic reptiles include 7 geckos, 13 skinks, 4 agamid lizards & 7 snakes.
Mammals	6	9 7 vulnerable 1 endangered	Threatened mammals include 2 bats, 2 macropods, 2 bandicoots, 2 dasyurids, 1 rodent. The endemics include 2 rodents, 1 possum, 1 bat, 1 macropod, 1 dasyurid.
Fish	16	- -	
Amphibians	10	- -	
Invertebrates	Numerous snails & earthworms	24 -	There are many endemic rainforest snails & earthworms. Blyth & Burbidge (2004) noted that 24 taxa of Kimberley camaenid land snails were to be listed as critically endangered or endangered.
Regionally extinct species		Golden bandicoot (*Isoodon auratus*) from DL, CK Burrowing bettong (*Bettongia lesueur*) from DL Golden-backed tree-rat (*Mesembriomys macrurus*) from DL, CK Brush-tailed phascogale (*Phascogale tapoatafa*) from DL Pale field-rat (*Rattus tunneyi*) from DL, CK Brushtail possum (*Trichosurus vulpecular*) from CK Northern quoll (*Dasyurus hallucatus*) from CK Western quoll (*D. geoffroyi*)	
Richness & endemism statistics		NK: 1627 plants/58 mammals/118 reptiles/28 frogs/258 birds/42 WA endemics CK: 35 mammals/84 reptiles/22 frogs/197 birds/6 WA endemics DL: 50 mammals/120 reptiles/21 frogs/309 birds/19 WA endemics	

Sources: NLWRA database, Woinarski (2001), McKenzie et al. (2002), Woinarski et al. (2000), How & Cowan (2006), Birds Australia (2002) database, Menkhorst & Knight (2001). Note: in some cases the former existence of a species in the focus area may be speculative.

There are at least 25 threatened vertebrate species in the Kimberley divided fairly evenly amongst mammals, reptiles and birds, and 24 threatened rainforest-associated snails, all except one occurring in the Ningbing Range area(Blyth & Burbidge 2004). The relatively high rate of threatened species is explained by a number of factors—some of the endemics have very restricted ranges (eg. the snails), the sandstone complex is a refuge from threatening processes elsewhere (eg. the mammals), and there are significant threats operating particularly in the lowlands (eg. riparian degradation threatening the purple-crowned fairy-wren) (Woinarski 2001b).

There are clear patterns of mammal loss in the Kimberley. The ranges of many species have contracted to the northwest margin. The southwest has lost one-quarter (7) of its mammals other than bats. Some regionally extinct species were reported in the late 1800s as common there. Knut Dahl (1897, cited by Woinarski 2001b), who collected widely in northwest Australia, reported about the burrowing bettong that: "the ground was nearly everywhere and in all directions excavated by the burrows of this little Macropod … all the scrubs, and especially the slopes … are inhabited by countless numbers"; and the golden bandicoot was "very numerous in the coast country around Roebuck Bay … great numbers being brought to me".

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Evolutionary refugia include the sandstone and limestone ranges, and the rainforests, evidenced by the relict and endemic species; and the numerous islands, microcosms of what used to be much more extensive landscapes prior to inundation.

Ecological refugia include the ranges, which provide diverse microclimates and stable refuge areas for fire-sensitive species; the rainforests, which provide dry season refuges; riparian zones; mangroves; springs, particularly those in the Edgar Ranges area; and wetlands, such as Gladstone Lake, which is listed as nationally important as a drought refuge, and for migratory species. The Ramsar-listed mudflats of Roebuck Bay and Eighty Mile Beach, and Roebuck Plains, are clearly significant refugia for migratory waders. The cave systems associated with the Devonian reef systems may also function as refugia, supporting abundant bat colonies for example, including threatened ghost bats (NLWRA 2002 database).

Human-induced refugia include the islands and the ranges. The northwest margin of the Kimberley (a coastal strip less than 20 km wide) has particularly high refugial value for mammals which have contracted from much larger areas, in some cases most of Australia. However, with threats like destructive fire regimes and pests intruding there, islands may soon remain the sole refugia of many mammals extinct or severely diminished on the mainland (Graham 2001b).

Significant wetlands: Apart from the two Ramsar listed wetlands noted, nationally significant wetlands (listed on the Directory of Important Wetlands) include Drysdale River (NK), Bund-Bunda Mound Springs (DL), and Willie Creek Wetlands (DL).

Other features: There are significant geological features in the focus area. In particular, the ancient Devonian barrier reef structures form impressive gorges and caves, and have remarkable fish fossils.

ECOLOGICAL PROCESSES

Key ecological processes for the tropical savannas have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes in the Kimberley, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches (such as riparian habitats) or refugia have been degraded by grazing or fire.

Hydroecology: Largely intact, but significantly compromised in the Ord system due to a large dam.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes. The Kimberley coastline is one of the most cyclone-prone coasts in the world (Interim Kimberley NRM Group 2004).

Climate: Largely intact, but significant compromise looming with global warming.

Coastal fluxes: Largely intact—tidal flats are highly productive for shorebirds.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

Although there has been little gross disturbance of the Kimberley, there has been gradual deterioration in conservation values, with insidious and synergistic impacts of grazing, fire, and invasive species (see Table K.4).

TABLE K.4 MAJOR THREATS

Threats	Impacts	Comments
Altered fire regimes	Change from Aboriginal regime to destructive burning across large areas & fire exclusion elsewhere • Destruction of fire-sensitive vegetation, eg. Northern Cypress-Pine (Fisher et al. 2003), rainforests—savanna rainforest patches lost >60% of their area from 1960-1990 (McKenzie et al. 1991); and pindan (Woinarski 2001) • In eucalypt woodlands, change in structure & phenology, reduced numbers of hollow-bearing trees (Williams *et al*. 1999; Bowman et al 1988xx) • Associated with fauna declines: granivorous birds (Franklin 1999), small mammals (Woinarski et al. 2001), frilled lizard (Griffiths & Christian 1996)	Traditional Aboriginal burning is thought to have caused a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. Now, the regime is much more extensive & destructive, & "it appears to have triggered a positive feedback cycle between fire frequency and flammable grass fuels" (Bowman et al 2004). Approx. one-third of North Kimberley burnt annually from 1990-99 (Fisher et al. 2003).
Feral animals	• Damage of rainforests by cattle & pigs (McKenzie et al. 1991). During the 1980s, 1 out of 20 rainforest patches had feral cattle; now all do & success rates of trapping of small mammals has fallen from 30-40% to 1-2%. (Norris & Low 2006). • Predation by cats (may contribute to mammal decline) (Woinarski et al. 2001)	Ferals include cats, cattle, donkeys, pigs, house mice, black rats. Cattle & donkeys are spreading within the Mitchell Plateau, & reaching high densities in many other areas (Graham 2001, 48). The arrival of the cane toad is inevitable.
Weeds	• Fire threats exacerbated by spread of buffel grass. • Degradation of riparian & other key productive habitats	Weeds include buffel grass, prickly acacia, noogoora burr, parkinsonia, bellyache bush, castor oil plant.
Grazing	Implicated in widespread fauna declines ▪ Changes in vegetation, eg. composition of perennial grasses, & reduced productivity for some wildlife, eg. granivores ▪ Introduction & spread of weeds ▪ Degradation of riparian areas , alluvial flats & rainforest patches (decline of purple-crowned fairy-wren due to damage of riparian habitats)	Dominant land use – developed in the late 1800s. Cattle use rainforest patches as heat refuges—trampling litter layer, opening them up, introducing savanna grasses, rendering them more susceptible to fire (Graham 2001, 29).
Other	• Changes to hydrology (Ord Dam) have caused erosion & changed river dynamics (Graham 2001). • Localised impacts due to mining & tourism.	There are proposals to dam the Fitzroy, develop agriculture & pipe water south.

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

The focus area has a highly inadequate reserve system, with only 6% extent conserved and very poor representation (see Table K.5). Furthermore, management is also mostly poor: there is largely uncontrolled stock access, minimal control of feral animals and limited prescribed burning (Sattler & Glanznig 2006). Dampierland and Central Kimberley are high priorities for NRS reservation.

In addition to NRS reserves, there is the Australian Wildlife Conservancy's Mornington Wildlife Sanctuary in Central Kimberley. Under development is the Saltwater Country Indigenous Protected Area in North Kimberley. The Purnululu National Park has been listed as a World Heritage Area.

TABLE K.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Bioregion	Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehensiveness I-IV (%)	Comprehensiveness V-VI (%)	Manag't Standard	NRS Priority (1-5, 1 highest)
CK	357,951 (5%)	2	15	0	Poor/fair	2
DL	91,239 (1%)	24	20	?	Poor/fair	1
NK	1,085,329 (13%)	49,451 (1%)	35	?	Poor/fair	3
Focus area	1,534,519 (6%)	49,477 (<1%)	--	--	**--**	

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

There has been limited conservation-focused planning and programs in the focus area (see Table K.6). Environment Kimberley and other community groups in the Kimberley are currently advocating publicly for a regional planning process to ensure coordinated rather than ad hoc development. This has arisen in response to the threats posed by industrialisation of the Kimberley through oil and gas projects.

TABLE K.6: PLANS, POLICIES & PROGRAMS

Plan/policy/program
Water: West Kimberley River Care – setting priorities for management on Fitzroy River
Pastoralism: East Kimberley Pastoral and Cultural Development Project – integrating agricultural and cultural knowledge for best practice on pastoral properties
NRM & sustainable development: Kimberley Development Commission project – investigating sustainable harvest & traditional knowledge of plants to develop enterprises / Draft Kimberley NRM plan (2004) / donkey control by the Department of Agriculture
Traditional knowledge: Saltwater Country Project – recording traditional knowledge & management planning (Kimberley Land Council)
Fire: TSCRC FIREPLAN project—Investigating prescribed burning and wildfire control: Training and skills development for on-ground property level fire management
Conservation: Cane Toad Awareness Project, values mapping project for Roebuck Bay (WWF)
Protected areas: Kimberley Regional Planning Study by Burbidge et al. (1991) / Kimberley Rainforest survey by McKenzie & Belbin (1991) with recommendations

CONSERVATION CAPACITY

Indigenous Conservation: The Kimberley Land Council has a long-standing Land and Sea Management program. However, in many cases in the Kimberley land claims remain unresolved so the energies of Traditional Owners are often focused on sorting land ownership issues rather than land management. The Land and Sea Management Unit is currently managing 26 projects, with 6 staff members. The Land Council is a member of the Northern Indigenous Land and Sea Management Alliance, which supports indigenous land management across Northern Australia.

Advocacy conservation groups: Advocacy groups are active on a range of issues in this focus area. Most of the current work involves campaigning to stop or ameliorate particular threats to nature in the region. The groups active are:

- Environs Kimberley, based in Broome, has 3 staff and an active volunteer base and works on a wide range of nature conservation issues throughout the region, with a particular focus on the West Kimberley. Major campaigns and programs include campaigning for protection of the Fitzroy River from major water extraction schemes, monitoring mining activities and lobbying for a Kimberley regional planning process instead of incremental industrialization.

- Cultural Heritage Environmental Advocacy for the Kimberley (CHEAK) is a recently formed local voluntary group, CHEAK is lobbying against the industrialisation effects of gas developments.

- WWF Australia is actively working on the Kimberley oil-gas industrialisation issue and also has on-ground projects working on wetlands and rivers conservation in the Kimberley.

- The Australian Conservation Foundation has a formal memorandum of understanding with the Kimberley Land Council and Environs Kimberley to work jointly on issues. It was one of the leaders of recent work seeking alternative sustainable economies for the Kimberley.

- The Wilderness Society has assisted with Kimberley issues, especially campaigning on water issues, from its Perth office.

The Northern Australian Environment Alliance (which has a secretariat based in the Kimberley) acts as a pan-Northern coordinating body for these and other advocacy groups.

Private land conservation groups: The Australian Wildlife Conservancy owns Mornington Station in the Central Kimberley, the largest private land reserve in Australia. Mornington has an active research program on fire and other management issues and is investigating the possibilities for working with neighbours to establish conservation covenants on adjacent lands.

Bush Heritage Australia has an active Indigenous engagement program and as elsewhere across the North is discussing Indigenous conservation possibilities with Traditional Owner groups and the Kimberley Land Council.

There is potential for further strategic purchases by the Australian Wildlife Conservancy, Bush Heritage Australia or other conservation-minded purchasers.

Other institutional capacity: There is a recently established Kimberley Natural Resource Management group. Land Conservation District Committees have been established, and they provide a venue for discussing conservation matters and integrating property and catchment planning (McKenzie et al. 2002). The Western Australian conservation department has conducted various biological surveys in the Kimberley. However, there are limited resources dedicated to managing protected areas or for off-reserve conservation. The Tropical

Savannas CRC has conducted considerable conservation-focused research, in particular on fire in the Kimberley. However, funding will not be continued past 2007.

ADEQUACY OF INFORMATION

There is very little documentation of the impacts of pastoralism in the Kimberley. There is now a quite good record of the current Kimberley mammal fauna from a number of surveys (Woinarski et al. 2000), but an understanding of the changing status of mammals is hampered by a fragmentary baseline record. Finer scale vegetation/regional ecosystem mapping is required. Floristic data is sparse. Data is lacking on the habitat requirements of fauna species. Further research is required on the conservation status of many taxa (NLWRA 2002 database).

CARPENTARIA TROPICAL SAVANNA

GENERAL DESCRIPTION

The Carpentaria Tropical Savanna focus area covers 145 000 km^2, primarily in the north-east Northern Territory but nudging just over the border into Queensland. The focus area encompasses the IBRA bioregions Gulf Coastal (GUC) and Gulf Fall and Uplands (GFU). It is less than half the size of the ecoregion delineated by WWF and described by Ford (2001), due to the exclusion of the Gulf Plains bioregion (see Selection of Focus Areas section for justification).

FIGURE C.1: LOCATION OF CARPENTARIA TROPICAL SAVANNA

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[16]

The focus area consists predominantly of undulating plains of sedimentary rocks of Precambrian age, stretching inland from the Gulf of Carpentaria, with scattered hills of Proterozoic and Palaeozoic rock. In the GFU bioregion there are Proterozoic ranges and dissected plateaus, rising no more than 360 m. Just off the coast are the Sir Edward Pellew Islands, of mostly Cainozoic limestones. There are some large rivers in the area, and the McArthur and Roper Rivers have extensive distributary channels and alluvial fans, forming large freshwater and saline wetlands and around the edge of the Gulf.

TABLE C.1 DOMINANT VEGETATION GROUPS (KM^2)

Bioregion	Eucalypt open woodlands	Eucalypt woodlands	Other forests & woodlands	Melaleuca forests & woodlands	Acacia forests & woodlands
GFU	55,409	46,929	7,212	2,716	3,747
GUC	3,893	5,142	13,219	1,545	2
Total	**59,302**	**52,071**	**20,431**	**4,261**	**3,749**

Source: NLWRA (2001)

The complex vegetation is dominated by eucalypt woodlands of various types, with an understorey of Spinifex or tussock grasses (see Table C.1). There are scattered small patches of rainforest in fire-protected and unusually moist areas. Along the coast are mangroves, littoral grassland, and tidal flats. On the coastal plains is a variety of wetland communities.

In combination with the Gulf Plains bioregion, the focus area forms a low, semi-arid division between the wetter Daly Basin-Arnhem Land and Cape York Peninsula focus areas. The rainfall is highly seasonal, falling mainly from December to March, averaging 400-1200mm. Cyclones are frequent. Average summer maxima are 36-39^{o}C.

[16] Sources: Ford (2001); NLWRA (2002) database; Woinarski et al. (2001)

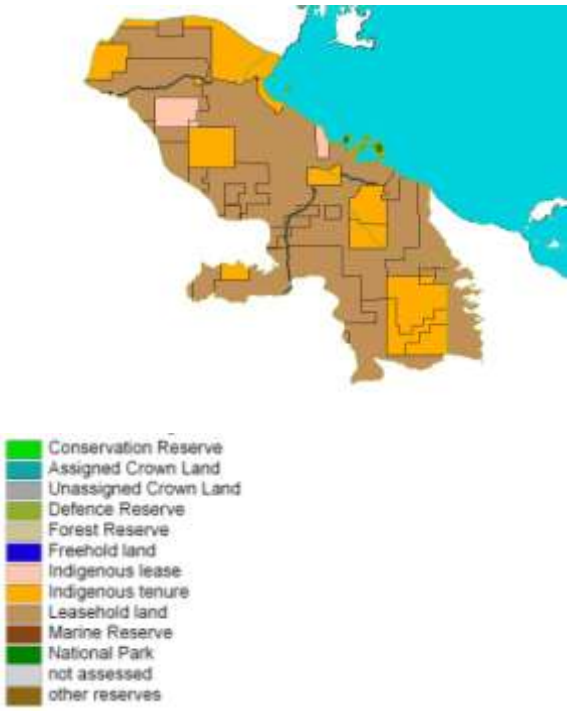
LAND USES, PEOPLE & INSTITUTIONS[17]

About two-thirds of the focus area is pastoral lease, used for extensive grazing of cattle (see Figure C.2). Many pastoral properties have been assessed as non-viable (Holmes 1990). The rest of the area is mostly Aboriginal land, but some Aboriginal land is also used for pastoralism. There is a large port and mining venture around Borroloola as well as various other mines.

The human population is sparse, with about 4000 people, averaging just .02 people/km^2, most of whom are Aboriginal from about 10 different major Indigenous language groups. A large proportion of the focus area is under native title claim.

There is a variety of Aboriginal councils and management boards, and about half-a-dozen formal groups, including two ranger groups, focused on land management activities. There are many Aboriginal lands without residents, limiting the capacity of people to manage traditional lands. The representative bodies are the Northern Land Council in the Northern Territory and the Carpentaria Land Council in Queensland.

FIGURE C.2: LAND USE



CONSERVATION VALUES

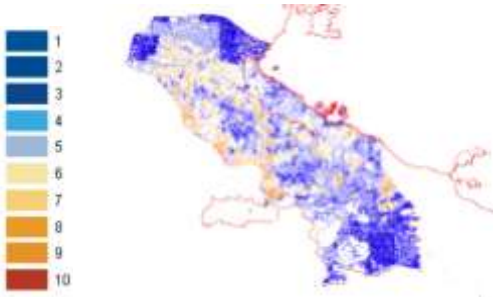
Having escaped the intense development pressure of southern Australia, this focus area has a largely intact natural landscape with functioning ecological processes. However, the condition is deteriorating due to pervasive threats, in particular grazing and invasive species.

[17] Sources: Woinarski et al. (2000); Baker et al. (2005); NLC (2004), AITSIS (2005), NNTT (2006)

FIGURE C.3: VEGETATION CONDITION (VAST)

Source: Thackway & Lesslie (2005)

FIGURE C.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE C.5: WILDERNESS QUALITY (NWI)

High quality wilderness

In the assessment of landscape health by Morgan (2001), the focus area rated fairly well, with all subregions ranked in the second-lowest stress class (see Table C.2). Note that the assessment did not include the effects of fire, one of the threatening processes in the focus area.

TABLE C.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE AND RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best)
GFU 1/2	5/5	0	3/3
GUC 1/2	5/5	1	3/2

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002)

Almost no vegetation has been cleared; however, vegetation condition (again without reference to fire), is variable, with a substantial proportion rated as 'modified' or 'transformed' (see Figure C.3).

The condition of rivers is variable, some retaining high integrity, but others suffering moderate levels of disturbance (see Figure C.4). Nationally important wetlands are considered in good condition, although the trend is in decline or unknown (NLWRA 2002). The average subregional condition of riparian zones is considered good (see Table C.2), although declining, except on the Pellew Islands, where condition is considered 'fair (recovery requires significant intervention)' and declining (NLWRA 2002 database).

Finally, in the National Wilderness Inventory, most of the focus area was assessed as having high wilderness quality (see Figure C.5), as it also was in the more recent Wilderness Delineation.

BIODIVERSITY VALUES

More arid than the Daly Basin-Arnhem Land and Cape York Peninsula it separates, Carpentaria supports less diversity. Furthermore, at least in the mammal and bird fauna there have been extensive contractions of range for many species, particularly in the grazed lowlands. However, there are significant wildlife habitats in its rainforests, wetlands, islands and stone country, and some of its biota is unique.

In the McArthur-South Nicholson Basins subregion (GFU 1), 8 of 13 regional ecosystems are considered unique (NLWRA 2002 database). Ecosystems considered threatened include the monsoon rainforest patches, the sandstone heathlands, mixed eucalypt open woodland on sandy alluvial terraces, and river red gum riparian communities. Threats are changed fire regimes, grazing, and invasive species.

The Pellew Islands have internationally significant breeding areas for seabirds and marine turtles (Chatto 2001).[18] More than 200 bird species have been recorded for the islands (NLC 2004). They also provide habitat for mammals in decline on the mainland, and have endemic plants.

The upland stone country has retained much of its small mammal fauna. The rainforest patches are particularly important, supporting not only the endemic carpentaria rock-rat (living in just four patches on one pastoral property), but at least four endemic plants, and an endemic gecko.

As part of a much more widespread decline, particularly of granivorous birds (Franklin 1999) and mammals (Woinarski et al 2001), several species have declined, in some cases to complete loss, in this area (see Table C.3). Because the area is poorly known, the details of the declines and whether they are continuing are unknown. There is a sharp disparity between small mammal populations in ungrazed areas in the ranges and the grazed lowlands, where they are now almost completely absent (Woinarski 2000).

[18] The Pellew Islands marine area is also very important, with extensive seagrass habitat. The area around the islands and running north to the Limmen Bight River, have the highest dugong density in Australia (NLC 2004, 338).

TABLE C.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	>8	1 1 vulnerable	Endemics have been found on Pellew Islands & in rainforest. There are thought to be more endemic plants.
Birds		11 1 endangered 5 vulnerable	Threatened birds include 2 finches, 1 pigeon, 1 owl, 1 fairy-wren, 1 shrike-tit, 1 snipe, 1 goshawk, 1 grasswren, 1 emu, 1 bustard. The carpentarian grasswren is almost endemic. The bird fauna is moderately diverse in both bioregions.
Reptiles	3	7 3 endangered 4 vulnerable	Threatened reptiles include 6 marine turtles, 1 freshwater turtle. There are 2 endemic freshwater turtles, 1 gecko.
Mammals	1	5 2 endangered 4 vulnerable	Threatened mammals include 3 rodents, 1 antechinus, 1 macropod, 1 bat. Endemic is a rodent. A dasyurid is almost endemic (also in the Gulf Plains)
Amphibians	1		Endemic toadlet
Fish		1 1 vulnerable	Threatened sawfish
Regionally extinct species		Partridge pigeon (*Geophaps smithii*) from both Golden-backed tree-rat (*Mesembriomys macrurus*) from GFU Golden bandicoot (*Isoodon auratus*) from both Kultarr (*Antechinomys laniger*) from both Black-footed Tree-rat (*Mesembriomys gouldii*) from GUC Woylie (*Bettongia penicallata*) from GFU	
Richness & endemism statistics		GFU: 1575 plants / 472 vertebrates / 232 birds / 141 NT endemics / 25 bioregion endemics GUC: 1071 plants / 433 vertebrates / 197 birds / 74 NT endemics / 8 bioregion endemics	

Sources: NLWRA (2002) database, Ford (2001), Woinarski et al. (2000), Baker et al. (2005), Birds Australia (2002) database, Menkhorst & Knight (2001).

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Evolutionary refugia include the ranges, the rainforests, and the islands, all of which harbor relictual and endemic species. Morton et al. (1995) recognised both the Pellew Islands—'highly significant' as an "insular refuge for endemic and rare species of plants and animals"—and the sandstone country— 'extremely significant' for the "range of endemic and rare species confined to sandstone escarpments and rainforest remnants or vine thickets".

Ecological refugia include the ranges, which provide diverse microclimates and stable refuge areas for fire-sensitive species; the rainforests, which provide dry season refuges; riparian zones; springs and wetlands. Lawn Hill Gorge, with permanent deep water and fringing habitats, and the perennial stream system of the Thorntonia Aggregation (with perhaps the only perennial streams in arid Queensland), are both 'significant' refugia (Morton et al. 1995).

Human-induced refugia include the islands and the ranges. Many mammals in this focus area can now only be found, or found in former abundance, on the Pellew Islands.

Significant wetlands: Nationally significant wetlands in the focus area include those near the mouth of the Roper River in Limmen Bight, and the Port Mcarthur tidal wetlands system, significant for migratory waders and dugongs (NLWRA 2002 database).

ECOLOGICAL PROCESSES

Key ecological processes for the tropical savannas have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes in Carpentaria, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches (eg. in the grazed lowlands) or refugia have been degraded by grazing or fire.

Hydroecology: Largely intact, but compromised where riparian areas have been degraded by grazing.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes—cyclones are likely to increase in intensity for example.

Climate: Largely intact, but significant compromise looming with global warming.

Coastal fluxes: Largely intact.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

Although there has been limited gross disturbance of the Carpentaria focus area, there has been considerable deterioration in conservation values due to the insidious and synergistic impacts of grazing, fire, and invasive species (see Table C.4). For example, the widespread decline of mammals in the lowlands is attributed to a combination of grazing and changed fire regimes (Woinarski 2000). For a large proportion of the area there is no information about threatening processes, let alone management of them.

TABLE C.4: MAJOR THREATS

Threats	Impacts	Comments
Grazing	▪ Degradation of rainforest patches & riparian habitats ▪ Reduced productivity of landscapes for some wildlife, eg. granivores, small mammals ▪ Erosion due to overstocking (Holmes 1990) ▪ Changes in vegetation, eg. in composition of perennial grasses ▪ Introduction & spread of weeds	Pastoral leases cover about 2/3 of the area. The decline of mammals & bird species in the grazed lowlands has been attributed primarily to grazing, in combination with changed fire regimes (eg. Woinarski 2000)
Altered fire regimes	Change from Aboriginal regime to destructive burning across large areas & fire exclusion elsewhere • Destruction of fire-sensitive vegetation, eg. northern cypress-pine (Bowman & Panton 1993), sandstone monsoon rainforests (Price & Bowman 1994.) • In eucalypt woodlands, change in structure & phenology, reduced numbers of hollow-bearing trees (Williams *et al*. 1999) • Vegetation thickening (Bowman et al. 2001) ▪ Associated with fauna declines: granivorous birds (Franklin 1999), mammals (Woinarski et al. 2001), frilled lizard (Griffiths & Christian 1996)	According to explorer records, there was a very high frequency of Aboriginal burning around the Gulf of Carpentaria (Fensham 1997), which is presumed to have resulted in fine-scale mosaic of different fire histories in vegetation. Large areas of country are currently unpopulated & have no fire management.
Feral animals	▪ Degradation of riparian habitats and water points by horses & donkeys (in high numbers) (NLC 2004) ▪ Degradation of wetlands by pigs & goats; goats a particular problem on the Port Arthur Tidal Wetlands System (NLWRA 2002 database) ▪ Likely or observed declines in goannas, quolls, snakes & freshwater turtles due to canetoads (NLC 2004). ▪ Likely declines in some fauna due to predation by cats (NLC 2004)	Ferals include donkeys, horses, goats, pigs, cats, canetoads NLC (2004) notes the "virtual disappearance" of goannas in many areas of the Roper Basin, presumed due to cane toads.
Weeds	▪ Displacement of native species & degradation of wildlife habitats ▪ Of particular concern for the future is the potential spread of exotic pasture plants—gamba grass & mission grass, which exacerbate the threat of extensive and intensive fire.	There are 24 'weeds of importance' listed by the NLC (2004) for the Roper Basin. In general there is very little information about the extent of weed infestation in most areas.
Other	▪ Degradation of habitats by tourism, particularly recreational fishing, is an emerging problem ▪ Pollution & a proposed diversion of the McArthur River by the McArthur River mine (NLC 2004).	There are extensive mining exploration leases in the area.

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

The Carpentaria focus area is poorly reserved, with <1% of the area in the National Reserve System (NRS) (see Table C.5). The Gulf Coastal bioregion is considered of highest NRS priority. Sattler & Glanznig (2006) remark that many localised conservation attributes such as habitat of the Carpentarian rock-rat and seabird breeding sites warrant formal protection. Other options for reserves include Indigenous Protected Areas or agreements with Traditional Owners for the Pellew Islands (ibid).

TABLE C.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Bioregion	Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehen siveness I-IV (%)	Comprehen siveness V-VI (%)	Manag't Standard	NRS priority (1-5, with 1 highest)
GFU	119,334 (1%)	83,475 (1%)	15	19	Good	3
GUC	4,931 (<1%)	0	1	0	Fair	1
focus area	124,265 (<1%)	83,475 (<1%)	--	--	--	

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

TABLE C.6: PLANS, POLICIES & PROGRAMS

Plan/policy/program
NRM: NLC Caring for Country strategy & caring for Country guidelines **/** Roper River Landcare Group Draft Catchment Management Plan 2003
Pastoralism: monitoring programs have been established on all pastoral leaseholds.
Conservation**:** Management plans for national parks **/** Oil Spill Response Atlas for coastal areas
Fire: TS CRC FIREPLAN project—Developing implementing and evaluating fire management of woody vegetation in the Gulf region. The Bush Fires Council NT does some fire management.
Species recovery: Gouldian finch recovery program

There has been very little conservation focus on the Carpentaria Tropical Savanna (see Table C.6). Problems such as invasive species and fire are addressed in an ad-hoc way (NLWRA 2002 database).

CONSERVATION CAPACITY

Indigenous Conservation: Development of the pastoral industry displaced many Traditional Owners from their country, and now only about one-third of the area is Aboriginal-owned. Much of that land is currently unmanaged due to the contraction of people to a few settlements, leading to problems, such as noted for the Calvert River Basin: "The biggest threat to this area is that there are no people on it and this has contributed to large fires, possible weed infestations and illegal cattle operations" (NLC 2004). Many Aboriginal landowners are seeking ways to make a living on country, and various options, including conservation land management, are being canvassed.

There are a very few land management groups operating in the area, carrying out some burning and weed management. Along the bottom of the Gulf, the only ranger capacity is the Lianthawirriyarra Sea Ranger Unit, working primarily around the Pellew Islands (ibid). Groups are inadequately funded.

There is the potential for the establishment of Indigenous Protected Areas by conservation minded landowners seeking further support for land management.

Carpentaria and Northern Land Councils are members of the Northern Indigenous Land and Sea Management Alliance, which supports land management across Northern Australia.

Advocacy conservation groups: The region has had a patchy focus from advocacy groups. Current work includes:

- Environment Centre of the Northern Territory (ECNT) is working on a campaign with local Traditional Owners to stop an open pit mine being built in the McArthur River.

The Northern Australian Environment Alliance (which has a secretariat based in the Kimberley) acts as a pan-Northern coordinating body for these and other advocacy groups.

Private land conservation groups: The eastern part of the area forms part of a designated focus area of Bush Heritage Australia and the organisation has an active Indigenous engagement program and as elsewhere across the North is discussing Indigenous conservation possibilities with Traditional Owner groups and the Carpentaria Land Council.

The Australian Wildlife Conservancy has recently purchased a property, Wongalorra, on the far-northern border of the focus area.

There is potential for further strategic purchases by Bush Heritage Australia, Australian Wildlife Conservancy or other conservation-minded purchasers.

Other institutional capacity: The subregions in the Gulf Fall and Uplands bioregion have an 'identified capacity to integrate conservation' in existing natural resource management processes, but those in the Gulf Coastal bioregion have 'significant constraints'(NLWRA 2002 database). The Tropical Savannas Cooperative Research Centre has conducted some research focused on pastoral management. However, CRC funding will not be continued past 2007.

ADEQUACY OF INFORMATION

There are significant data gaps for this focus area, with no fine-scale vegetation mapping, and very limited survey data for plants and animals. There is "little information about threatening processes, impacts, and the trajectory of status for species or ecosystems" (NLWRA 2002 database).

VICTORIA PLAINS TROPICAL SAVANNA

GENERAL DESCRIPTION

The Victoria Plains Tropical Savanna focus area covers 225 000 km^2 in the Northern Territory and Western Australia. The focus area encompasses the IBRA bioregions Ord-Victoria Plains (OVP) and Sturt Plateau (STU), and is equivalent to the ecoregion of the same name delineated by WWF and described by Woinarski (2001c).

FIGURE VP.1: LOCATION OF VICTORIA PLAINS TROPICAL SAVANNA

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[19]

The focus area has a varied geomorphology, but little landscape diversity. In the west are flat to undulating plains of clay and red loam soils, with occasional sandstone outcrops (such as the Bungle Bungle Ranges). In the eastern part, the Sturt Plateau has red sandy-loam soils, and is flat apart from occasional mesas and lateritic outcrops. Elevation ranges from 50-480 m, and the focus area forms the upper catchment of two of the largest rivers in northern Australia.

VP.1 DOMINANT VEGETATION GROUPS (KM^2)

Bioregion	Hummock grasslands	Eucalypt woodlands	Tussock grasslands	Eucalypt open woodlands	Acacia forests & woodlands
OVP	45,138	19,030	33,902	20,299	336
STU	17,982	39,295	911	6,905	25,044
Total	**63,120**	**58,325**	**34,812**	**27,204**	**25,380**

Source: NLWRA (2001)

The most extensive vegetation is eucalypt-dominated woodlands with a tall grass or spinifex understory (see Table VP.1). There are also tussock and hummock grasslands. In the east are Lancewood thickets and bullwaddy woodlands. These thickets support rainforest type plants, and have been considered by some as rainforest. There are also patches of mesic vegetation in riparian zones and sheltered gorges in the Bungle Bungles and other gorge country, and heathlands on sandstone escarpments.

The focus area spans the tropical to arid zones, with Tanami Desert on its southern edge. It is predominantly semi-arid, with monsoonal rains falling mainly from November to March. In a largely north-south gradient, the annual rainfall averages 1000-400 mm. It is hot, with monthly average maxima ranging from 25^o to 35^{o}C.

[19] Sources: Woinarski (2001c), NLWRA (2002) database

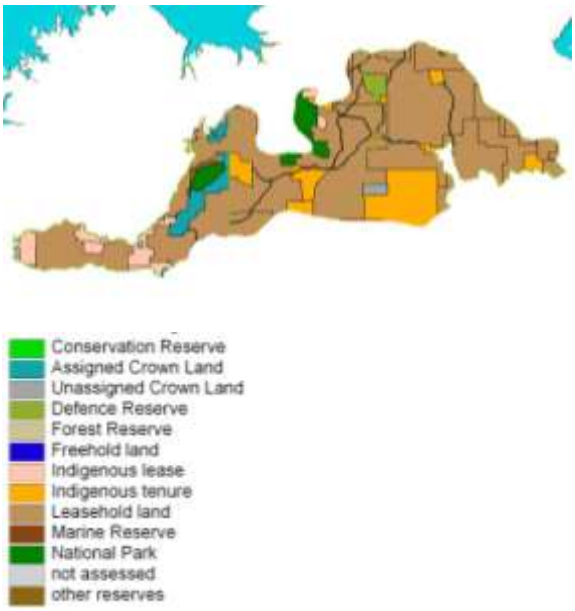
LAND USES, PEOPLE & INSTITUTIONS[20]

Most of the focus area is used for pastoralism, either as pastoral lease or on Aboriginal freehold land (covering <10% of the area) (see Figure VP.2). At least 6 Aboriginal Land Trusts are used for pastoralism—many Trusts were formally pastoral properties, converted following land claims. Conservation, defence, mining, tourism and urban settlements are minor land uses.

This focus area has a very small human population (<5000 people) with a population density of just 0.1-0.2 people/km^2.

The majority of the population is Aboriginal. There are at least 10 major Indigenous language groups in the focus area. Much of the focus area is under native title claim. The representative bodies are the Northern Land Council and the Central Land Council (in the NT) and Ngaanyatjarra Council (in WA).

FIGURE VP.2: LAND TENURE



CONSERVATION VALUES

Having escaped the intense development pressure of southern Australia, this focus area has a semi-natural landscape with functioning ecological processes. However, the condition has substantially deteriorated due to pervasive threats such as grazing, invasive species and changed fire regimes.

LANDSCAPE CONDITION

In the assessment of landscape health by Morgan (2001), Victoria Plains rated variably, with the Ord subregion (OVP) rating highly, the South Kimberley Interzone (OVP) rating poorly, and the other subregions all in the second-best class (see Table VP.2). Note that the assessment did not include the effects of fire, one of the threatening processes in the focus area.

Virtually no vegetation has been cleared. However, the condition (again without reference to fire) is variable, with a substantial proportion ranked as 'modified' or 'transformed', due to grazing (see

TABLE VP.2: LANDSCAPE HEALTH, VEGETATION RETENTION, RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best)
OVP 1/2/3/4	6/4/5/5	0	1/2/2/2
STU 1/2/3	5/5/5	1	3/2/2

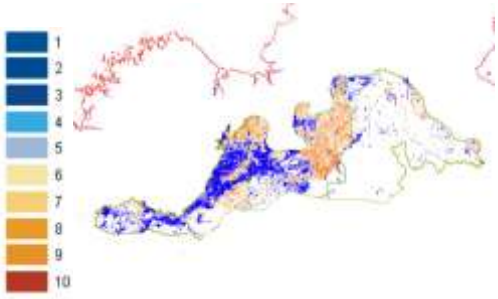
Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

[20] Sources: Baker et al. (2005), AIATSIS (2005), NNTT (2006).

FIGURE VP.3: VEGETATION CONDITION (VAST)

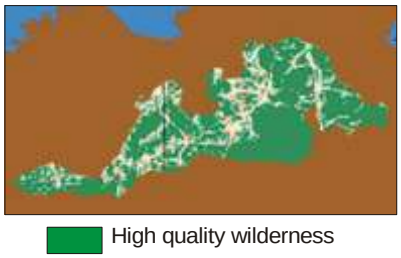
Source: Thackway & Lesslie (2005)

FIGURE VP.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE VP.5: WILDERNESS QUALITY (NWI)



Source: Lesslie & Masslen (1995)

Figure VP.3). The grazing pressure is signified by the relatively high density of bores (compared to other bioregions in the Northern Territory) on grazing properties: 0.9-1.2/100 km^2 for OVP and 0.7-0.9/100km^2 for STU (Baker et al. 2005).

Likewise, river condition is variable (see Figure VP.4). The average subregional condition of riparian habitat is considered mostly fair, but the Ord subregion (OVP) is ranked degraded, with recovery unlikely in the medium term (see Table VP.2).

Finally, in the National Wilderness Inventory, about half of the focus area was assessed as having high wilderness quality (see Figure VP.5). However, in the more recent Wilderness Delineation project, the only substantial area rated of wilderness quality was in the OVP bioregion.

BIODIVERSITY VALUES

The Victoria Plains is an intergrade zone, with the southern extent of much of the northern monsoonal biota and the northern extent of some of the arid biota (Woinarski 2001c).

The grasslands and woodlands support a “very rich and abundant assemblage of granivorous birds” (ibid). The Lancewood and Bullwaddy stands in this focus area are the most extensive in Australia. Although generally “fairly depauperate”, they support abundant populations of the threatened spectacled hare-wallaby (ibid).

Scattered across the focus area, mainly in OVP, there are numerous rainforest patches (about 800 in the Northern Territory, with a total extent of just 15km^2), which support endemic and threatened snail species, and endemic earthworms (Baker et al. 2005, Graham 2001e).

There is some endemism associated with sandstone outliers, particularly the Purnululu Range, with an endemic skink and several endemic plants (Woinarski 2001c). In addition, two lizards, a snake and two burrowing frogs are largely restricted to the focus area. It is likely that systematic surveys of limestone and sandstone caves in the Gregory National Park will find endemic invertebrates (ibid).

Threatened ecosystems in the focus area include wetlands, damplands and riparian habitat in the Kimberley subregion; fire-sensitive plant assemblages on sandstone cliffs; plant assemblages of sand plain seepage areas; monsoon rainforest patches; and communities on the Lake Wilson and Lake Gregory wetland systems (Graham 2001d). There are >30 species listed as threatened, and at least 6 mammals are regionally extinct (see Table VP.3).

TABLE VP.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	1 (+several)	14 -	There is an endemic acacia (& others in Purnululu NP).
Birds		10 2 endangered 4 vulnerable	Threatened birds include 2 finches, 1 pigeon, 1 shrike-tit, 1 snipe, 1 goshawk, 1 duck, 1 fairy-wren, 1 bustard, 1 emu. The bird fauna is moderately diverse.
Reptiles	1	1 -	There is an endemic skink. The threaten reptile is a crocodile (in WA).
Mammals		4 3 vulnerable	Threatened mammals include 2 bats, 1 bandicoot, 1 macropod.
Freshwater fish		1 0	A grunter is threatened (NT).
Invertebrates		3 0	3 snails are listed (NT), 2 as critically endangered. Likely to be several endemics.
Regionally extinct species	Burrowing bettong (*Bettongia lesueur*) from OVP Brushtail possum (*Trichosurus vulpecula*) from OVP Mala (*Lagorchestes hirsutus*) from OVP Crescent nailtail wallaby (*Onychogalea lunta*) from OVP		Golden bandicoot (*Isoodon auratus*) from both Carpentarian Antechinus (*Pseudantechinus mimulus*) from STU Northern Quoll (*Dasyurus hallucatus*) from STU Western Quoll (*Dasyurus geoffroii*) from both
Richness & endemism statistics	OVP: 1300 plants (NT) / 409 vertebrates (NT) / 240 birds / 38 mammals (WA) / 110 reptiles (WA) / 17 frogs (WA) / 66 NT endemics / 33 bioregion endemics (NT) / 9 WA endemic mammals, reptiles, frogs STU: 1074 plants / 410 vertebrates / 215 birds / 69 NT endemics / 4 bioregion endemics		

Sources: NLWRA (2002) database, Baker et al. (2005), Graham(2001a, 2001b) , Birds Australia (2002) database, Menkhorst & Knight (2001).

Note: Bioregion endemics (NT) may exist outside the state. Endemics do not include invertebrates. The former existence of a species in the focus area may in some cases be speculative.

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Evolutionary refugia include sandstone ranges, notably the Bungle Bungle Range, and rainforests, evidenced by relict and endemic species. In sheltered gorges of the Bungle Bungle Range are relict plants—a fern, resurrection grasses and a tall palm—from wetter climates (Morton et al. 1995).

Ecological refugia include the ranges, which provide diverse microclimates and refuge areas from fire; the rainforests, which provide dry season refuges; riparian zones; wetlands and springs, eg. in the Osmand Ranges (although Graham (Graham 2001c) says spring communities need further assessment to determine their refugial values). Morton et al. (1995) recognise the Ramsar-listed and largest human-created waterbody in

Australia, Lake Argyle, as a 'significant' refuge for waterbirds during drought and as a migration stop-over for shorebirds; and Graham (Graham 2001d) considers Lake Wilson an important drought refuge.

Human-induced refugia include parts of the ranges, with some gorges inaccessible to feral animals as well as protected from fire.

Significant wetlands: Besides the Ramsar-listed Lake Argyle, there are two wetlands listed as nationally significant in the Directory of Important Wetlands: Lake Wilson and the Paruku Wetland Complex. In the latter complex, Lake Gregory is considered to qualify for Ramsar listing (Graham 2001).

Other features: Graham (2001d) notes there is geology of interest associated with the Halls Creek Fault.

ECOLOGICAL PROCESSES

Key ecological processes for the tropical savannas have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes in Victoria Plains, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches (eg. in heavily grazed areas) or refugia have been degraded by grazing or fire.

Hydroecology: Compromised in many areas where riparian areas have been degraded by grazing.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

There has been gross disturbance of some parts of the Victoria Plains Tropical Savanna due to overgrazing and the Ord impoundment. Although there has been little gross disturbance in the majority of the focus area, there has been gradual deterioration in conservation values and compromise of ecological processes, particularly due to the insidious and synergistic threats of grazing, changed fire regimes, weeds, and feral animals. See Table VP.4 for information about threats.

VP.4: MAJOR THREATS

Threats	Impacts—observed, likely or future	Comments
Grazing	▪ Massive degradation in some habitats due to heavy grazing, in particular riparian zones & alluvial flats (Graham 2001; Woinarski 2001) ▪ Degradation of rainforest patches. Reduced productivity of landscapes for some wildlife, eg. granivorous birds (in combination with fire) ▪ Changes in vegetation structure & composition, eg. composition of perennial v annual grasses, & hydroecology (Graham 2001b) ▪ Transformation of grassland to dense woodland (Sharp & Whittaker 2003) ▪ Introduction & spread of weeds	Pastoralism occurs in about 90% of the area. There was sustained overgrazing, particularly in the 1960s & 1970s due to changed breeds, artificial water points & nutrient/mineral supplements (Sharp & Whittaker 2003) Large areas in the degraded Ord system were compulsorily destocked, recovery has been gradual (Graham 2001a). Degradation in Ord system results in annual deposition of 24 million tonnes of sediment in Ord River (Winter 1990).
Altered fire regimes	▪ Late season extensive & destructive fires resulting in homogeneity across large areas due to attempted fire exclusion (Woinarski 2001b) ▪ Invasion of grasslands by shrubs & small trees (Sharp & Whittaker 2003) ▪ Reduction of Lancewood-Bullwaddy habitats (Woinarski & Fisher 1995); degradation of rainforest (Baker et al 2005) ▪ Decline in Callitris pine & obligate-seeding shrubs (Sharp & Bowman 2004) ▪ Reduced numbers of hollow-bearing trees ▪ Declines in some fauna, eg. granivorous birds (Franklin 1999), small mammals (Woinarski et al. 2001)	Traditional Aboriginal burning is thought to have caused a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. Now, the regime is much more extensive & destructive, & "it appears to have triggered a positive feedback cycle between fire frequency and flammable grass fuels" (Bowman et al 2004). Pastoralists attempt to exclude fire and in combination with grazing, this has caused transformation of grasslands into woodland.
Feral animals	▪ Degradation by feral cattle, donkeys & camels, particularly around water points ▪ Degradation of rainforest due to buffalo (Baker et al. 2005) ▪ Cats may contribute to mammal decline (Woinarski et al. 2001) ▪ Decline in quolls, goannas, snakes due to cane toads (Baker et al 2005) ▪ Potential significant impact on mammals due to foxes, expanding in range from south (ibid)	Ferals include cattle, donkeys, horses, camels, buffalo, pigs, cats, foxes, honey bees & cane toads. High densities of feral stock, horses & donkeys (NLC 2004, Woinarski 2001b). Buffalo & pigs seem to be expanding their range & it may be possible to control them while it remains economically feasible to do so (NLC 2004).
Weeds	▪ Displacement of native species & degradation of wildlife habitats, in particular riparian habitats ▪ Of particular concern for the future is the spread of exotic pasture plants, eg. gamba grass and mission grass, which exacerbate the threat of extensive and intensive fire.	Little is known about weed status & impacts. Significant weeds include Buffel grass, Para grass, Mesquite, Devil's Claw, Neem, Parkinsonia. Increased use of exotic pasture grasses is key threat.
Other	▪ Major impacts on Ord system due to large impoundment.	The Sturt Plateau is being targeted for agricultural development with subdivisions of pastoral properties.

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

The Victoria Plains is very poorly conserved, with <1% of the area in reserves (see Table VP.5). The Sturt Plateau bioregion is a very high priority for NRS reservation.

TABLE VP.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Bioregion	Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehensiveness I-IV (%)	Comprehensiveness V-VI (%)	Manag't Standard	NRS priority (1-5, with 1 highest)
OVP	671,582 (5%)	0	4	0	Fair	3
STU	20,534 (<1%)	0	16	0	Good	1
focus area	692,116 (<1%)	0	--	--	--	

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

Due to limited capacity, there has been little conservation management in the Victoria Plains (see Table VP.6.)

TABLE VP.6: PLANS, POLICIES & PROGRAMS

Plan/policy/program
Conservation: Purnululu National Park Management Plan / Sturt Plateau Plan
Land management plans/strategies: NLC Caring for Country strategy & caring for Country guidelines **/** Victoria River District Natural Resource Plan
NRM activities: Some catchment-wide weed programs (but lacking resources & integration**) /** Donkey control program; **/** Victoria River District Conervation Association has undertaken some riparian exclosure fencing / some fire management through regional offices of Bushfires Council
Pastoralism: Indigenous Pastoral Project is establishing partnerships between Aboriginal and non-Aboriginal pastoralists as a basis for improved land management

CONSERVATION CAPACITY

Indigenous Conservation: In the Northern Territory part of this region the Northern Land Council has a long-standing and extensive Land and Sea Management program. There are a number of ranger programs in the region. However, these function under short-term and inadequate funding arrangements (NLC 2004).

The Kimberley Land Council has a long-standing Land and Sea Management program. However, in many cases in the Kimberley land claims remain unresolved so the energies of Traditional Owners are often focused on sorting land ownership issues rather than land management.

Both the Kimberley and Northern Land Councils are members of the Northern Indigenous Land and Sea Management Alliance, which supports land management across Northern Australia.

There is strong interest in developing enterprises to support Aboriginal economic development (NLC 2004). The Victoria River District Conservation Association employs Ngaliwurru Landcare on land management contracts on non-Aboriginal land. The Indigenous Pastoral Project is establishing partnerships between Aboriginal and non-Aboriginal pastoralists as a basis for improved land management (NLC 2004).

Advocacy conservation groups: We know of no specific advocacy work in the focus area. Environs Kimberley and the Environment Centre of the Northern Territory have a watching brief on various issues in the area.

Private land conservation groups: We know of no activity in the Victoria Plains region by private land conservation groups.

Other institutional capacity: There is variable, but mostly quite low, capacity within existing natural resource management processes in the focus area (NLWRA 2002 database). There is some capacity within the pastoral industry for NRM activities, in particular the Victoria River District Conservation Association. The Tropical Savannas Cooperative Research Centre has conducted considerable conservation-focused research, and produced a range of assessments and plans. However, CRC funding will not be continued past 2007.

BIOME INTRODUCTION: DESERTS/XERIC SCRUBS

INTRODUCTION

More than one-third of the Australian continent, a vast 3.5 million km^2, is part of the Deserts and Xeric Scrubs biome.

In this paper we consider a substantial proportion of that area, focusing on six of the most intact biogeographic areas: Central Ranges, Gibson Desert, Great Victoria Desert, Nullarbor Plains, Great Sandy-Tanami Deserts and Simpson-Strzelecki Desert.

Of all countries, Australia has the largest remaining wild deserts (below an identified threshold of human influence) (CIESIN & WCS 2003). Furthermore, Mittermeier et al. (2003) identified Australian deserts as one of 24 global wilderness areas (defined as areas > 1 million hectares, > 70% intact and with human densities <5 people/km^2).

Mittermeier et al. (2003) found that Australian deserts do not stand out for overall species richness or endemicity (particularly compared with speciose tropical forests such as Amazonia). However, they do stand out among large wilderness areas for reptile species richness (top 2, exceeded only by Amazonia) and reptile endemism (top 4), and less prominently for bird species richness (top 11). Furthermore, in comparison with six other deserts identified as wilderness areas, the Australian deserts rated highly for reptile species richness (top 1) and endemicity (top 2), bird species richness (top 2), plant species richness (top 3), and amphibian richness (top 2) and endemicity (top 3).

Australia's arid systems are unusual in relation to others, with their combination of highly unpredictable climate extremes, very infertile and spatially sorted soils, spatial heterogeneity of biota at different scales, and unusual dominant groups of biota. They are also well vegetated in comparison to many other deserts.

Stafford Smith and Morton (1990) characterise the key parameters shaping the ecology of Australia's arid zone. The three key aspects of the physical environment are:

- the unpredictability of rainfall, with temporal variability amongst the highest in the world;
- big rainfall events, which structure landscapes and create biotic patterns, and sustain high levels of biomass; and
- the ancient, well-sorted, infertile landscape, with the levels of nitrogen and phosphorous amongst the lowest in comparably arid areas.

These physical characteristics shape the vegetation in the following ways:

- plant productivity is highly patterned, in mosaics determined by moisture and fertility;
- there is a high diversity of life history strategies due to the irregularity of the climate, and extremes of soil moisture are particularly influential;
- low fertility limits the potential for herbivores, and there are predictable patterns of production and digestibility across the landscape;
- nutrients are limited, but carbohydrates are plentiful, released as nectar, fruits, arils, and sap; and
- high perennial biomass, slow rates of decomposition and plentiful carbohydrate-based tissue promote fire, an important force in the arid zone, recycling scarce nutrients.

In turn, these characteristics of the vegetation and physical environment shape the arid zone fauna in the following ways:

- food, rather than water, is the critical determinant of persistence and reproduction—most animals obtain sufficient moisture from their food, but are limited by nutrients;
- herbivores are generally constrained, and tend to either focus opportunistically on ephemeral availability of high quality plant resources or develop special strategies for persisting on perennial plants;
- termites are dominant as they favour high-biomass, low-nutrient vegetation;
- environments with relatively continuous production, such as riverine channels, which are small and scattered, are favoured by herbivorous mammals;
- social insects, such as termites and ants, are prominent because they are able to buffer the pulses of production and forage widely;
- water and nutrient availability are also reflected in patterns of higher-order consumers—leading to dominance by reptilian and invertebrate predators in nutrient- and moisture-poor landscapes; and
- despite climate fluctuations, many animal populations are relatively stable due to their buffering capacities.

These characteristics of the Australian arid zone are considered in more detail in the following sections, where we briefly discuss biological history, biodiversity patterns and ecological processes.

A BRIEF BIOPHYSICAL DESCRIPTION

Australia's deserts and xeric scrubs are defined climatically as arid, with annual mean rainfall less than 250-300mm. However, means are misleading when the rainfall is so highly erratic. Much of it is delivered in infrequent large rain events, and the majority of years deliver much less than the mean. In contrast, temperatures are seasonally variable, with summer temperatures regularly exceeding 40^0 C, but frosts common on winter nights in some areas.

Much of the landscape in this biome is ancient, "amongst the oldest landscape remnants on earth", with parts dating from the Cambrian (Jacobson 1994). The eroded summits of the ranges and river systems like the Finke are remnants of the Palaeozoic landscape (ibid). Some rivers terminate in inland lakes; most peter out in sand. Groundwater systems are also ancient, some aquifers containing water millions of years old. The dominant landforms of vast sand plains and sand dunes, however, are typically much younger, formed in the Quaternary as aridity increased. Soils are mostly infertile, very low in nitrogen and phosphorous.

About 80% of the Australian arid zone is vegetated, dominated by five broad vegetation types: hummock grasslands, acacia shrubland, tussock grasslands, chenopod shrublands, and eucalypt shrubland (NLWRA 2001).

Shaped by patterns of moisture and nutrient availability, there are three basic types of landscape in the arid zone (Stafford Smith & Morton 1990): on relatively rich soils are tussock grasslands (eg. Mitchell grasslands) and chenopod shrublands; on the predominant infertile soils are spinifex grasslands and acacia woodlands; but scattered amongst them are patches of more productive country, where water and nutrients are concentrated by topographical or geological features, such as floodouts, calcareous outcrops, river channels and floodplains, where vegetation even amounts to trees.

BIOLOGICAL HISTORY

The current arid zone was once part of a warm and humid forested environment. Its transition to woodlands (and fire), then scrublands, grasslands and desert came about with major episodes of climate change in the Late Miocene and the late Pleistocene, and a general trend towards aridity (Martin 2006). The modern climatic regime was established by the early Pleistocene, although rainfall was higher (ibid). During the most recent bouts of global glaciation, from about half a million years ago, conditions became increasingly harsh. Thus, the last glacial period was the harshest and the present interglacial period is drier than the previous interglacial (ibid).

These climatic changes wrought many extinctions. Those taxa that did not go extinct survived by contraction to wetter refugia; adjustments of behaviour, physiology and morphology etc; and speciation (ibid, Dawson & Dawson 2006). The contemporary arid flora has developed from that existing in less arid times, and many taxa were in central Australia long before it became arid (Martin 2006). For example there are arid-adapted plant species from about 30 rainforest genera (Beadle 1981, cited in Martin 2006).

The vertebrates have evolved some remarkable adaptations to aridity. For example, most desert rodents (and many other vertebrates as well) do not need access to free water since they gain it metabolically from food, have highly concentrated urine and low water content in their faeces, and are active at night (Murray et al. 1998). Some species take advantage of rainfall and increased productivity by population irruptions. Even water-dependent species have adapted to aridity. The widespread fish, *Leiopotherapon unicolour*, has "an extraordinary proclivity to disperse, high fecundity, ability to breed in small ponds, extreme physiological tolerances" (Unmack 2001). There is one record of hundreds of young swimming 16 km in 6 hours along a wheel rut, sometimes with their back out of water (ibid, citing Shipway 1947).

While there is biodiversity richness in the arid zone, particularly in termites and lizards, there are relatively low rates of endemism. In plants, Crisp et al. (2001) suggest this is due to the extinction of most endemics during glacial maxima, particularly the last one. Much of the current plant biota is that which was able to repopulate the arid zone from refugia once the extreme harshness had abated. In the fauna, rates of endemism are limited by the great mobility of many species, one of the key strategies for persistence in the arid zone. Schodde (1982) estimated that about half of the land bird species of the Australian arid zone are widely mobile.

ECOLOGICAL PROCESSES

Soule and colleagues (2004) highlight the importance for conservation of understanding and accommodating large-scale and long-term ecological processes that sustain natural systems. They review seven categories of ecological phenomena that:

> require landscape permeability and that must be considered when planning for the maintenance of biological diversity and ecological resilience in Australia: (1) trophic relations at regional scales; (2) animal migration, dispersal, and other large scale movements of individuals and propagules; (3) fire and other forms of disturbance at regional scales; (4) climatic variability in space and time and human forced rapid climate change; (5) hydroecological relations and flows at all scales; (6) coastal zone fluxes of organisms, matter, and energy; and (7) spatially dependent evolutionary processes at all scales.

The conservation virtue of most of the arid zone in Australia is that landscape permeability—necessary for exchanges of energy, water and nutrients, and plant and animal interchange, between both contiguous and distant locations at diverse scales—is still to a large extent intact. However, despite the apparent naturalness of the environment, widespread extinctions of mammals are testament to the fact that there has been considerable compromise of some ecological processes, a point made many decades ago by biologist H.H. Finalyson (1936):

> The man in the street has heard so much of a vast and empty centre that the conception of an untrodden wilderness enduring for all time has taken root…Incredulity is often expressed that such occupation as obtains in many parts of the interior could have caused appreciable changes to the original conditions. It is not so much however, that species are exterminated by the introduction of stock, though this has happened often enough, but the complex equilibrium which governs long established floras and faunas is drastically disturbed or demolished altogether. Some forms are favoured at the expense of others; habitats are altered; distribution is modified, and must evidence of the history of the life of the country slips suddenly into obscurity.

We briefly consider aspects of six categories of ecological processes to demonstrate their relevance to designing conservation approaches for the arid focus areas.

FIRE IN ARID AUSTRALIA

Fire is a key ecological driver in arid Australia, and the alteration of fire regimes since the collapse of Aboriginal land management is one of the key threats.

The dominant vegetation in the arid zone, spinifex grasslands, covering >25% of the Australian landscape, is highly flammable (Allan & Southgate 2002). With loss of anthropogenic burning over much of the arid zone, the landscape now alternates "from large areas long unburnt to large areas recently burnt, usually following exceptional rainfall periods and lightning-caused ignitions (Burrows et al. 2006). Fires in spinifex now frequently exceed 10,000km^2 in extent. (Allan & Southgate 2002)

The mosaic fire patterns resulting from traditional Aboriginal burning were evident in aerial photographs of an area in the Western Desert taken in 1953, when Aboriginal people still lived there. In a study area of 240 000 ha, there was a mosaic of >800 fire scars, with 75% of the burnt patches <32 ha and the mean patch about 54 ha (Burrows et al. 2006). This contrasts with recent fire patterns mapped from satellite images, which reveals very large, contiguous recent fire scars. The number of burnt patches declined from 846 in 1953 to a low of 4 in 1981, with the mean patch area about 1000 times larger. In 1981, 87% of the area had been burnt within the past 5-6 years compared to 22% in 1953. Thus there was marked reduction in the diversity of states of post-fire succession within the landscape and a massive increase in fire scale.

As Saxon (1984, quoted in ibid) stated, "When large areas of a single landscape type are subjected to large uniform disturbances, they threaten the survival of wildlife species which depend on irregular boundaries of natural fire patterns to provide a fine grained mosaic of resources". It has been shown that the almost extinct mala for one was dependent on having access to a range of post-fire successional stages (Bolton & Latz 1978).

CRITICAL SPECIES INTERACTIONS

'Critical species' are those major ecological players, also known as 'keystone' or 'strongly interacting' species, which have a major impact on the habitat in which they live. Their decline or disappearance is often felt in the ecosystem at large, and may initiate ecological chain reactions or trophic cascades (Soule et al. 2004).

Some of the critical species in the deserts are:

- Termites—with their capacity to digest infertile plant biomass, they serve as the energy basis for much life in the desert, including a very high diversity of lizards.[21]
- Ants—as food for many species, and for seed dispersal (Davidson & Morton 1984).
- Dingos—as a predator, and for suppression of foxes and cats

GRAZING IN ARID AUSTRALIA

Pastoral development of arid Australia started in the 1870s. In a very short time, "the land and vegetative resource was devastated over a large percentage of the area by the combination of rabbit plagues, high stock numbers, severe economic depression and prolonged drought..." (Palmer 1990, speaking of western NSW). Also largely due to pastoral development, traditional Aboriginal occupation and management was rapidly displaced in many places.

The history of pastoralism has seen regular peaks and collapses in stock numbers due to climatic variation, and the industry has largely functioned, as Newsome et al. (1996) say, “as if it is always going to rain”. As a result, there has been considerable degradation, particularly during extended droughts.

There has been extensive pastoral development in the more fertile, mostly fringe areas of the arid zone, including the sinking of bores. This has significantly altered hydroecology in parts of the arid zone, with the proliferation of permanent waterpoints in country previously waterless or intermittently watered. It has benefited some species, for example birds like galahs that need to drink. But by facilitating grazing and changing predator dynamics, the proliferation of waterpoints is a key threat for many other arid species (James et al. 1999, Landsberg et al. 1997). Droughts now mean food shortages rather than water shortages for stock, which means that stock is maintained for longer periods on properties during droughts. On average, in assessed chenopod and acacia shrublands, 15-38% of species, known as decreasers, are disadvantaged by artificial water-points, while 10-33%, known as increasers, are advantaged (Landsberg et al. 1997).

Grazing has disproportionately damaged small but important resource-rich patches, such as riverine flood plains (Griffin & Friedel 1996). It has caused vegetation changes, reducing palatable perennial grasses and increasing unpalatable ephemerals and shrubs (in association with lack of fire) (ibid). Pastoralism has also brought with it many weeds and pests. Of particular concern is the effect of the introduced exotic pasture, buffel grass, which has naturalised over extensive areas. It competes with native plants, changes the availability of water and nutrients, increases grazing pressure, and alters the fire regime, causing more destructive fires and facilitating encroachment of fire into refugial areas, such as vine thickets (Friedel et al. 2006). Buffel grass is implicated in the declines of threatened species, including the endangered slater’s skink and desert sand skipper in central Australia.

[21] Termites are so abundant in some places, particularly spinifex grasslands and mulga shrublands, that their mass can equal that of all vertebrates (Dawson & Dawson 2005, citing Watson et al.).

LONG DISTANCE BIOLOGICAL MOVEMENT

It is important to conserve the capacity in deserts for large-scale biological movements. Because of extreme variability in productivity, a large proportion of species must migrate or disperse during part of their life-cycle or in response to unpredictable climatic events. The conservation of such species requires protection of landscape patches to support mobility and refugia that provide resources for mobile species during times of stress (Morton et al. 1995). The maintenance of productive and refugial areas at different scales is obviously important for sustaining species with different degrees of mobility.

Some of the long distance biological movements that occur in the deserts are those by:

- Waterbirds—eg. some travel thousands of kilometres from the coast to breed in inland lakes after floods.
- Birds—tracking nectar, fruit & insect foods. Eg. in an arid region in western Australia, the number of bird species varied from 10 in a drought year to more than 90 in a wet year (Dawson & Dawson 2006).
- Mammals—eg. red kangaroos, seeking productive patches after rain. Even small mammals may move relatively large distances— eg. lesser hairy-footed dunnarts move >10km to reap the benefits of a recent rainfall event (Dickman et al. 1995).

DISTURBANCE

Disturbance is natural and inevitable, and important for maintaining species diversity in tropical savannas. However, anthropogenic disturbance is often damaging because it "exceeds the historic range of variability and intensity of natural disturbance regimes" (Soule et al. 2004). For example, in arid Australia, there have been extensive changes in fire regimes (see Fire box).

CLIMATE

Rainfall variability and unpredictability in arid Australia dominates its ecology, resulting in great variability in abundance and distribution of biota and life history strategies (Stafford Smith and Morton 1990, Newsome et al. 1996). The Southern Osciallion El Niño /La Niña cycles are the key driver of oscillations between 'droughts and flooding rains', and they over-ride seasonal influences. The variability between years is exemplified by 113 years of rainfall records at Alice Springs, which showed that several events of at least 50 mm rainfall may occur in a year, but many years pass without any such events (Stafford Smith & Morton 1990). The resulting variability in productivity was demonstrated in a 12-year study in western NSW, when ground cover varied through an El Nino/La Nina rainfall cycle from 9% to 77% (Dawson & Ellis 1994, cited in Dawson & Dawson 2006).

Global warming will exert considerable pressure on all biomes, and many species are likely to go extinct, particularly when climate change is combined with other anthropogenic pressures, such as those caused by invasive species, fire and grazing, and due to the loss or degradation of climate refugia. Thus far, warming has manifested mostly strong in parts of the arid zone, with documented increases in temperature of 0.1^{o}C to 0.2^{o}C per decade. Some of the potential detrimental impacts of human-induced climate change in deserts include:

- Range contractions for some native species
- Range expansions for some invasive species and diseases
- Altered fire regimes
- Extended time between big rainfall events, threatening wildlife dependent on temporary wetlands

HYDROECOLOGY

Hydroecology refers to the links between water, vegetation and wildlife, including water flows below and above the ground. Arid floodplains do not receive regular flood pulses and are considered to be amongst the most hydrologically variable in the world (Capon 2005, citing Puckridge et al. 1998, 2000).

Due to the variability of rain in the arid zone, there are many thousands of ephemeral wetlands, ranging in size from a few square metres to thousands of square kilometres. An 11-year study of surface water across the driest 70% of Australia found that the total wetland area varied by an order of magnitude from <315 000 ha to 3305 000 ha (Roshier et al. 2001). Wetlands are key habitats for wildlife in deserts. More than 8 million water birds were estimated to use arid zone wetlands in 1995, a dry year (ibid, citing Kingsford & Halse 1998). Even small changes in rainfall patterns (eg. due to climate change) would have dramatic effects. For example, a relatively small 10% increase in annual rainfall would transform Lake Eyre into a permanent water body (ibid, citing Kotwicki & Allan 1998). If intervals between floods increase, the banded stilt, which breeds on large temporary inland wetlands, will breed less frequently, and not at all if the gap exceeds reproductive lifespan. As it is, breeding is infrequent for this stilt, with just 14 major breeding events recorded from 1900 to 1995.

While rain-sourced surface water is variable, that provided by groundwater is reliable, and many refugial sites are so because of permanent springs and seeps. Such sites also allowed permanent human settlement in central Australia even during the hyper-arid previous glacial period (Jacobson 1994, citing Smith 1989). Palm Valley in the MacDonnell Ranges is one such place, supporting relictual rainforest vegetation, perhaps since the mid-Pleistocene (Wischusen et al. 2004). The released water is tens to hundreds of thousands of years old, and significant recharge of the groundwater system may not have occurred for 50,000 years, since a previous wetter interglacial period (ibid).

SPATIALLY DEPENDENT EVOLUTIONARY PROCESSES

Effective conservation must protect landscapes to allow for long term changes in the range of species, and the movement of genes across land and seascapes. With climate fluctuations “no one place can be considered permanently occupiable by some plant and animal species” and typical representational targets for reservation do not guarantee security for much of the arid zone wildlife (Morton 1990).

In deserts maintaining permeability requires protecting, for example:

- Habitat heterogeneity at different scales
- Integrity of watercourses—to maintain flows to inland lakes such as Lake Eyre requires protecting rivers thousands of kilometers away.
- Fire and climate refugia—eg. in moist gorges.

VERTEBRATE EXTINCTIONS AND DECLINES

Sadly, one of the most globally significant features of the Australian arid zone is that it has one of the worst anthropogenic extinction records. Of 71 mammal species, 11 were rendered extinct and 20 in severe decline (now confined to islands or more temperate parts of their range) since European colonisation (Burbidge & Mckenzie 1989, Morton 1990, Southgate et al. 2007).

Based on survey records and a compilation of Aboriginal information in Burbidge et al. (1988), it is thought that most extinctions in the central and western deserts occurred during the late 1940s to early 1960s. The most recent occurred less than 20 years ago, with the loss of mala from central Australia. Extinctions are not only recent history, but look set to continue, with declines in abundance and reduced range of several other species (Woinarski et al. 2000). Furthermore, the wave of extinctions has advanced north into the wetter tropical savannas, as noted elsewhere.

Various theories have been proposed to explain the losses, and it is likely that the explanation lies in a convergence, or species-specific subsets, of pressures brought with European colonisation. Likely factors include destruction or domination by rabbits and cattle of the most productive patches of habitat, which would have been critical refugia particularly during drought (Morton 1990); predation by foxes and cats, in particular where predator abundance was elevated due to rabbits and mice, or where habitats were modified by grazing or frequent burning (Smith & Quin 1996); and changed fire regimes (Bolton & Latz 1978; Burbidge et al. 1988). All of the extinct mammals were medium-sized, in a weight range from 35–5500 g (Burbidge & Mckenzie 1989). The losses were concentrated in this weight range probably because larger species could move further to access refugia and smaller species occurred more abundantly across the landscape (Morton 1990).

There is concern also that birds may eventually go the way of mammals with a time lag on extinctions that is running out (eg. Recher & Lim 1990), although this scenario is contested (eg. Garnet 1999). Reid and Fleming (1992) found significant changes in the arid bird fauna since European colonisation, with the status of about half of the 230 species in the arid zone having changed. In sum, they found that 19 species (8%) were recognised nationally as threatened, 12 species (5%) have declined and/or are at risk in two or more of the 14 regions they considered, and 40 species (17%) had declined in at least one region. In contrast, about 20% of species had increased in range or abundance. They concluded that the most important factor in the declines was vegetation change due to livestock and rabbits; but altered fire regimes and feral predators were also implicated in some.

There are also some reptile fauna in decline and there may be more extensive declines than recorded, judging by the responses of some reptiles to land management changes (Woinarski et al. 2000). Some litter-dwelling lizards are disadvantaged by frequent fire and/or grazing; some relatively large sedentary lizards may be vulnerable to feral predators and/or may not disperse well to new areas when their local habitat is degraded; and some relatively large snakes may be affected by feral predators, changed fire regimes, clearing, loss of normal prey species, or removal of cover.

GREAT SANDY-TANAMI DESERTS

GENERAL DESCRIPTION

The Great Sandy-Tanami Desert focus area covers a vast area of 824 000 km^2, across the centre of the Northern Territory and almost to the Western Australia coast. The focus area encompasses four IBRA bioregions: Tanami (TAN), Davenport Murchison Rangers (DMR), Great Sandy Desert (GSD) and Little Sandy Desert (LSD). It is equivalent to the ecoregion of the same name delineated by WWF (Hopkins 2001c).

FIGURE GST.1: LOCATION OF GREAT SANDY-TANAMI DESERTS

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[22]

The major landforms are red Quarternary sand plains and sand dunes. The vast flatness is broken by hills and low ranges, mostly rising no more than 400 m, but peaking at about 900 m. There are ancient Cambrian and Precambrian rocks in these ranges. The area also has large saline lakes and playas. Soils are predominantly shallow sands and nutrient-poor massive earths.

The vegetation is predominantly hummock grassland (about 85%), with some eucalypt woodlands, acacia shrublands and mallee woodlands (see Table GST.1). Around the lakes are samphire shrublands and mulga shrublands.

GST.1 DOMINANT VEGETATION GROUPS (KM^2)

Bioregion	Hummock grassland	Eucalypt open woodland	Acacia shrubland	Mallee	Mangrove group
DMR	5,004	38,115	1,866	11,106	5
GSD	363,823	3,490	9,018	359	9,998
LSD	100,305	-	867	-	2,235
TAN	231,499	13,389	5,605	1,560	685
Total	**699,631**	**54,984**	**17,356**	**13,025**	**12,941**

Source: NLWRA (2001)

The climate is semi-arid to arid, with some monsoonal influence in the north. Rainfall averages 300-500 mm, but is highly erratic, with most years receiving less than the average. Summers are hot, with mean maxima of about 40°C, and winters are cold, falling below freezing at times.

[22] Sources: NLWRA (2002) database; Baker et al. (2005)

LAND USES, PEOPLE & INSTITUTIONS[23]

The dominant land uses are traditional Aboriginal use and pastoralism. In the NT, about three-quarters is Aboriginal-owned and one-quarter is pastoral leases (see Figure GST.2). In WA, the majority is unallocated crown land. Mining and conservation are minor land uses. A considerable part of the area is uninhabited.

FIGURE GST.2: LAND TENURE

The population is very small, with only about 10 000 people, mostly in Tennant Creek, and bioregional population densities range from .01-.07/km^2. The majority of the population is Aboriginal.

There are at least 15 major Indigenous language groups in the focus area. The Warlpiri people inhabit a large area centred on the Tanami Desert. Much of their country was considered too poor for pastoralism and was unalienated Crown land until handed back as freehold under the Aboriginal Land Rights (NT) Act 1976. Likewise, title over country has been recognised for the Pitjantatjara and Yankuntjatjara around Uluru, and the Karajarri People and Tjurabalan People in the Great Sandy Desert and Tanami Desert. A large proportion of the remaining crown land is also under native title claim.

Aboriginal people in the focus area are represented by the Central Land Council (in NT) and the Ngaanyatjarra Council, Kimberley and Council and Yamatji Barna Baba Maaja (in WA).

TABLE GST.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE AND RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best)
DMR 1/2/3	5/5/5	0	3/3/3
GSD 1/2/3/ 4/5/6	5/5/5 5/5/5	0	3/2/3 3/3/3
LSD 1/2	6/6	0	2/2
TAN 1/2/3	5/5/5	0	3/3/3

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

[23] Sources:Baker et al. (2005), Rose (1995), McKenzie et al. (2002), NNTT (2006)

CONSERVATION VALUES

Having escaped the intense development pressure of southern and coastal Australia, this focus area has a largely natural landscape with ecological processes functioning at the landscape scale. However, there has been significant loss of biodiversity values with many extinctions in the mammal fauna.

LANDSCAPE CONDITION

FIGURE GST.3: VEGETATION CONDITION (VAST)

Source: Thackway & Lesslie (2005)

FIGURE GST.4: RIVER CONDITION

Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE GST.5: WILDERNESS QUALITY (NWI)

Source: Lesslie & Masslen (1995)

In the assessment of landscape health by Morgan (2001), all subregions were classified in the second lowest stress category, except those in the Little Sandy Desert, rated in the lowest stress class (see Table GST.2). Note that fire was not considered in this health assessment. However, McKenzie et al. (2002) considered that the condition of the Great Sandy Desert is unknown and the trend declining, and also questioned the high rating accorded to the Little Sandy Desert.

Almost no vegetation has been cleared in the focus area. Furthermore, vegetation condition (again without reference to fire) is classed almost wholly as 'high quality' (see Figure GST.3).

The few rivers in the focus area have a high level of natural integrity (see Figure GST.4). Nationally important wetlands are in fair to good condition (NLWRA 2002). The average subregional condition of riparian zones is considered 'fair (recovery requires significant intervention)', except in Little Sandy Desert, where it is considered good (see Table GST.2). However, in all subregions, the trend is considered to be declining (NLWRA 2002 database).

Finally, in the National Wilderness Inventory, most of the focus area was assessed as having high wilderness quality (see Figure GST.5).

BIODIVERSITY VALUES

Along with the rest of inland Australia, the focus area has had a climatically turbulent recent history, with cycles of extreme aridity during ice ages, the most recent only 10-18,000 years BP, which would have wiped out much of the biota. Much of the present vegetation would have expanded out of refugia once the extreme harshness abated (Crisp et al. 2001). Thus, the present ecosystems are relatively young.

Ten regional ecosystems in the Great Sandy Desert and Little Sandy Desert are considered threatened (NLWRA 2002 database). They include riparian zones, wetlands, water pools, springs, and salt lakes affected by grazing by cattle, donkeys and camels. In particular, the mound spring community of Dragon Tree Soak (GSD) is considered endangered due to camel damage (Graham 2001a). In addition, widespread vegetation types have been affected by fire, and samphire communities are considered threatened in the GSD.

As with most Australian arid areas, there is a rich lizard fauna in the focus area, particularly with skinks. At least one gecko and two skinks are probably endemic to the Great Sandy Desert (Morton et al. 1995).

The mammal fauna *was* quite diverse, but has been substantially whittled by extinctions, with almost total loss of medium weight species, and many others threatened. For example, around Uluru, the remains of owl meals in caves show there used to be at least 46 species of native mammals (comprising 34 terrestrial species and 12 microbats). This has shrunk by about half to 15 terrestrial mammals and at least 7 bats (Baynes & Baird 1992). As shown in Table GST.3, 30-40% of the original mammal fauna is regionally extinct (at least 23 mammal species from one or more bioregions), and 10 species are listed as threatened.

It is considered highly likely that there are endemic troglobitic faunas associated with cave systems along palaeodrainage lines in the Great Sandy Desert (McKenzie et al. 2002).

TABLE GST.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	3 GSD 3 TAN 5 DMR	2 1 vulnerable	
Birds		8 1 endangered 5 vulnerable	Threatened species include 2 parrots, 1 bustard, 1 emu, 1 snipe, 1 goshawk, 1 owl, 1 thornbill. The bird fauna is typical of this climatic zone, & fluctuates with rainfall. Diversity declines have been recorded in DMR for unknown reasons.
Reptiles	3 GSD	3 1 endangered 2 vulnerable	Threatened species include 2 skinks, 1 python. Endemics include 2 skinks, 1 gecko
Mammals		10 3 endangered 4 vulnerable	Threatened species include 1 bandicoot, 3 dasyurids, 1mouse, 2 marsupial moles, 1 possum, 1 bat Is Sandhill Dunnart endemic to GSD?
Invertebrates	Several likely	- -	Endemic troglobites are considered likely in GSD.
Regionally extinct species	Golden bandicoot (*Isoodon auratus*) from TAN, DMR, LSD Western quoll (*Dasyurus geoffroii*) from all Northern quoll (*D. hallucatus)* from TAN Red-tailed phascogale (*Phascogale calura*) from all Desert bandicoot (*Perameles eremiana*) from TAN, GSD, LSD Pig-footed bandicoot (*Chaoropus ecaudatus*) from all Lesser bilby (*Macrotis leucura*) from TAN, GSD, LSD Bilby (*Macrotis lagotis*) from DMR Woylie (*Bettongia penicillata*) from all Burrowing bettong (*Bettongia lesueur*) from all Mala (*Lagorchestes hirsutus*) from all Central hare-wallaby (*Lagorchestes asomatus*) from TAN, GSD, LSD Spectacled hare-wallaby (*Lagorchestres conspicillatus*) from GSD Crescent nailtail wallaby (*Onychogalea lunata*) from all		Lesser stick-nest rat (*Leporillus apicalis*) from GSD, LSD Long-tailed hopping mouse (*Notonys longicaudatus*) from GSD Short-tailed hopping mouse (*Notomys amplus*) from TAN, GSD Dusky hopping house (*Notomys fuscus*) from DMR Central rock-rat (*Zyzomis penunculatus*) from TAN, DMR, GSD Pale field-rat (*Rattus tunneyii*) from DMR Shark Bay mouse (*Psuedomys fieldi*) from GSD Brush-tailed possum (*Trichosurus vulpecular*) from DMR, GSD Numbat (*Myrmecobius fasciatus*) from GSD, Ghost bat (*Macroderma gigas*) from GSD, LSD Malleefowl (*Leipoa ocellate*) from GSD Thick-billed grasswren (*Amytormis textiles*) from GSD
Richness & endemism statistics	DMR: 842 plants / 341 vertebrates / 167 birds / 1 bioregion endemic / 34 NT endemics GSD: 1000 plants (NT) / 357 vertebrates (NT) / 32 mammals (WA) / 92 reptiles (WA) / 12 frogs (WA) / 215 birds / 16 bioregion endemics (NT) / 37 NT endemics / 15 WA endemics TAN: 1029 plants (NT) / 382 vertebrates (NT) / 14 mammals (WA) / 57 reptiles (WA) / 11 frogs (WA) / 207 birds / 19 bioregion endemics (NT) / 42 NT endemics / 3 WA endemics LSD: 30 mammals / 97 reptiles / 9 frogs / 146 birds / 23 WA endemics		

Sources: NLWRA (2002) database, Baker et al. (2005), Woinarski et al. (2000), Morton et al. (1995), How & Cowan (2006), Birds Australia (2002) database, Menkhorst & Knight (2001).
Note: In some cases the former presence of a species in the focus area may be speculative.

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Evolutionary refugia include the Davenport and Murchison Ranges, a 'highly significant' refuge with an extensive network of waterholes containing a rich arid zone fish fauna, high plant diversity, and some endemic and probably relict plant species (Morton et al. 2005). Dragon Tree Soak (a 'significant' refuge in GSD) is believed to contain relict riverine vegetation from the early to mid Holocene.

Ecological refugia include Lake Surprise (TAN), a 'significant' refuge containing the only surface water available in a vast area; and the Tanami drainage system, a 'highly significant' refuge for several rare species (ibid). Lake Amadeus, the Karinga Creek system and Dragon Tree Soak (GSD) are 'significant' refuges as they provide dependable moisture to plants through groundwater seepage and springs. Lake Gregory (TAN) is a 'significant' major drought or non-breeding refuge for waterbirds and a major migration stopover area for shorebirds at times. Rudall River and Lake Dora contain permanent pools and soaks. Uluru (Ayers Rock) and Kata Tjuta (The Olgas) (GSD) are not only national icons, but 'extremely significant' ecological refuges with relatively moist habitat for rare, relict and unusual species (ibid).

Human-induced refugia would include refuges from wildfire and pests, perhaps in relatively inaccessible sites in the most rugged parts of the ranges. The Tanami drainage system is considered one such 'highly significant' refuge, due to the relative absence of exotic competitors and predators (ibid). It would also include areas remote from artificial water points that facilitate grazing and predation.

Significant wetlands: There are eight wetlands in the focus area listed in the Australian Directory of Important Wetlands. Feral animals, in particular camels, are a significant threat to at least six of these wetlands (NLWRA 2002 database). Other threats include cattle, rabbits and tourism.

Other significant features include Uluru, a large, red sandstone dome that rises 350 m above the surrounding plain. It is the summit of a buried sandstone hill, formed by the erosion and sedimentation of ancient mountain ranges. It is highly significant in Aborigine mythology, and one of the most significant Australian tourist destinations.

Another feature is the mangroves along the Mandora Marsh area, 60 km inland and cut off from the coast—they are the most inland distribution of mangroves in Australia (Graham 2001a).

ECOLOGICAL PROCESSES

Key ecological processes for the arid zone have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches (such as riparian habitats) or refugia have been degraded by grazing or fire.

Hydroecology: Compromised where there is a relatively high density of artificial waterpoints for cattle.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

The major threats in this focus area are grazing; feral animals (foxes, cats, camels, donkeys, rabbits, wild cattle); changed fire regimes (with extensive wildfires now the norm); and weeds (see Table GST.4).

TABLE GST.4 MAJOR THREATS

Threats	Impacts	Comments
Altered fire regimes	Change from Aboriginal mosaic burning to attempted exclusion (on pastoral properties) and extensive wildfires. • Destruction of fire-sensitive vegetation eg. decline of mulga woodlands • Declines in some fauna, eg. granivorous birds & mammals • Increased homogeneity of burning history, with reduced patchiness & thus reduced habitat & resources for some fauna	Traditional Aboriginal burning is thought to have caused a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. Now, with the large-scale loss of traditional management, the regime is much more extensive & destructive, with large-scale wildfires.
Feral animals	• Predation pressure on mammals, birds, lizards by cats & foxes; implicated in extinction of mammals • Predation pressure increased due to build-up, then decline, of rabbit as prey (Smith & Quin) • Degradation of water points & vegetation by camels, rabbits, camels, donkeys, horses, cattle	Ferals include camels, cats, foxes, cattle, rabbits, horses, donkeys. Rabbit populations have been reduced by calicivirus. Camels are a particular problem around wetlands, & populations have increased significantly. Cats & foxes are ubiquitous.
Weeds	• Competition, increased fire destruction due to buffel grass • Displacement of native vegetation.	Weeds include buffel grass, couch grass, mesquite, olive hymenachne, paddy's lucerne, parkinsonia, ruby dock, Mexican poppy, bellyache bush.
Grazing	• Degradation of fertile areas, such as riparian & wetland habitats • Changes in vegetation, eg. loss of palatable perennials. • Introduction & spread of weeds, particularly buffel grass, & fire exclusion	Chenopod shrublands in GSD have been particularly affected by grazing (Woinarski et al. 2000)
Other	Localised degradation by tourism & mining	Graham (2001) notes the possibility of a large irrigated agriculture industry, which has been proposed for La Grange, & the need to gain a better understanding of impacts on groundwater resources & wetlands

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

The reserve system is highly inadequate with just over 2% of the focus area in the National Reserve System (see Table GST.5). Management of reserves is also inadequate. For example, Graham (2001a) notes for GSD reserves in WA there is no pest control or fire management, there is uncontrolled stock access and the extent of other threats has not been determined. All bioregions are in the second highest category of NRS priority for further reservation.

However, there are some very significant Indigenous Protected Areas in the focus area: just declared is the 4 million ha Northern Tanami IPA (IUCN VI), which supports >30 threatened plant species. The 270,000 ha Paruku (Lake Gregory) IPA protects a very important inland wetland which has the largest Australian breeding colony of little black cormorants and is a major stopover for migrating shorebirds. Furthermore, another vast area in the southern Tanami, covering about 8 million ha, is under development as an IPA.

TABLE GST.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Bioregion	Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehensiveness I-IV (%)	Comprehensiveness V-VI (%)	Manag't Standard	NRS priority
DMR	113,997 (2%)	1,816 (<1%)	11	?	Fair	2
GSD	1,005,582 (3%)	0	17	0	Poor	2
LSD	558,448 (5%)	0	22	0	Poor	2
TAN	0	239,417 (1%)	0	4	Fair	2
focus area	1,678,027 (2%)	241,233 (<1%)	--	--	--	

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

TABLE GST.6: PLANS, POLICIES & PROGRAMS

Plan/policy/program
CALM Regional Management Plan - addresses land & wildlife conservation issues, but is not specific for this area
Protected areas: Plans of Management for Uluru and Kata Tjuta NPs
NRM: Centre Land Watch, by Centralian Land Management Association - a pastoralists' natural resource monitoring program
Water: La Grange groundwater management committee established (in response to irrigation proposal)

There are very few conservation-focused plans, policies or programs in this focus area (see Table GST.6).

CONSERVATION CAPACITY

Indigenous Conservation: In the Tanami, there is one Aboriginal Landcare group. We know of no other formal land management groups.

Advocacy conservation groups: We know of no consistent activity in the Great Sandy or Tanami Deserts by advocacy conservation groups.

Private land conservation groups: Birds Australia bought Newhaven, a former pastoral property in the south-eastern part of the Great Sandy Desert in the Northern Territory. It is now owned and managed by the Australian Wildlife Conservancy.

Other institutional capacity: There is very little capacity within existing natural resource management processes for conservation due to the low population and limited resources. There is a recently established Desert Knowledge Cooperative Research Centre, with research projects focused on sustainable livelihoods and business opportunities; viable desert settlements, and economic flows and institutions (McAllister & Stafford Smith 2006).

ADEQUACY OF INFORMATION

Particularly in the Great Sandy Desert and Little Sandy Desert, there is very little known about biodiversity and current threats (McKenzie et al. 2002).

CENTRAL RANGES

GENERAL DESCRIPTION

The Central Ranges focus area covers 214 000 km^2, mostly in the Northern Territory, but also in South Australia and Western Australia. The focus area encompasses three IBRA bioregions: Central Ranges (CR), Finke (FIN) and MacDonnell Ranges (MAC). It is equivalent to the ecoregion of the same name delineated by WWF (2001), except for the exclusion of the Burt Plain bioregion (see Selection of Focus Areas section for explanation).

FIGURE CR.1: LOCATION OF CENTRAL RANGES

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[24]

There is a variety of landforms of diverse geology in this focus area. There are vast flat to undulating sandplains and sand dunes, broken by low sandstone ranges, with weathered tablelands, and the higher MacDonnell Ranges with the highest peak at over 1500m. Soils are mainly shallow sands, massive earths and loams on the lowlands. On the ranges are mainly skeletal or shallow sands. While the sand dunes and sandplains are geologically young, the ranges are ancient of pre-Cambrian—some more than 2000 million years old—and Proterozoic origins. Most of the rivers only flow for short periods after rain, and disappear into desert sands.

TABLE CR.1 DOMINANT VEGETATION GROUPS (KM^2)

Bioregion	Hummock grassland	Acacia shrubland	Acacia forest & woodland	Chenopod	Tussock grassland
CR	43,642	26,891	19,699	6,415	1,825
FIN	32,865	17,280	303	11,985	5,629
MAC	19,000	15,432	-	450	35
Total	**95,507**	**59,603**	**20,002**	**18,850**	**7,489**

Source: NLWRA (2001)

Vegetation types are predominantly hummock grasslands, shrublands and low open woodlands (see Table CR.1). There are taller woodlands along watercourses. Shrublands are predominantly of acacias and also of saltbush/bluebush; and woodlands are of desert oak, mulga or Callitris pine; along watercourses are river red gums.

The climate is arid with annual rainfall averaging 200-300mm, mostly due to a weak monsoonal influence. However, rainfall is highly erratic, with a few high rainfall events often delivering most of the rain, and most years falling well below the average. Summers are hot, with temperatures sometimes exceeding 50°C, and winters are cold, sometimes with frosts.

[24] Sources: NLWRA (2002) database; Baker et al. (2005); Latz (1995)

LAND USES, PEOPLE & INSTITUTIONS[25]

The dominant land uses are pastoralism and traditional Aboriginal uses. About one-third of the area is pastoral leases, and two-thirds is Aboriginal freehold (see Figure CR.2). Conservation is a minor land use, as are mining (although large areas are licensed for mineral exploration) and tourism.

FIGURE CR.2: LAND TENURE

The majority of the population of about 35,000 lives in Alice Springs. Elsewhere, the population is very sparse, with a density of .01-.03 people/km^2.

There are at least half a dozen major Aboriginal language groups in the focus area. With the establishment of pastoralism in Central Australia in the late 1800s, Aboriginal people in many areas were deprived of the capacity to manage their traditional lands. Aboriginal stockmen and station workers provided most of the labour for pastoralism. Most of the land that remained under Aboriginal control was that which was too unproductive for pastoralism. Increasingly, however, Aboriginal people have regained ownership of pastoral leases, some of which are still managed as such. Arrente and Mbantuarinya People hold title and recognised rights in the Alice Springs region. Title has been won over Ngaanyatjarra Lands in the Central Ranges. Other areas are under claim.

In the Northern Territory, Aboriginal people in the focus area are represented by the Central Land Council; in South Australia by the Aboriginal Legal Rights Movement Inc. and in Western Australia by the Ngaanyatjarra Council Aboriginal Corporation.

CONSERVATION VALUES

Having escaped the intense development pressure of southern and coastal Australia, this focus area has a largely natural landscape with ecological processes functioning at the landscape scale. However, there has been significant loss of biodiversity values with many extinctions in the mammal fauna.

[25] Sources: Baker et al. (2005), Graham & Cowan (2001), Rose (1995)

LANDSCAPE CONDITION

In the assessment of landscape health by Morgan (2001), the Central Ranges focus area rated moderately well, with an average rating of 5 (out of 6, see Table CR.2). However, the Everard Block subregion (CR2) is rated only 3. Note that the assessment did not include the effects of fire, one of the threats in the focus area.

Minimal vegetation has been cleared. Vegetation condition (again without reference to fire), however, is variable, with a substantial proportion rated as 'modified' or 'transformed', primarily due to grazing pressures (see Figure CR.3).

Rivers are mostly in good condition with high natural integrity (see Figure CR.4). The average subregional condition of riparian zones is considered good or unknown, except in the Finke P1 subregion, where riparian condition is considered 'fair (recovery requires significant intervention)' (see Table CR.2). However, the trend is declining or unknown (NLWRA 2002 database).

Finally, in the National Wilderness Inventory, much of the focus area was assessed as having high wilderness quality, although it has been significantly compromised in the Finke and MacDonnell Ranges bioregions (see Figure CR.5). The more recent Wilderness Delineation shows a similar pattern.

TABLE CR.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE AND RIPARIAN CONDITION

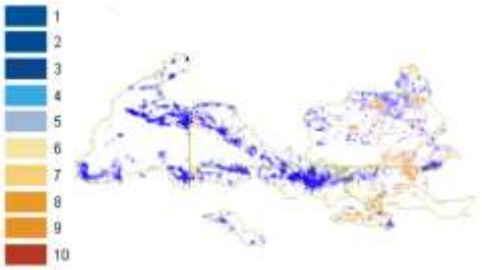
Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best, 5 unknown)
CR 1/2/3	6/5/3	0	3/5/5
FIN 1/2/3/4	5/5/5/5	0	2/3/3/5
MAC 1/2/3	5/5/4	1	3/3/3

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

FIGURE CR.3: VEGETATION CONDITION (VAST)

Source: Thackway & Lesslie (2005)

FIGURE CR.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE CR.5: WILDERNESS QUALITY (NWI)

High quality wilderness

Source: Lesslie & Masslen (1995)

BIODIVERSITY VALUES

The focus area is a centre of plant richness, but has lost a significant proportion of its mammal fauna.

Along with the rest of inland Australia, the focus area has had a climatically turbulent recent history, with cycles of extreme aridity during ice ages, the most recent only 10-18,000 years BP, during which much of the biota retreated to refugia. Thus, the present ecosystems are relatively young.

There are just five threatened regional ecosystems in the focus area, all in the CR bioregion, all acacia and/or hakea woodlands (NLWRA 2002 database). They are threatened mostly by a combination of fire and rabbit/cattle grazing.

The focus area is rich in plant diversity, and is recognised as one of eight such centres in Australia by Crisp and colleagues (2001). This diversity is focused in the ranges, particularly the MacDonnell Ranges. About 700 plant species have been recorded in the West MacDonnell National Park alone (Sattler & Glanznig 2006). In contrast to richness, plant endemicity is relatively low—about 30 species.[26] Crisp et al. (2001) postulate this is due to "selective extinctions" of narrowly endemic species during the Pleistocene glaciation periods. They note that all the present-day centres of endemism are near-coastal, due to the widespread aridity of glacial maxima like that at 18,000 BP, when much of Australia was a cold desert. Many of the endemics, adapted to specific sites in the Central Ranges, "would have had nowhere to go". They note that it is not aridity *per se* that mitigates against endemicity, but the instability of recent climatic history.

There is also a high diversity of reptiles in the focus area. In the West MacDonnell National Park alone, more than 80 species have been recorded (Sattler & Glanznig 2006). There are two endemic reptiles recorded in the focus area.

The mammal fauna *was* diverse, but has been substantially whittled by extinctions, with almost total loss of medium weight species, and many others threatened. As shown in Table CR.3, 23 mammal species have disappeared from one or more of the bioregions in this focus area, and 9 are listed as threatened.

Fish diversity is low in the arid zone, but compared to other arid rivers, the Finke River system has high diversity with 9 species (Unmack 2001).

There is little known about invertebrates, but there has been a remarkable radiation of Camaenid land-snails, with about 70 species, mostly with restricted ranges (Morton et al. 1995, Scott 1997). The Finke Gorge National Park contains at least 25 snail species. Many snails are now threatened.

[26] However, taking a broader regional perspective, covering a larger area known as the Central Mountain Ranges area, there is a far higher rate of endemism. Latz & Pitts (1995) note that of the 1300 plant species occurring there, 120 (9.2%) are endemic. More than 60% of the endemics occur in highlands and mountains. About 60 plant species are considered relictual.

TABLE CR.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	3 FIN 27 MAC	15 9 vulnerable	All but one of the threatened species is in the MacDonnell Ranges, as are most of the endemics.
Birds		4 2 vulnerable	Threatened species include 1 parrot, 1 snipe, 1 bustard, 1 emu. Bird diversity is typical of semi-arid areas. There is an apparent decline in ground-nesting birds & ground-feeding insectivores in CR. Some species have been lost from FIN.
Reptiles	2 MAC	2 1 endangered 1 vulnerable	Threatened taxa are 2 skinks. The endemics are a skink & a blind snake.
Mammals		9 2 endangered 2 vulnerable	Threatened species include 2 rodents, 4 dasyruids, 1 macropod, 1 possum
Fish		1 -	Threatened species is a goby
Amphibians	1 MAC	- -	Endemic is a tree frog.
Invertebrates	>22	21 -	All but one of threatened invertebrates (a sand skipper) are snails, in MAC
Regionally extinct species	Golden bandicoot (*Isoodon auratus*) from all Western quoll (*Dasyurus geoffroii*) from all Red-tailed phascogale (*Phascogale calura*) from all Desert bandicoot (*Perameles eremiana*) from CR Pig-footed bandicoot (*Chaoropus ecaudatus*) from all Lesser bilby (*Macrotis leucura*) from all Bilby (*Macrotis lagotis*) from all Brush-tailed bettong (*Bettongia penicillata*) from all Burrowing bettong (*Bettongia lesueur*) from all Mala (*Lagorchestes hirsutus*) from all Central hare-wallaby (*Lagorchestes asomatus*) from CR Spectacled hare-wallaby (*Lagorchestres conspicillatus*) from MAC, FIN Crescent nailtail wallaby (*Onychogalea lunata*) from all Lesser stick-nest rat (*Leporillus apicalis*) from all Long-tailed hopping mouse (*Notonys longicaudatus*) from MAC, FIN		Short-tailed hopping mouse (*N. amplus*) from all Dusky hopping house (*Notomys fuscus*) from FIN Djoongari (*Pseudomys fieldi*) from CR Central rock-rat (*Zyzomis penunculatus*) from FIN Pale field-rat (*Rattus tunneyii*) from MAC, FIN Shark Bay mouse (*Psuedomys fieldi*) from MAC, FIN Brush-tailed possum (*Trichosurus vulpecular*) from FIN Numbat (*Myrmecobius fasciatus*) from CR Ghost bat (*Macroderma gigas*) from all Slender-billed thornbill (*Acanthiza iredelai iredelai*) from FIN Malleefowl (*Leipoa ocellate*) from all Night parrot (*Pezoporus occodentalis*) from MAC, FIN Thick-billed grasswren (*Amytormis textiles*) from MAC, FIN Grey currawong (*Strepera versicolor*) from CR Great desert skink (*Ergenia kintorel*) from MAC, FIN
Richness & endemism statistics	CR: 581 plants (NT) / 220 vertebrates (NT) / 16 mammals (WA) / 64 reptiles (WA) / 5 frogs (WA) / 151 birds / 16 bioregion endemics (NT) / 20 NT endemics /4 WA endemics FIN: 856 plants / 373 vertebrates / 197 birds / 25 bioregion endemics (NT) / 30 NT endemics MAC: 1130 plants / 430 vertebrates / 215 birds / 83 NT endemics / 71 bioregion endemics		

Sources: NLWRA (2002) database, Baker et al. (2005), Morton et al. (1995), How & Cowan (2006), Birds Australia (2002) database, Menkhorst & Knight (2001).

Note: Bioregion endemics are endemic in the NT but may exist in other states. The former existence of a species in the focus area may in some cases be speculative.

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Evolutionary refugia include ranges and, in particular, moist gorges within those ranges, where some species, refugees from past wetter climes, have been able to survive the onslaught of aridity. Morton et al. (1995) classify the Western MacDonnell Ranges (WMR), Eastern MacDonnell Ranges (EMR) and George Gill Range (GGR) as 'extremely significant' refugia, as habitat for endemic and relict plants. They list 112 endemic, relict, and significant species for WMR and EMR, and 14 relict plants for the GGR, as well as some invertebrate (mostly snails), and vertebrate endemics or relicts. There is also relictual fauna in the streams of the GGR (Davis et al. 1993), and presumably elsewhere. Wischusen et al. (2004) present evidence that Palm Valley, a refugial area in the MacDonnell Ranges, is sustained by groundwater recharged during interglacial wet periods during the Pleistocene, and suggest it may have functioned as a refuge since the mid-Pleistocene.

Ecological refugia include the ranges noted above, particularly in moist gorges such as Palm Valley, as well as wetlands. The Karinga Creek system, for example, provides a complex array of habitats with dependable supplies of moisture (NLWRA 2002 database). Graham and Cowan (2001) suggest the Rock Pools of the Walter James Range and Lake Christopher have the potential to provide such refuge during periods of drought, or as breeding locations during seasonal rainfalls. Unmack (2001) highlights the role of river gorges with permanent waterholes in the Finke River system as refugia for fish.

Human-induced refugia would include refuges from wildfire and pests, perhaps in relatively inaccessible sites in the most rugged parts of the ranges. The ranges are refugia for threatened species. It would also include areas remote from artificial water points that facilitate grazing and predation.

Significant wetlands: There are four wetlands in the focus area listed in the Australian Directory of Important Wetlands: the Finke River Headwater Gorges System, the Karinga Creek Palaeodrainage System, Lake Amadeus (partly), and the Rock Pools of the Walter James Range. Feral animals, such as camels, have been identified as threats to three of these four wetlands (NLWRA 2002 database).

ECOLOGICAL PROCESSES

Key ecological processes for the arid zone have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches (such as riparian habitats) or refugia have been degraded by grazing or fire.

Hydroecology: Compromised where there is a relatively high density of artificial waterpoints for cattle.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

The major threatening processes in this focus area are feral predators (foxes and cats) and introduced herbivores (cattle, rabbits, camels, donkeys and horses) causing degradation; changed fire regimes (with extensive wildfires now the norm); grazing and weeds. See Table CR.4 for further information about threats.

TABLE CR.4 MAJOR THREATS

Threats	Impacts	Comments
Altered fire regimes	Change from Aboriginal mosaic burning to attempted exclusion (on pastoral properties) and extensive wildfires. • Destruction of fire-sensitive vegetation eg. decline of mulga woodlands (Latz 1995) & *Callitris* stands (Bowman & Latz 1993) • Declines in some fauna, eg. granivorous birds (Franklin 1999), & mammals • Increased homogeneity of burning history, with reduced patchiness & thus reduced habitat & resources for some fauna	Traditional Aboriginal burning is thought to have caused a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. Now, with the large-scale loss of traditional management, the regime is much more extensive & destructive, with large-scale wildfires.
Feral animals	Major threatening processes & implicated in mammal extinctions: • Predation pressure on mammals, birds, lizards by foxes, cats, dogs; implicated in extinction of mammals (Smith & Quin 1996) • Predation pressure increased due to build-up, then decline, of mice as prey (ibid) • Degradation of water points & vegetation by rabbits, camels, donkeys, horses, cattle	Ferals include camels, cats, foxes, dogs, cattle, rabbits, horses, donkeys, big-headed ant, gambusia, honey bees, house mice. Rabbit populations have been reduced by calicivirus.
Weeds	• Degradation of wetlands by hymenachne • Competition, increased fire destruction due to buffel grass (Friedel. et al 2006) • Displacement of native vegetation eg. by naturalized pasture grasses, & in riparian habitats by athel pine.	Weeds include athel pine, buffel grass, castor oil plant, olive hymenachne, parkinsonia, couch grass, rubber bush, paddy's lucerne, Bathurst burr
Grazing	• Large areas degraded by over-grazing, particularly in Finke chenopod ecosystems. • Degradation of fertile areas, such as riparian & floodplain habitats • Changes in vegetation, eg. loss of palatable perennials. • Introduction & spread of weeds, particularly Buffel grass, & fire exclusion • Degradation of fertile patches (Morton 1990).	Pastoral leases cover about one-third of the focus area. In 1984 it was estimated that 13% of the land used for pastoralism in central Australia was affected by vegetation degradation and substantial soil erosion in 1975 (Rose 1995).
Other	Localised degradation by tourism & mining	

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

Apart from the MacDonnell Ranges bioregion, there is very little of the focus area protected in the national reserve system (see Table CR.5). Both Finke and Central Ranges are top priority NRS bioregions.

There are, however, a couple of very large Indigenous Protected Areas (DEW 2007): Ngaanyatjarra IPA covering about 10 million ha (IUCN category VI), mostly in the Central Ranges bioregion; and Watarru

TABLE CR.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Bioregion	Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehen siveness I-IV (%)	Comprehen siveness V-VI (%)	Manag't Standard	NRS priority (1-5, with 1 highest)
CR	0	313,038 (3%)	0	?	--	1
FIN	411 (<1%)	1,736 (<1%)	?	4	Good	1
MAC	346,236 (9%)	25,039 (1%)	52	4	Very good	3
focus area	346,647 (2%)	49,477 (<1%)	--	--	**--**	

Source: Sattler & Glanznig (2006)

IPA, covering 1.2 million ha, which is partially in the Central Ranges bioregion. Under development is the Angas Downs IPA in Finke bioregion.

POLICIES, PLANS & PROGRAMS

There are very few conservation-focused plans, policies or programs in this focus area (see Table CR.6).

TABLE CR.6: VARIOUS PLANS, POLICIES & PROGRAMS

Plan/policy/program
Conservation: CALM Regional Management Plan, incorporating the WA part of CR, but not specific for the bioregion / Finke assessment & conservation plan / Plans of Management for national parks
NRM: Centre Land Watch, by Centralian Land Management Association – a pastoralists' natural resource monitoring program / Pastoral Land Resource Capability Mapping in the Finke River Catchment
Sustainable development: Bush resources study (Morse 2005) / Creation of an Indigenous Food Fund by Coles Supermarkets

CONSERVATION CAPACITY

Indigenous Conservation: Land Management on Aboriginal lands is constrained by lack of resources and lack of people on country, although there has been some development of outstations in the focus area. We know of no Aboriginal land management groups in Central Ranges and Finke bioregions. In the MacDonnell Ranges bioregion, the Tjuwanpa Rangers are a relatively new group, involved in park management, with intentions to expand into Aboriginal Land Trust areas. Funding is a significant constraint.

Advocacy conservation groups: We know of no recent advocacy activity.

Private land conservation groups: We know of no activity in the Central Ranges from private land conservation groups.

Other institutional capacity: There is variable but generally limited capacity for natural resource management in the focus area due to low population and inadequate resources (see Table CR.7). There are two Landcare groups and Conservation Volunteers in the MAC bioregion, but no land management groups in CR or FIN. There is a recently established Desert Knowledge Cooperative Research Centre, with research projects focused on sustainable livelihoods and business opportunities; viable desert settlements, and economic flows and institutions (McAllister & Stafford Smith 2006).

ADEQUACY OF INFORMATION

Apart from specific sites, such as the MacDonnell Ranges, where there has been considerable survey work, the focus area is poorly known. Due to lack of surveys, there is considerable difficulty in identifying biodiversity values.

GIBSON DESERT

GENERAL DESCRIPTION

The Gibson Desert focus area covers about 170 000 km^2 in Western Australia. It is equivalent to the IBRA bioregion of the same name (GD), as well as the ecoregion of the same name as delineated by WWF (Hopkins 2001b).

FIGURE GD.1: LOCATION OF GIBSON DESERT

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[27]

GD.1 DOMINANT VEGETATION GROUPS (KM^2)

Hummock grassland	Acacia forests & woodlands	Acacia shrubland	Grassland groups	Chenopod groups
135,467	11,067	5,117	2,161	1,635

Source: NLWRA (2001)

The dominant landforms are sand dunes (GD2) and gravelly sandplains with low rocky ridges and uplands (GD1). The dominant vegetation is spinifex grasslands, and there are also significant areas of acacia woodlands and shrublands (see Table GD.1). There are eucalypt woodlands on Quarternary alluvia associated with palaeo-drainages. The climate is arid with a mean annual rainfall of 200mm. Rain falls mainly in the summer, but is erratic. Summers are hot with daily maximum temperatures often exceeding 45^{o}C and winters are cool with overnight temperatures often falling below zero.

LAND USES, PEOPLE & INSTITUTIONS[28]

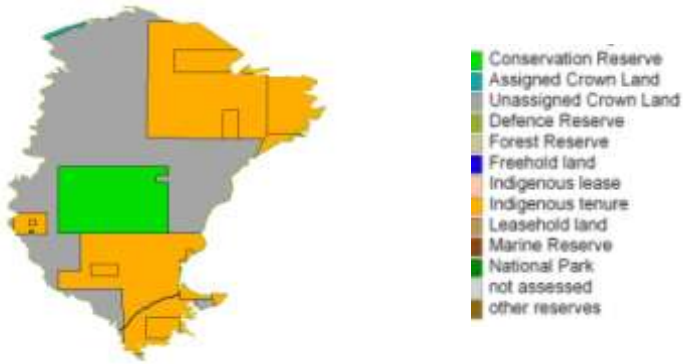
This region is largely uninhabited except for some communities on Aboriginal land, which covers about 10% of the focus area (see Figure GD.2). Although pastoral leases cover close to one-third of the area, many are not actively used. Some sheep and cattle grazing occur on the margins of the desert. Close to half the land area is unallocated crown land. Conservation is a minor use at just over 10% of the focus area. There is also some mining and mining exploration.

[27] Sources: NLWRA (2002) database

[28] Sources: Graham et al. (2001a, 2001b), AIATSIS (2005), NNTT (2006)

Two major language groups in the Gibson Desert are Mardu and Ngaanyatjarra peoples. Their title has been recognised over a large proportion of the focus area. Aboriginal people in the focus area are represented by the Ngaanyatjarra Council Aboriginal Corporation Area.

FIGURE GD.2: LAND TENURE



CONSERVATION VALUES

Having escaped the intense development pressure of southern and coastal Australia, this focus area has a largely natural landscape with ecological processes functioning at the landscape scale. There is likely to be high reptile diversity, but there has been significant loss of biodiversity values with extinctions in the mammal fauna.

LANDSCAPE CONDITION

In the assessment of landscape health by Morgan (2001), the Gibson Desert rated highly, with both subregions in the lowest stress class (near pristine) (see Table GD.2). Note that the assessment did not include the effects of fire.

Minimal vegetation has been cleared, and vegetation condition (again without reference to fire) is entirely 'high quality' (see Figure GD.3).

TABLE GD.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE & RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best, 5 unknown)
GD 1/2	6/6	0	3/5

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

There are no permanent rivers, but ephemeral creeks are in good condition with high natural integrity (see Figure GD.4). The average subregional condition of nationally important wetlands is good, although declining (NLWRA 2002, 32). The average subregional condition of riparian zones, along ephemeral creek lines, is also good, or unknown, with the trend static or unknown (see Table GD.2).

Finally, in the National Wilderness Inventory, almost all of the focus area was assessed as having high wilderness quality (see Figure GD.5).

BIODIVERSITY VALUES

Along with the rest of inland Australia, the Gibson Desert has had a climatically turbulent recent history, with cycles of extreme aridity during ice ages, the most recent only 10-18,000 years BP, during which much of the biota retreated to refugia. Thus, most of the present ecosystems are relatively young, consisting of species that expanded out of ice age refugia (Crisp et al. 2001).

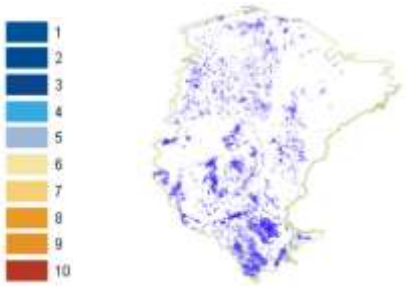
Three regional ecosystems are considered threatened: hummock grasslands, gorge communities in the desert ranges, and a wetland woodland. Camels and changed fire regimes are implicated in all three, and foxes and grazing pressure also for one or more.

The biodiversity is very poorly known, and apart from presumed high reptile diversity, in common with other arid areas, no standout values have been identified. At least 16 mammal species (more than 40% of the original mammal fauna) are thought to have disappeared from the focus area since European colonisation (McKenzie et al. 2002) (see Table GD.3).

FIGURE GD.3: VEGETATION CONDITION (VAST)

Source: Thackway & Lesslie (2005)

FIGURE GD.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE GD.5: WILDERNESS QUALITY (NWI)

High quality wilderness

Source: Lesslie & Masslen (1995)

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

There are no identified e*volutionary refugia. Ecological refugia* include at least 8 wetlands and creek systems, which provide drought or breeding refugia, in particular, Gibson Desert Gnamma Holes and Lake Gruszka (Graham et al. 2001a). *Human-induced refugia* would include refuges from grazing, destructive fire and pests; for example, those areas that have never been grazed or which are inaccessible to camels.

Significant wetlands: The two wetlands noted above are both listed in the Directory of Important Wetlands. Lake Gruszka is a large seasonal/intermittent freshwater wooded lake, and Gibson Desert Gnamma Holes is a series of rock pools. Although in good condition, both are threatened by feral animals, the former also by changed fire regimes, and the latter also by siltation (Graham et al. 2001a).

TABLE GD.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Birds		3 3 vulnerable	Threatened birds include 1 thornbill, 1 parrot, 1 mallee-fowl. Bird fauna is considered typical of semi-arid areas, & has a high rate of Australian endemics.
Reptiles		1 1 vulnerable	Threatened species is a skink.
Mammals		5 3 vulnerable 2 endangered	Threatened species include 3 dasyurids, 1 bandicoot, 1 macropod.
Regionally extinct species	Red-tailed phascogale (*Phascogale calura*) Golden bandicoot (*Isoodon auratus*) Desert bandicoot (*Perameles eremiana*) Pig-footed bandicoot (*Chaoropus ecaudatus*) Lesser bilby (*M. leudura*) Burrowing bettong (*Bettongia lesueur*) Woylie (*B. penicallata*) Spectacled hare-wallaby (*Lagorchestes conspicillatus*) Central hare-wallaby (*L. asomatus*)		Mala (*L. hirsutus*) Crescent nail-tailed wallaby (*Onychogalea lunata*) Lesser stick-nest rat (*Leporillus apicalis*) Long-tailed hopping mouse (*Notomys longicaudatus*) Djoongari (*Pseudomys fieldi*) Brush-tailed possum (*Trichosurus vulpecular*) Western quoll (*Dasyurus geoffroii*) Numbat (*Myrmecobius fasciatus*) Night parrot (*Pezoporus occidentalis*)
Richness & endemism statistics	27 mammals / 74 reptiles / 3 frogs / 136 birds / 6 WA endemics		

Sources: NLWRA (2002) database, Woinarski et al. (2000), Menkhorst & Knight (2001), How & Cowan (2006), Birds Australia (2002) database. Note: In some cases the former existence of a species in the focus area may be speculative.

ECOLOGICAL PROCESSES

Key ecological processes for the arid zone have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches (such as riparian habitats) or refugia have been degraded by grazing or fire.

Hydroecology: Largely intact.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

The major threats in this focus area are grazing, feral animals (foxes, cats, camels and rabbits); changed fire regimes (with infrequent, extensive wildfires now the norm); and weeds. Graham et al. (2001) note that threatening processes in subregion GD2 are not significant. See Table GD.4.

TABLE GD.4 MAJOR THREATS

Threats	Impacts	Comments
Altered fire regimes	Change from Aboriginal mosaic burning to occasional extensive wildfires. • Increased homogeneity of burning history, with reduced patchiness & thus reduced habitat & resources for some fauna • Destruction of fire-sensitive vegetation, such as acacia woodlands (Williams et al. 2002). • May have contributed to decline/loss of fauna	Traditional Aboriginal burning is thought to cause a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. With the loss of traditional management, the regime is more infrequent & extensive with large-scale wildfires. Buffel grass intensifies fire regimes, causing more frequent & intense fires, creating a positive feedback loop (Butler & Fairfax 2003). McKenzie et al. (2002) note that large, intense summer wildfires are degrading hummock grasslands and mulga woodland communities. There is no fire management in the area.
Feral animals	Implicated in mammal extinctions: • Predation pressure on mammals, birds, lizards by foxes & cats; implicated in extinction of mammals (Smith & Quin). Predation pressure increased due to build-up, then decline, of mice as prey (ibid) • Degradation of vegetation & water points by rabbits, camels, cattle, pigs	Ferals include camels, cats, foxes, dogs, cattle, rabbits, horses, donkeys, house mice. Rabbit populations have been reduced by calicivirus. The impact of feral herbivores in GD1 is likely to be considerable although not quantified, and there are no feral predator control programs (Graham et al. 2001). High feral cat densities stymied attempts to reintroduce burrowing bettongs (Woinarski et al. 2000, citing Christensen and Burrows 1994).
Weeds	Displacement of native vegetation & alteration of fire regimes	Weeds include buffel grass, which is of particular biodiversity concern.
Grazing	Grazing causes: • degradation of critical habitat areas, such as wetlands • changes in vegetation, e.g. loss of palatable perennials. • Suppression of fire & introduction of weeds	Pastoral leases exist mainly on the periphery areas, and some are not operated.

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

The Gibson Desert has a few extensive reserves, and is considered a relatively low NRS priority (see Table GD.5). However, the reserve system is highly biased as none of the Dune Field subregion is reserved. Reserve management suffers from lack of fire management and pest management (McKenzie et al. 2002). There is one Indigenous Protected Area partially in the Gibson Desert: the Ngaanyatjarra IPA.

TABLE GD.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Area (ha) & extent reserved IUCN I-IV	Area (ha) reserved IUCN V-VI	Comprehensiveness I-IV (%)	Comprehensiveness V-VI (%)	Manag't Standard	NRS priority (1-5, with 5 lowest)
2,067,479 (13%)	0	46	0	Fair/good	4

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

Apart from a national park management plan, we know of no plans or programs that directly and actively apply to this focus area (see Table GD.6).

TABLE GD.6: VARIOUS PLANS, POLICIES & PROGRAMS

Plan/policy/program
Management plan for Gibson Desert Nature Reserve
CALM Regional Management Plan - addresses land & wildlife conservation issues, but is not specific for this bioregion

CONSERVATION CAPACITY

Indigenous Conservation: Indigenous conservation work is constrained by lack of resources and lack of people on country. We are not aware of any formal Aboriginal land management groups in the region.

Advocacy conservation groups: We know of no activity in the Gibson Desert from advocacy conservation groups.

Private land conservation groups: We know of no activity in the Gibson Desert from private land conservation groups.

Other institutional capacity: There is very limited capacity for natural resource management in the focus area due to lack of population and resources (NLWRA 2002 database). There is a recently established Desert Knowledge Cooperative Research Centre, with research projects focused on sustainable livelihoods and business opportunities; viable desert settlements, and economic flows and institutions (McAllister & Stafford Smith 2006).

ADEQUACY OF INFORMATION

There are major inadequacies in the information for this focus area. There has been no bioregional survey of flora and fauna, and there is very little information about habitat requirements of many species and the impacts of threatening processes (McKenzie et al. 2002).

SIMPSON-STRZELECKI DESERT

GENERAL DESCRIPTION

The Simpon-Strzelecki Desert focus area covers 299 000 km^2, and straddles four states: predominantly in the Northern Territory and South Australia, and also in Queensland and New South Wales. It is part of the Lake Eyre Basin. The focus area is equivalent to the IBRA bioregion of the same name (SSD), but encompasses only part of the Simpson Desert ecoregion delineated by WWF and described by Wilson (2001), due to the exclusion of the Channel Country bioregion (for explanation see Section of Focus Areas section).

FIGURE SSD.1: LOCATION OF SIMPSON-STRZELECKI DESERT

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[29]

The Simpson-Strzelecki Desert consists mostly of sand dunes and sand plains. The dunes are up to 35 metres high, and up to >200 km long, formed from Quaternary sands deposited by wind over Quaternary clay sheets. The area contains significant wetlands, with large salt lakes (filling only occasionally) and clay pans, and inland rivers, which are only intermittently wet, and that terminate at Lake Eyre. The majority of the area (86%) is atop the Great Artesian Basin, whose waters come to the surface through artesian springs and numerous bores.

SSD.1 DOMINANT VEGETATION GROUPS (KM^2)

Hummock grassland	Acacia shrubland	Acacia open woodland	Mangrove group	Other forests & woodlands
189,454	26,932	16,028	13,163	13,047

Source: NLWRA (2001)

The dominant vegetation is hummock grasslands, covering about two-thirds of the area (see Table SSD.1). There are also significant areas of acacia shrublands and woodlands. Dune crests (if not bare) are held together by cane grass, and spinifex occupies the side slopes and interdune areas. Samphire shrublands fringe bare salt pans and coolibah and redgum woodlands fringe the watercourses.

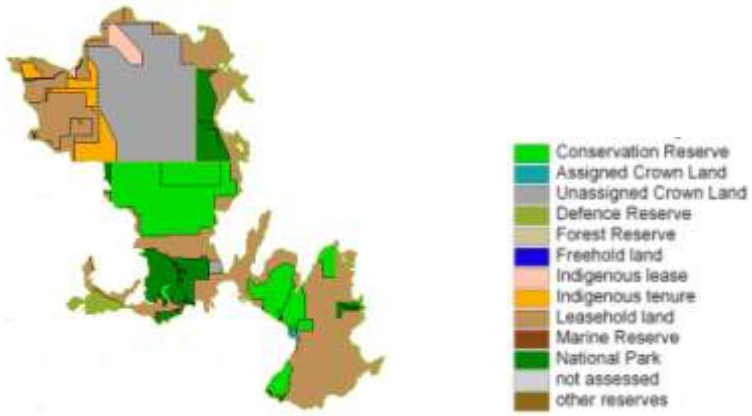
The climate is arid, with an annual rainfall averaging 150-200 mm. However, the rainfall is highly erratic, and most years receive less than average. Sometimes there are no significant falls for years. The region around Lake Eyre is the driest in the country, receiving an average <100mm annually. Summers are hot, with maximum temperatures averaging 36-39^{o}C, and winters are mild.

[29] Sources: NLWRA (2002) database; Baker et al. (2005); GABCC (1998); Wilson (2001), Purdie (1984).

LAND USES, PEOPLE & INSTITUTIONS[30]

Dominant land uses are traditional Aboriginal use, pastoralism (cattle) and conservation (see Figure SSD.2). Less dominant land uses are mining and tourism. Most pastoral properties are >4,000 km^2, and run by large pastoral companies.

FIGURE SSD.2: LAND TENURE



The focus area is very sparsely populated. In the Northern Territory portion, there are just 750 people at an average density of .01 people/km^2.

It has been surmised by archaeologists that the Simpson Desert (and other sandridge deserts) were among the last areas to be inhabited by Aboriginal people, perhaps in the past 5000 years on a permanent basis (Shephard 1992, citing Veth 1989). Habitation was facilitated by social and technological changes, such as those that allowed exploitation of seeds as a staple food source, and methods for accessing and conserving limited water supplies (ibid). There are at least a dozen major Indigenous language groups in the focus area. The Wangkangurru People inhabited the central and southern-central areas, the Arrente People the western margins, and the Karanguru and Wangkamana Peoples the eastern fringes. Aboriginal people in the focus area are represented by the Central Land Council (in NT), the Carpentaria Land Council (in Qld) and the Aboriginal Legal Rights Movement (in SA).

CONSERVATION VALUES

Having escaped the intense development pressure of southern and coastal Australia, this focus area has a largely natural landscape with ecological processes functioning at the landscape scale. There is outstanding waterbird and lizard diversity; however, there has been significant loss of biodiversity values with extinctions in the mammal fauna.

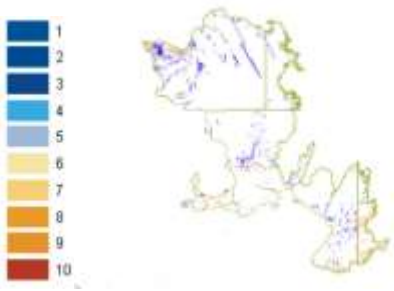
[30] Sources: Baker et al. (2005); Wilson (2001), Shephard 1992), AIATSIS (2005), NNTT (2006)

LANDSCAPE CONDITION

FIGURE SSD.3: VEGETATION CONDITION (VAST)

Source: Thackway & Lesslie (2005)

FIGURE SSD.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE SSD.5: WILDERNESS QUALITY (NWI)

High quality wilderness

Source: Lesslie & Masslen (1995)

In the assessment of landscape health by Morgan (2001), the Simpson-Strzelecki Desert rated variably, with one subregion in the lowest stress class (near pristine) and four in the second lowest stress class, but two subregions rating poorly, in the third highest stress class (see Table SSD.2). Note that the assessment did not include the effects of fire.

Minimal vegetation has been cleared, and vegetation condition (again without reference to fire) is mostly 'high quality' (see Figure SSD.3).

Rivers are mostly in good condition with high natural integrity (see Figure SSD.4). The average subregional condition of nationally important wetlands is mostly good and the trend static or unknown (NLWRA 2002). The average subregional condition of riparian zones is also mostly good or unknown, except for the Dieri subregion (SSD3), where condition is considered 'fair (recovery requires significant intervention)' (see Table SSD.2).

Finally, in the National Wilderness Inventory, most of the focus area was assessed as having high wilderness quality (see Figure SSD.5). The more recent Wilderness Delineation shows a similar pattern.

TABLE SSD.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE & RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best, 5 unknown)
SSD 1/2/3	5/5/6	0	3/3/2
SSD 4/5/6/7	3/5/5/3	0	5/5/3/3

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

BIODIVERSITY VALUES

The focus area along with the rest of inland Australia has had a climatically turbulent recent history, with cycles of extreme aridity during ice ages, the most recent only 10-18,000 years BP. Thus, most of the present ecosystems are relatively young, consisting of plant species that expanded out of refugia (Crisp et al. 2001).

The SSD area is dominated by hummock grasslands, and contains >10% of the total extent of hummock grassland in Australia (NLWR 2001). They are important habitat, particularly for reptiles. The eucalypt woodlands, mostly confined to watercourses, have the highest number of species recorded compared to all other broad habitat types, particularly for bird, bat, and frog species (Wilson 2001). Of 70 ecosystems in the SSD area, seven are regarded as threatened: two are riparian habitats threatened by grazing, two are artesian spring communities threatened also by grazing, one is mulga on sandplains threatened by rabbits, one is a chenopod community threatened by grazing, and the other an *Alectryon* shrubland threatened by cattle and rabbits. The ecological communities associated with artesian springs are listed as federally endangered. The springs occur where water from the Great Artesian Basin reaches the surface through faults or near the margins of the Basin. They support rare and endemic plants, fish and invertebrates. Because of the extinction and degradation of many artesian springs, many species are likely to have become extinct.

Due to the large-scale drainage of the Eyre Basin, there are relatively frequent floods in the focus area caused by rainfall occurring outside the region. Lakes that are normally dry are filled every few years (or decades) and rapid vegetation growth is triggered. The lakes support large bird populations, and some of them also support abundant fish populations (Wilson 2001).

There is quite high vertebrate diversity in the focus area, particularly in the reptiles (Shephard 1992). The mammal fauna was diverse, but has been substantially whittled by extinctions, with almost total loss of medium weight species, and many others threatened. As shown in Table SSD.3 at least 15 species are thought to have disappeared since European colonisation, and 8 species are listed as threatened. Dieri is the most diverse of the seven SSD subregions, with 400 plant taxa, 51 reptiles, 34 mammals and 180 birds (NLWRA 2002 database).

TABLE SSD.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	4	11 1 endangered 6 vulnerable	Threatened species include 4 acacias. There are also at least 3 acacia endemics.
Birds	1	14 1 endangered 2 vulnerable	Threatened species include 1 chat, 1 plains-wanderer, 2 grasswrens, 1 parrot, 1 bustard, 1 cockatoo, 2 raptors, 2 ducks, 1 pigeon, 1 brolga, 1 stone-curlew. The Eyrean grasswren is endemic. SSD is moderately important for several limited range species of chenopod shrublands.
Reptiles	1	1 -	The woma is listed under NSW legislation. The Lake Eyre dragon is restricted to Lake Eyre & surrounding salt lakes.
Mammals		8 8 vulnerable	Threatened species include 2 dasyurids, 2 rodents, 2 macropods, 1 bat, 1 bandicoot
Invertebrates	1	1 -	1 snail is listed under NT legislation. 1 crustacean is endemic.
Regionally extinct species	Golden bandicoot (*Isoodon auratus*) Desert bandicoot (*Perameles eremiana*) Pig-footed bandicoot (*Chaoropus ecaudatus*) Bilby (*Macrotis lagotis*) Lesser bilby (*M. leudura*) Burrowing bettong (*Bettongia lesueur*) Spectacled hare-wallaby (*Lagorchestes conspicillatus*) Crescent nail-tailed wallaby (*Onychogalea lunata*)		Desert rat-kangaroo (*Caloprymnus campestris*) Lesser stick-nest rat (*Leporillus apicalis*) Long-tailed hopping mouse (*N. longicaudatus*) Short-tailed hopping mouse (*N. amplus*) Brush-tailed possum (*Trichosurus vulpecular*) Ghost bat (*Macroderma gigas*) Western quoll (*Dasyurus geoffroii*) Night parrot (*Pezoporus occidentalis*)
Various richness & endemism statistics	800 plants / 694 plants (NT) / 317 vertebrates (NT) / 228 birds / 17 bioregion endemics (NT) / 19 NT endemics		

Sources: NLWRA (2002) database, Baker et al. (2005), Shephard (1992), Purdie (1984), Birds Australia (2002) database, Morton et al. (1995), Knight & Menkhorst (2001)

Note: In some cases the former existence of a species in the focus area may be speculative.

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Evolutionary refugia include the artesian springs, with relictual and endemic species, and some of the lakes, eg. Lake Eyre has an endemic crustacean. The lakes are remnants of wetter times when there were much larger and permanent water bodies in central Australia.

Ecological refugia include springs and wetlands. Morton et al. (1995) nominated three lakes / floodplains as significant refugia: Lake Eyre, Strzelecki Creek floodplain and Lake Blanche, and Lake Frome. Their chief refugial value is as occasional habitat for waterbirds. Lake Eyre is as a major breeding area for waterbirds—it sometimes harbours more than 300,000 birds of at least 36 species,

and several species breed on islands within the Lake. Paroo Wetlands and Bulloo Overflow also provide drought refuge for waterbirds (NLWRA 2002 database).

Human-induced refugia would include refuges from grazing, destructive fire and pests. The Hay River was identified by Morton et al. (1995) as a significant refuge—it is one of the few pristine arid rivers and "supports a dense and varied shrub and woodland vegetation which is apparently free of exotic wildlife". Mallee remnants, now rare in eastern Australia, comprise refuges for mallee-dependent organisms including rare and threatened species (NLWRA 2002 database).

Significant wetlands: There are nationally and internationally significant wetlands in the focus area. Coongie Lakes are Ramsar-listed—they are threatened by rabbits. In addition, wetlands listed in the Australian Directory include Strzelecki Creek Wetland System, Inland Saline Lakes such as Lake Frome, Lake Eyre, Dalhousie Mound Springs and Lake Eyre Mound Springs. Most are threatened by exotic animals and grazing, and the springs are threatened by artesian water drawdown (NLWRA 2002 database).

Lake Eyre is Australia's largest lake, and one of the largest internal drainage basins in the world. It fills only occasionally (four times last century) (Neagle 2002), but receives smaller flows on average every second year. The key threats are upstream alterations to hydrology and introduction of exotic fish (Morton et al. 1995); and future climate changes.

Other features: There are also important fossil sites in the focus area—there are Tertiary vertebrate fossils in river and lake sediments, including the Diprotodon sites at Lake Callabonna (SA), and Miocene eucalypts from Sturt Creek, south of Lake Eyre.

ECOLOGICAL PROCESSES

Key ecological processes for the arid zone have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches (such as riparian habitats) or refugia have been degraded by grazing or fire.

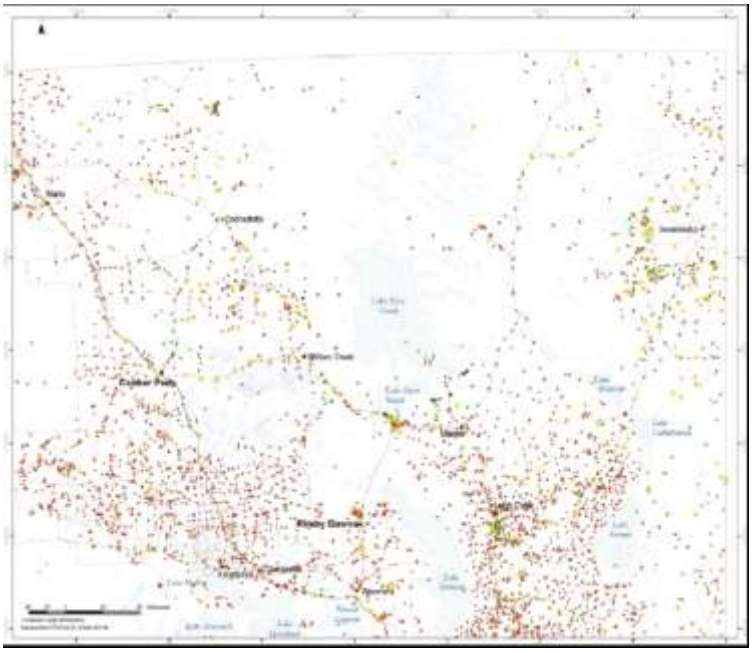
Hydroecology: Largely intact, but compromised where there is a high density of artificial waterpoints (see Figure SSD.6) and loss of groundwater pressure affecting artesian springs. Hydroecological processes are particularly important in the SSD focus area, underpinning extraordinary bursts of productivity when floods occur. For example, floods in 1990 had Lake Eyre, Lake Blanche and the Lower Cooper teeming with up to one million waterbirds (Arid Areas Catchment Water Management Board 2006).

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

FIGURE SSD.6: DRILL HOLES IN THE FAR NORTH ZONE OF SOUTH AUSTRALIA



Source: Arid Areas Catchment Management Water Board (2006, Figure 3.7)

Note: this map encompasses other northern bioregions besides Simpson-Strzelecki Desert (including some of the Channel Country and Stony Plains)

THREATS

The major threats are grazing by cattle, feral animals (foxes, cats, camels and rabbits), changed fire regimes (with infrequent, extensive wildfires now the norm), and altered hydrological regimes (see Table SSD.4).

TABLE SSD.4 MAJOR THREATS

Threats	Impacts	Comments
Altered fire regimes	Change from Aboriginal mosaic burning to occasional extensive wildfires. • Increased homogeneity of burning history, with reduced patchiness & thus reduced habitat & resources for some fauna • Destruction of fire-sensitive vegetation, such as saline vegetation communities on palaeodrainage lines and salt lakes (Myers et al. 2004) & mulga woodlands (Williams et al. 2002). • Decline/loss of fauna	Traditional Aboriginal burning is thought to have caused a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. With the loss of traditional management, the regime is more infrequent & extensive with large-scale wildfires. Buffel grass has intensified fire regimes, causing more frequent & intense fires, creating a positive feedback loop (Butler & Fairfax 2003).
Feral animals	• Predation pressure on mammals, birds, lizards by foxes & cats; implicated in extinction of mammals (Smith & Quin). Predation pressure increased due to build-up, then decline, of mice as prey (ibid) • Degradation of vegetation & water points by rabbits, camels, cattle, pigs • Displacement of native fish in mound springs by gambusia	Ferals include camels, cats, foxes, dogs, cattle, rabbits, horses, donkeys, house mice, gambusia, pigs. Rabbit populations have been reduced by calicivirus. In 2002, there were >10,000 camels in the SA portion of Simpson Desert (SA State of Environment Report).
Weeds	Displacement of native vegetation & alteration of fire regimes—eg. buffel grass caused decline of all native plant growth forms & species richness at Simpsons Gap National Park (Friedel et al. 2006, citing Clarke et al. 2005). Spring habitats are threatened by weeds.	Weeds include buffel grass *Acacia farnesiana*, parkinsonia, bathurst burr, noogoora burr, feathertop rhodes grass, castor oil plant, Mexican poppy, paddy's lucerne, ruby dock. Buffel grass invasion is of particular biodiversity concern.
Grazing	Grazing has had significant impacts: • Degradation of critical habitat areas, such as springs & wetlands • Changes in vegetation, e.g. loss of palatable perennials. • Suppression of fire & introduction of weeds • Drawdown of artesian water reduces spring viability. • Proliferation of water points – facilitates feral predators & grazing by domestic & feral herbivores.	Pastoral leases exist mainly on the periphery. There is ongoing development on some properties with new water points being developed to extend grazing. Presence of artificial water points underpins key threatening processes associated with grazing & predation. In 1990s, natural water points numbered 151 and artificial water points numbered 1099 (about 90% of total) (GABCC 1998) (see Figure SDS.6).
Other	Localised degradation caused by mining & tourism: • Over-extraction of groundwater for mining projects • Vegetation loss, erosion, weed spread by mining & tourism Predation by silver gulls, preventing breeding success of banded stilts, an Australian endemic wader, on Lake Eyre (Neagle 2002)	>4,500 km of seismic tracks occur in the southern Simpson Desert (Shephard 1992)

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

The SSD focus area is relatively well-endowed with protected areas by Australian standards, although reserves are inadequately managed. In total almost 30% of the area is protected and the area is considered a low priority for the National Reserve System (see Table SSD.5). In addition to NRS

TABLE SSD.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehensiveness I-IV (%)	Comprehensiveness V-VI (%)	Manag't Standard	NRS priority
3,313,149 (11%)	4,819,103 (16%)	13	19	Poor	5

Source: Sattler & Glanznig (2006)

reserves, Bush Heritage Australia manages Ethabuka and Cravens Peak, on the edge of the Simpson Desert, for conservation.

POLICIES, PLANS & PROGRAMS

Most of the plans, policies and programs in the focus area have been focused on water resources—rives and groundwater plans and strategies (see Table SSD.6). There is a regional biodiversity plan for South Australian subregions (NLWRA 2002 database), but not for the other subregions. Activities in the Desert Channels bioregion in Queensland are particularly important for the SSD focus area in their impact upon hydroecology, so relevant plans for that bioregion have also been listed.

TABLE SSD.6: VARIOUS PLANS, POLICIES & PROGRAMS

Plan/policy/program
Natural Resource Management: Lake Eyre Basin Strategic Plan / Georgina, Diamantina Rivers & Cooper Creek Catchment Plans / SA Arid Lands NRM Region Initial NRM Plan / Desert Channels NRM plan
Protected areas: Plans of management for national parks
Water: Water Resource Plans for Paroo, Cooper, Bulloo Rivers / Great Artesian Basin Strategic Management Plan / GAB Resource Study / Qld Great Artesian Basin Water Resource Plan
Pastoralism: Review of pastoral lease management in Queensland & recent amendments to Land Act / Pastoral lease assessment program (SA) / Marree Soil Conservation Board District Plan
Conservation: 'Wildlife Habitat and Inland Floodplains Management' project - PIRSA Pastoral Program (part of Rangeland 2005 Program)

CONSERVATION CAPACITY

Indigenous Conservation: Indigenous conservation work is constrained by lack of resources and lack of people on country. We are not aware of any formal Aboriginal land management groups in the region.

Advocacy conservation groups: There are no advocacy groups actively working in the region. Advocacy groups are represented on some committees examining statewide issues relevant to the region such as the Queensland Leasehold land review and the Great Artesian Basin Advisory Committee. In the 1990s some Queensland conservation groups successfully worked in alliance with local graziers to stop proposals for irrigated cotton activities in the Channel Country.

Private land conservation groups: Bush Heritage Australia owns two properties—Ethabuka and Mt. Craven—on the north-eastern edge of the Simpson Desert. The organisation is planning further strategic work in the Simpson Desert and adjacent Channel Country regions.

Other institutional capacity: There is some NRM capacity in the SSD focus area, with 4 of 7 subregions having instruments for natural resource management in place with some outcomes (NLWRA 2002 database). The Biodiversity Audit (NLWRA 2002) concluded for the SSD area that 'limited measures will result in significant gains' for recovery of threatened species and threatened ecosystem. There is a recently established Desert Knowledge Cooperative Research Centre, with research projects focused on sustainable livelihoods and business opportunities; viable desert settlements, and economic flows and institutions (McAllister & Stafford Smith 2006).

ADEQUACY OF INFORMATION

Information on biodiversity is patchy with sporadic biologic surveys from the region. In recent years, there has been considerable biological research conducted in the north-eastern fringe of the area, at Ethabuka Station and adjacent areas, particularly on mammal ecology.

GREAT VICTORIA DESERT

GENERAL DESCRIPTION

The Great Victoria Desert focus area covers 419 000 km^2, straddling Western Australia and South Australia. It is equivalent to the IBRA bioregion of the same name (GVD), as well as the ecoregion of the same name delineated by WWF and described by Hastwell (2001).

FIGURE GVD.1: LOCATION OF GREAT VICTORIA DESERT

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[31]

The focus area is a vast sand belt, dominated by sand dunes and sand plains. These are geologically young, but underlain by ancient rocks 1000 million to 2900 million years old.[32] The Great Victoria Desert is the largest dune desert in Australia. Other landforms include gibber plains,[33] low ranges (35 million years old), dissected tablelands, silcrete rises and laterite breakaways, and chains of dry salt lakes, many the dried remnants of former drainage channels.

GVD.1 DOMINANT VEGETATION GROUPS (KM^2)

Hummock grassland	Mallee	Acacia forest & woodland	Acacia shrublands	Acacia open woodlands
214,981	57,203	56,204	34,075	11,026

Source: NLWRA (2001)

Despite its aridity, the focus area is well vegetated. Dominant vegetation types are hummock grasslands, acacia woodlands and shrublands, and mallee woodlands (see Table GVD.1).

The climate is arid, with mean annual rainfall ranging from <150 mm to 250 mm. Rainfall is aseasonal and highly variable between years. Summers are very hot, with temperatures 30-45^{o}C, and winters are mild, although night temperatures can fall well below 0°C.

[31] Sources: NLWRA (2002) database, Hastwell (2001), Shephard (1995), Barton & Cowan (2001a, 2001b, 2001c)

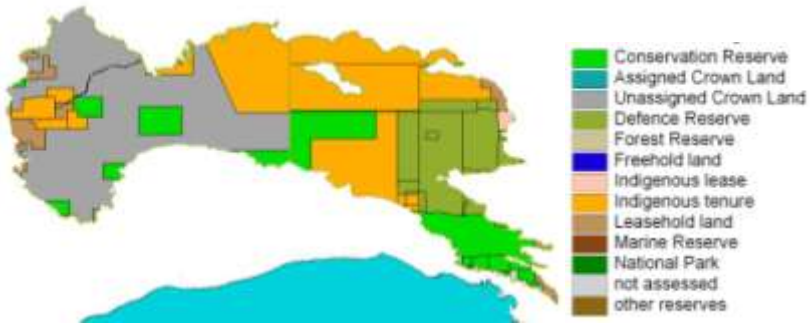
[32] The sandplains were formed "during glacial periods when strong winds redistributed sands eroded from outcropping crystalline basement and sedimentary rocks." Much of it was reworked by westerly winds into west-east dunefields. The exact age of the sands is unknown (Shephard 1995).

[33] Gibber plains are where the soil is covered by a "closely-spaced layer of pebbles, and glazed with a thin wind-polished layer of iron oxides" (Hastwell 2001). They are typically almost devoid of vegetation, except after rain when there may be a dense cover of ephemeral species.

LAND USES, PEOPLE & INSTITUTIONS[34]

Dominant land uses are traditional Aboriginal use and conservation (see Figure GVD.2). Less dominant uses are pastoralism, mining and defence. Some pastoral leases are owned by mining companies and only lightly stocked. Pastoralism is unviable over most of the area and carried out mainly on the eastern, western and southern fringes. There has been considerable mining exploration in the area. There was also a weapons testing range and nuclear weapons test sites, which were significantly contaminated.

FIGURE GVD.2: LAND TENURE



The focus area is very sparsely populated, mostly by Aboriginal people. There is evidence of Aboriginal occupation by 20-24,000 years ago. With European colonization, there were forced, as well as voluntary, movements of Aboriginal people from their lands, There are about 10 major Indigenous language groups within the focus area, including the Mandjidja, Nakako, Ngatatjara, Yankunytjatjara and Pitjantjatjara peoples. Title has been recognised over a large proportion of the focus area and a few outstations have been established. Representative bodies are the Pitjantjatjara Council and the Maralinga Tjarutja (in SA), and the Ngaanyatjarra Council (in WA).

CONSERVATION VALUES

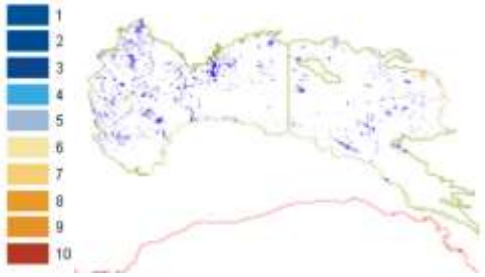
Having escaped the intense development pressure of southern and coastal Australia, this focus area has a largely natural landscape with ecological processes functioning at the landscape scale. There is outstanding lizard diversity; however, there has been significant loss of biodiversity values with many extinctions in the mammal fauna.

[34] Sources: Shephard (1995), AIATSIS (2005), NNTT (2006)

FIGURE GVD.3: VEGETATION CONDITION (VAST)

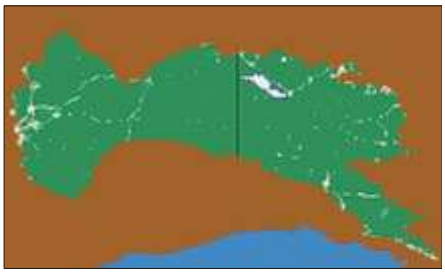
Source: Thackway & Lesslie (2005)

FIGURE GVD.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE GVD.5: WILDERNESS QUALITY (NWI)



High quality wilderness

Source: Lesslie & Masslen (1995)

In the assessment of landscape health by Morgan (2001), the Great Victoria Desert rated well, with four bioregions in the lowest stress class (near pristine) and two in the second lowest (see Table GVD.2). Note that the assessment did not include the effects of fire.

Minimal vegetation has been cleared, and vegetation condition (again without reference to fire) is virtually all 'high quality' (see Figure GVD.3).

Watercourses (a few creek systems that flow intermittently) are mostly in good condition with high natural integrity (see Figure GVD.4). The average subregional condition of riparian zones is unknown except for the Shield subregion (GVD1), where it is considered 'fair (recovery requires significant intervention)', with the trend declining (NLWRA 2002 database) (see Table GVD.2). The threats include grazing pressure, feral animals, changed fire regimes, and changed hydrology from dewatering of mines and lowering of water tables.

Finally, in the National Wilderness Inventory, most of the focus area was assessed as having high wilderness quality (see Figure GVD.5). The more recent Wilderness Delineation for the South Australian portion shows a similar pattern.

TABLE GVD.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE AND RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best, 5 unknown)
GVD 1/2/3	6/5/6	0	2/5/5
GVD 4/5/6	5/6/6	0	5/5/5

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

BIODIVERSITY VALUES

Along with the rest of inland Australia, the focus area has had a climatically turbulent recent history, with cycles of extreme aridity during ice ages, the most recent only 10-18,000 years BP. Thus, most of the present ecosystems are relatively young.

There are just five regional ecosystems considered threatened: three types of acacia woodland, yellow sandplain communities and assemblages of the Queen Victoria Spring (by dewatering) (NLWRA 2002 database).

There is a biogeographically significant corridor of almost unbroken mallee across the Great Victoria Desert, which functions to link some mallee-inhabiting fauna from south-eastern and south-western Australia (Shepherd 1995). Plant diversity is quite high. In the Queen Victoria Spring Nature Reserve (in WA), for example, there are 552 species of vascular plants (Langlands et al. 2006) and in the Yellabinna subregion there are 691 plant species (NLWRA 2002 database).

Most outstanding is the lizard diversity, one of the world's richest (Shephard 1995). In the WA portion there are about 100 reptile species. There is a similar level of richness in the eastern section, with 95 species recorded, and well over 100 species all up. On one sandridge alone, 47 reptile species were found. At least a dozen factors contribute to this diversity, including fire to generate a patchwork of habitats in various states of recovery (Haydon et al. 2000).

The mammal fauna *was* diverse, but has been substantially whittled by extinctions, with almost total loss of medium weight species, and many others threatened. As shown in Table GVD.3 about one-third (16 species) of the original mammal species are thought to have disappeared since European colonization and five species are listed as threatened.

TABLE GVD.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	7	13 1 endangered 8 vulnerable	
Birds		8 3 vulnerable	Threatened species include 1 parrot, 1 malleefowl, 1 thornbill, 1 bustard, 1 cockatoo, 1 kite, 1 grasswren, 1 button-quail. The bird fauna is typical of this climatic zone & has the highest proportion of Australian endemics.
Reptiles	5	1 1 vulnerable	Threatened species is a skink. The 5 endemics are 2 dragons, 2 skinks, 1 blind snake.
Mammals		5 2 endangered 3 vulnerable	Threatened species include 3 dasyruids, 1 macropod, 1 bat
Regionally extinct species	Golden bandicoot (*Isoodon auratus*) Desert bandicoot (*Perameles eremiana*) Pig-footed bandicoot (*Chaoropus ecaudatus*) Bilby (*Macrotis lagotis*) Lesser bilby (*M. leurura*) Burrowing bettong (*Bettongia lesueur*) Woylie (*B. penicillata*) Mala (*Lagorchestes hirsutus*) Crescent nailtail wallaby (*Onychogalea lunata*)		Lesser stick-nest rat (*Leporillus apicalis*) Greater stick-nest rat (*L. conditor*) Long-tailed hopping mouse (*Notonys longicaudatus*) Djoongari (*Pseudomys fieldi*) Plains mouse (*P. australis*) Brush-tailed possum (*Trichosurus vulpecular*) Western quoll (*Dasyurus geoffroii*) Numbat (*Myrmecobius fasciatus*) Ghost bat (*Macroderma gigas*)
Richness & endemism statistics	686 plants (Yellabina region, 1987) / 33 mammals (WA) / 101 reptiles (WA) / 95 lizards (NT) / 6 frogs (WA) / 178 birds / 18 WA endemic mammals, reptiles, frogs		

Sources: NLWRA (2002) database, Morton et al. (1995), Shephard (1995), How & Cowan (2006), Birds Australia (2002) database, Copley & Kemper (Copley & Kemper 1992)(1992), Menkhorst & Knight (2001).

Note: In some cases the former existence of a species in the focus area may be speculative. Endemic species in WA or NT may exist elsewhere in Australia.

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Ecological refugia include the Serpentine Lakes (in the Unnamed Conservation Park) (Morton et al. 1995). Breakaways and ranges probably also act as refugia (Barton & Cowan (2001).

Human-induced refugia would include refuges from destructive fire and pests, perhaps in relatively inaccessible sites in the most rugged parts of the ranges. It also includes most of the Great Victoria Desert, which has not been grazed by cattle.

Significant wetlands: There is one wetland in the focus area listed in the Australian Directory of Important Wetlands: the Yeo Lake and Lake Throssell complex. Its condition is good, and improving due to removal of stock (McKenzie et al. 2002).

Other significant features: The Serpentine Lakes, a >100 km long chain, as well as other saline playas, are geologically interesting as remnant landforms from ancient (perhaps 50 million year old) river systems.

ECOLOGICAL PROCESSES

Key ecological processes for the arid zone have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches or refugia have been degraded by grazing or fire.

Hydroecology: Largely intact.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes.

THREATS

The major threats are feral animals (foxes, cats, camels and rabbits); and changed fire regimes (with infrequent, extensive wildfires now the norm) (see Table GVD.4).

TABLE GVD.4: MAJOR THRATS

Threats	Impacts	Comments
Altered fire regimes	Change from Aboriginal mosaic burning to occasional extensive wildfires. • Increased homogeneity of burning history, with reduced patchiness & thus reduced habitat & resources for some fauna • Destruction of fire-sensitive vegetation • May have contributed to decline/loss of fauna	Traditional Aboriginal burning is thought to have caused a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. With the loss of traditional management, the regime is more infrequent & extensive with large-scale wildfires. Haydon et al. (2000) found that from 1972-91, 2–5% of the landscape burned each year, and that average fire return was not less than 20 years.
Feral animals	• Predation pressure on mammals, birds, lizards by foxes & cats; implicated in extinction of mammals (Smith & Quin). Predation pressure increased due to build-up, then decline, of mice as prey (ibid) • Degradation of vegetation & water points by rabbits, camels, cattle	Ferals include camels, cats, foxes, dogs, cattle, rabbits, goats, house mice. Rabbit populations have been reduced by calicivirus.
Grazing	Some areas on the GVD fringes degraded by grazing: • Degradation of fertile areas & wetlands • Changes in vegetation, eg. loss of palatable perennials.	Pastoral leases exist only on the fringes of the GVD—the heartland has not been grazed (& is almost free of exotic plants).
Other	Localised degradation caused by mining, defence & tourism: • Contamination by nuclear weapons testing • Degradation through road-building & increased popularity of 4WD driving.	Nuclear weapon tests were conducted at Maralinga and Emu by the UK from 1953-1963. Sites were contaminated with radionuclides, with the presence of plutonium-239 of great concern. There was a rehabilitation program, but questions about its effectiveness (Shephard 1995). Also, disturbance with the Woomera rocket & weapons testing range (ibid)

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

There are some large national parks in this focus area, and as a consequence it is considered a low priority for the National Reserve System (see Table GVD.5). The poetically named 'Unnamed Conservation Park' has been proclaimed a Biosphere Reserve.

TABLE GVD.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehensiveness I-IV (%)	Comprehensiveness V-VI (%)	Manag't Standard	NRS priority (1-5, 5 lowest)
5,883,099 (14%)	4,436,236 (11%)	44	?	Fair/good	5

Source: Sattler & Glanznig (2006)

There are also two Indigenous Protected Areas in the GVD: the 700,000 ha Walakara IPA and the 1.28 million ha Watarru IPA (which is also partially in the Central Ranges bioregion). They are Anangu Pitjanjatjara lands.

POLICIES, PLANS & PROGRAMS

There are very few conservation-focused plans, policies or programs outside reserves in this focus area (see Table GVD.6). The only predator control has been some aerial dingo baiting in pastoral areas (McKenzie et al. 2002). Fire management is very limited. The Spinifex Agreement between the Western Australian government and the Pila Nguru (Aboriginal Corporation) will see more lands in the area managed for conservation (Barton & Cowan 2001a, Barton & Cowan 2001c).

TABLE GVD.6: VARIOUS PLANS, POLICIES & PROGRAMS

Plan/policy/strategy/program
CALM Regional Management Plan, incorporating the WA part of GVD – addresses land & wildlife conservation issues, but is not specific to the bioregion
Plans of Management for national parks
Spinifex Agreement—between WA government & the Pila Nguru (Aboriginal Corporation) - all lands associated with this agreement will be managed for conservation

CONSERVATION CAPACITY

Indigenous Conservation: Management on Aboriginal lands is constrained by lack of resources and lack of people on country, although there has been some development of outstations in the focus area. We are unaware of any formal Aboriginal land management groups.

Advocacy conservation groups: We know of no recent advocacy work in this region. .

Private land conservation groups: We know of no private land conservation group work in the Great Victoria Desert

Other institutional capacity: Half the subregions have some identified capacity for conservation-focused natural resource management (NLWRA 2002 database). There is a recently established Desert Knowledge Cooperative Research Centre, with research projects focused on sustainable livelihoods and business opportunities; viable desert settlements, and economic flows and institutions (McAllister & Stafford Smith 2006).

ADEQUACY OF INFORMATION

There have been patchy biodiversity studies, as well as assessments of biota on current and proposed reserves, but no systematic biological surveys (McKenzie et al. 2002). There is little fine scale floristic data available and limited information about “habitat requirements of virtually all invertebrate species, most ephemeral plants, persisting critical weight range mammals and uncommon vertebrate and plant species”, nor is there “data to provide a regional context on life-history (including population trend) of any species, even rabbits, and no quantitative data on the affect of exotic predators, introduced herbivores or weed colonisation” (ibid).

NULLARBOR PLAINS

GENERAL DESCRIPTION

The Nullarbor Plains focus area covers 197 000 km^2 in South Australia and Western Australia. The focus area is equivalent to the IBRA bioregion of the same name (NUL), as well as the ecoregion of the same name delineated by WWF (Hopkins 2001d).

FIGURE NUL.1: LOCATION OF NULLARBOR PLAINS

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[35]

The Nullarbor Plain is mostly a vast, flat, treeless plain, of Tertiary limestone with shallow calcareous soils. There are also sand plains and sand dunes, and occasional breakaways and quartzite hills. There are salt lakes, and other remnant landforms of an ancient paleodrainage system. This system flows into a large karst system of caves, and subterranean rivers and lakes. Significant features include 'shallow surface depressions (the donga, ridge and corridor terrain), collapse dolines, blowholes, drip pits, rillenkarren, rundkarren, pavements, solution pans and rockholes. Where the Nullarbor Plain borders the Great Australian Bight to the south, there are sandy beaches and cliffs.

NUL.1: DOMINANT VEGETATION GROUPS (KM^2)

Chenopod groups	Mallee	Eucalypt open woodland	Casuarina forests & woodlands	Acacia forests & woodlands
167,989	15,103	4,886	2,297	2,226

Source: NLWRA (2001)

The Nullarbor is best-known for its lack of trees, due to calcareous soils as well as aridity. The dominant vegetation is chenopod groups, covering about 85% of the area (see Table NUL.1). This consists of bluebush and saltbush—small, drought-resistant and salt-tolerant shrubs. On peripheral areas are woodlands of mallee, other eucalypts, casuarinas and acacia (in total about 12%).

The climate is arid and aseasonal, with average rainfall of 150-200mm. However, rainfall is erratic, and most years experience much less than the average. Summers are hot, and winters are mild, with cold nights.

[35] Sources: NLWRA (2002) database; McKenzie et al. (2002)

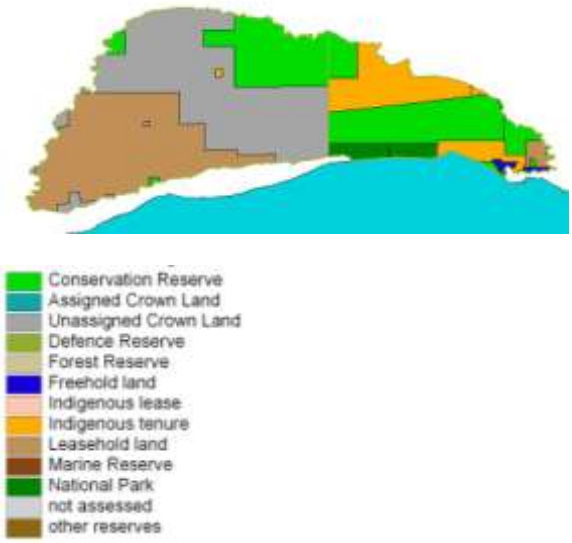
LAND USES, PEOPLE & INSTITUTIONS[36]

Dominant land uses include sheep grazing, traditional Aboriginal uses and conservation. About one-third of the area is pastoral leases (mostly in Western Australia on the coastal edge), and there are also considerable areas of unallocated Crown land (see Figure NUL.2).

Pastoralism was first established in 1858, but many enterprises have been developed only recently, in the 1960s.

There are at least two major Indigenous language groups in the focus area—the Mirning and Nganganyatara Peoples. A large proportion of the focus area is under native title or under claim. Aboriginal people are represented by the Aboriginal Legal Rights Movement (in SA) and the Ngaanyatjarra Council and Goldfields Land and Sea Council (in WA).

FIGURE NUL.2: LAND TENURE



CONSERVATION VALUES

Having escaped the intense development pressure of southern and coastal Australia, this focus area has a largely natural landscape with ecological processes functioning on a large scale. There is outstanding karst fauna; however, there has been significant loss of biodiversity values with extinctions of a high proportion of the mammal fauna and degradation of vegetation.

LANDSCAPE CONDITION

In the assessment of landscape health by Morgan (2001), the Nullarbor Plains rated well, with all bioregions in the lowest stress class (see Table NUL.2). Note that the assessment did not include the effects of fire. Note also that McKenzie et al. (2002) disagree with the rating, at least for the two subregions in WA, which they assess as being in "poor condition" from habitat modification (due to weeds, fire and feral predators and herbivores).

TABLE NUL.2: LANDSCAPE HEALTH AND VEGETATION CLEARANCE

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best, 5 unknown)
NUL 1/2/3	6/6/6	0	3/5/5

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

[36] Sources: NLSWRA (2002); Woinarski et al. 2000; McKenzie et al. (2002), AIATSIS (2005), NNTT (2006)

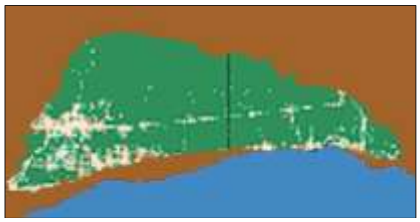
FIGURE NUL.3: VEGETATION CONDITION (VAST)

Source: Thackway & Lesslie (2005)

FIGURE NUL.4: RIVER CONDITION

Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE NUL.5: WILDERNESS QUALITY (NWI)



Source: Lesslie & Masslen (1995)

Minimal vegetation has been cleared, and vegetation condition (again without reference to fire) is mostly 'high quality', although a considerable portion of the grazed area in the south-west has been classed as 'modified' (see Figure NUL.3).

The scarce creek systems are in good condition with high natural integrity (see Figure NUL.4). The average subregional condition of the very limited riparian habitat is good or unknown (NLWRA 2002 database) (see Table NUL.2).

Finally, in the National Wilderness Inventory, most of the focus area was assessed as having high wilderness quality, apart from parts of the grazed section (see Figure NUL.5). The more recent Wilderness Delineation for the South Australian portion shows a similar pattern.

BIODIVERSITY VALUES

There are specific conservation values, particularly associated with the karst system, but also pervasive and refugial values due to the lack of gross landscape modification. The Nullarbor Plains is known for its rich troglobite and troglophile fauna, but has lost a significant proportion of its mammal fauna. In 1992, the Commonwealth Government commissioned a report on the suitability of the Nullarbor region for World Heritage listing. Because the proposal was not supported by the WA Government, it did not progress.

Along with the rest of inland Australia, the focus area has had a climatically turbulent recent history, with cycles of extreme aridity during ice ages, the most recent only 10-18,000 years BP. Thus, most of the present ecosystems are relatively young.

Just one regional ecosystem in the focus area is considered threatened: the wetlands in subregions NUL 1 and 2.

The karst system is the largest in the world, and supports rich communities, in particular of troglobites and troglophiles. Most are endemic to individual systems as they have had no means of dispersal. The invertebrates, six listed as threatened under state legislation, are threatened by human use of the caves (McKenzie et al 2002). The caves are important not only for existent wildlife, but for what they tell about past wildlife. Sub-fossil deposits have facilitated the reconstruction of past fauna composition.

Apart from the cave fauna, the Nullarbor Plains is considered to be relatively species poor, however knowledge is incomplete. (McKenzie et al 2002). There are just two known endemic taxa—the Nullarbor form of the cinnamon quail-thrush and the Nullarbor bearded dragon (McKenzie et al 2002). In this area, many western species are at their eastern limit and vice versa for eastern species.

The mammal fauna *was* diverse, but has been substantially whittled by extinctions, with almost total loss of medium weight species, and many others threatened. Almost half of the original mammal fauna, 25 species, are thought to have disappeared since European colonisation (ibid), and 10 species are listed as threatened (see Table NUL.3). One bird species is also regionally extinct.

TABLE NUL.3: SIGNIFICANT SPECIES

Group	Endemic taxa (species & subspecies)	Threatened taxa: federal & territory / federal listings	Comments
Plants		4 1 vulnerable	
Birds	1	6 4 vulnerable	Threatened species include 1 parrot, 1 malleefowl, 1 thornbill, 1 grasswren, 1 cockatoo, 1 stone-curlew. Endemic subspecies of quail-thrush. Bird fauna is typical of the climatic zone, but some species have been lost.
Mammals		10 3 endangered 7 vulnerable	Threatened species include 4 dasyruids, 3 rodents, 2 bandicoots, 1 bat
Invertebrates		6 -	5 cave spiders & 1 cave isopod are listed as vulnerable in SA
Regionally extinct species	Desert bandicoot (*Perameles eremiana*) Western-barred bandicoot (*P. bouganville*) Pig-footed bandicoot (*Chaoropus ecaudatus*) Bilby (*Macrotis lagotis*) Burrowing bettong (*Bettongia lesueur*) Woylie (*B. penicillata*)	Crescent nailtail wallaby (*Onychogalea lunata*) Lesser stick-nest rat (*Leporillus apicalis*) Greater stick-nest rat (*L. conditor*) Western mouse (*Pseudomys occidentalis*) Djoongari (*P. fieldi*) Long-tailed hopping mouse (*Notonys longicaudatus*) Western quoll (*Dasyurus geoffroii*)	
Various statistics	794 plants / 392 vertebrates (1984 survey) / 18 mammals (WA) / 75 reptiles (WA) / 86 reptiles (1984 survey) / 249 birds (1984 survey) / 178 birds (bird atlas) / 5 frogs (WA) / 11 WA endemic mammals, reptiles, frogs		

Sources: NLWRA (2002) database, Woinarski et al. (2000), Menkhorst & Knight (2001).

Note: In some cases the former existence of a species in the focus area may be speculative.

SIGNIFICANT REFUGIA/LANDSCAPE FEATURES

Evolutionary refugia include several caves hosting relictual and endemic invertebrates, such as crustaceans, centipedes, cockroaches, carabid beetles, Orthopterans, Pseudoscorpions and spiders (Morton et al. 1995; McKenzie et al. 2002).

Ecological refugia would include the caves also, as well as wetlands, both subterranean and surface.

Significant wetlands: There are no wetlands listed in the Australian Directory of Important Wetlands, although there are a number of regionally important wetlands.

ECOLOGICAL PROCESSES

Key ecological processes for the arid zone have been identified and exemplified in the biome introduction. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches or refugia have been degraded by grazing, fire or weeds.

Hydroecology: Largely intact.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing, weeds and altered fire regimes.

THREATS

The major threats are feral animals (foxes, cats, camels and rabbits), stock (sheep), weeds, and changed fire regimes (infrequent, extensive wildfires) (see Table NUL.4). Native vegetation cover has been replaced over large areas by Ward's weed.

TABLE NUL.4: MAJOR THREATS

Threats	Impacts	Comments
Altered fire regimes	Change from Aboriginal mosaic burning to occasional extensive wildfires: • Increased homogeneity of burning history, with reduced patchiness & thus reduced habitat & resources for some fauna • Destruction of fire-sensitive vegetation • Likely to have contributed to decline/loss of fauna	Traditional Aboriginal burning is thought to have caused a fine-scale mosaic of patches with different fire histories creating sufficient heterogeneity to provide resources for wildlife with different needs. With the loss of traditional management, the regime is more infrequent & extensive with large-scale wildfires.
Feral animals	• Degradation of vegetation by rabbits—eg. 1974 pasture assessment found 40% of WA section in poor condition due to rabbits, fire & drought (Woinarski et al. 2000). Large-scale elimination of perennial shrubs due to ringbarking by rabbits (ibid, citing Beard 1975). • Predation pressure on mammals, birds, lizards by foxes & cats; implicated in extinction of mammals (Smith & Quin). Predation pressure increased due to build-up, then decline, of mice as prey (ibid) • Degradation of water points by camels	Ferals include camels, cats, foxes, dogs, rabbits, house mice. Rabbits were common enough to support a rabbit skin & meat industry until recently (McKenzie et al. 2002)—populations have been reduced by calicivirus.
Weeds	• Displacement of large areas of native vegetation by Ward's weed & other exotic plants.	At least 65 weed species (Woinarski et al 2000).
Grazing	Considerable portions in the south-west have been degraded by sheep grazing: • Substantially modified habitat, spread of weeds. • Degradation of fertile areas & wetlands • Changes in vegetation, eg. loss of palatable perennials.	
Other	Localised degradation caused by tourism: • Damage to caves	

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

There are some large protected areas in the Nullarbor Plains, and the bioregion is considered only moderate priority for the National Reserve System (see Table NUL.5). Management is considered only fair because biodiversity values and management issues are poorly identified, weeds and degradation are widespread, and there is no wildfire management (Sattler & Glanznig 2006).

There is also one Indigenous Protected Area— Yalata IPA, covering about half a million hectares on the edge of the Nullarbor Plain.

TABLE NUL.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehen siveness I-IV (%)	Comprehen sivenessV-VI (%)	Manag't Standard	NRS priority (1-5, with 5 lowest)
3,576,772 (18%)	3,035,147 (15%)	44	?	Fair/good	3

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

There are few conservation-focused plans, policies or programs outside reserves in this focus area (see Table NUL.6). Fire management is almost nonexistent. There is one major project, *East meets West,* implemented through NatureLinks, which is focused on managing biodiversity from Eyre Peninsula through the Nullarbor Plain and Great Victoria Desert to Western Australia by reconnecting habitat and integrating management of terrestrial, coastal and marine habitats. The Spinifex Agreement between the WA government and the Pila Nguru (Aboriginal Corporation) will see some lands in the area managed for conservation (Barton & Cowan 2001d).

TABLE NUL.6: PLANS, POLICIES & PROGRAMS

Plan/policy/strategy/program
CALM Regional Management Plan, incorporating the WA part of NUL – addresses land & wildlife conservation issues, but is not specific to the bioregion
Plans of Management for national parks
Spinifex Agreement: between WA government & the Pila Nguru (Aboriginal Corporation) - all lands associated with this agreement will be managed for conservation
East meets West project, NatureLinks: integrated biodiversity management & restoration of habitat

CONSERVATION CAPACITY

Advocacy conservation groups: We are unaware of any recent advocacy work.

Private land conservation groups: We know of no activity on the Nullarbor Plains from private land conservation groups.

Indigenous Conservation: Management on Aboriginal lands is constrained by lack of resources and lack of people on country, although there has been some development of outstations in the focus area. We are unaware of any formal Aboriginal land management groups.

Other institutional capacity: Just one of the subregions has been identified as having some capacity to integrate conservation within existing natural resource management processes (NLWRA 2002 database).There is a recently established Desert Knowledge Cooperative Research Centre, with research projects focused on sustainable livelihoods and business opportunities; viable desert settlements, and economic flows and institutions (McAllister & Stafford Smith 2006).

ADEQUACY OF INFORMATION

There was a bioregional survey in 1984, which provided substantial information about the focus area. There is no fine-scale vegetation mapping, and there is need for more comprehensive surveys of flora and fauna, better understanding of habitat requirements and life history of most species, and effects of exotic predators, weeds and fire (McKenzie et al. 2002).

BIOME INTRODUCTION: MEDITERRANEAN WOODLANDS

Globally, the Mediterranean biome (woodlands, forests and scrub) is under severe pressure. According to analysis by TNC scientists, the biome has the second highest conservation risk index of the 13 global terrestrial biomes (Hoekstra et al. 2004). This is due to the combination of extensive habitat loss—more than 40% has been transformed to alien species—and under-protection—just 5% is protected.

The Australian examples of this biome—including the Murray-Darling Woodlands and Mallee, the Southwest Australia Savanna, the Jarrah-Karri Forest and Shrublands, Esperance Mallee**,** and the Great Western Woodlands—are mostly consistent with this global pattern. Only the last of these is still relatively intact, the others having been subjected to heavy logging and agricultural pressure.

Because of the severe pressure on this biome globally, of all countries Australia now has the largest remaining wild Mediterranean ecosystems (based on a comparison of the remaining areas meeting a defined threshold of minimal human influence) (CIESIN & WCS 2003).

In this paper we consider conservation values, threats and opportunities in this one and only relatively natural Mediterranean woodland. In this introduction to the biome, we consider the biological history and ecological processes common to these areas, focused particularly on the southwest which retains the most intact Mediterranean ecoregions in Australia

BIOLOGICAL HISTORY

There has been a long trend towards aridity in Australia, since the Oligocene/Miocene. Among many changes, this has facilitated the rise of open woodlands and heathlands at the expense of closed forests, and the speciation of more arid-adapted plant families like myrtaceae, proteaceae and mimosaceae. Although the Mediterranean climate has probably been present for about 20 million years (Hopper & Gioia 2004), in recent geological history (the late Pleistocene) there have been rapid climate fluctuations with ice ages coming and going, causing range changes and extinctions across Australia.

In contrast to this climatic history, the geological history in the southwest of Western Australia has been stable for a very long time. The landscapes are ancient, with some of the world's oldest rocks. The flat southwest has been eroding away for millions of years, flattening ranges and leaching the soils of nutrients. There is now a complex mosaic of soil types due to erosion of lateritic landforms (Watson et al. in press).

One of the major challenges in understanding the history of the Mediterranean biome, at least in the southwest, is to explain the rich, endemic flora. In what is classed the Southwest Australian Floristic Region, a total of 7380 native taxa have thus far been documented (although far from all described). This is expected to increase to at least 8000 native species with ongoing taxonomic surveys (Hopper & Goia 2004). About half of these are endemic to the region (ibid). For this richness and endemicity the region has international significance—and has been deemed one of 25 global biodiversity hotspots (Myers et al. 2000).[37]

The origins of the flora are antique, variable and complex (Hopper & Goia 2004). Geological stability—the southwest is amongst the oldest unglaciated regions on Earth—has allowed "exceptional opportunities for continuous terrestrial evolution." Lineages have originated within and from outside the area and at a range of times from the Carboniferous to the late Cenozoic. Many of the lineages of great antiquity have low dispersal

[37] Hotspots were selected on the basis of exceptional numbers of endemics and exceptional loss of habitat.

capabilities, resulting in narrow geographic ranges and high species turnover in the landscape. They cope with rarity in naturally fragmented populations with "complex interplays between chromosomal systems and ecological adaptation". Because of the rich diversity and the relative similarity of the current flora with the Pliocene flora, it seems that the plants probably escaped comparatively unscathed from Quaternary ice ages, with far fewer extinctions than was the norm in temperate regions elsewhere in Australia or overseas. Other contributing factors to the richness include soil variability and isolation, with the Nullarbor Plain forming an arid barrier between east and west movement. While other factors are yet to be understood, it is clear that the area "exemplifies plant evolution in temperate environments at its most sophisticated and durable" (ibid).

Vertebrate endemism and richness are low by comparison, although there are quite high levels of endemism in frogs, freshwater fish and reptiles (Wardell-Johnson & Horwitz 1996). Bird richness (and endemism) are low in comparison to structurally similar forests in southeastern Australia. This is partly because of low ecosystem productivity but also due to extinctions during periods of extreme Pleistocene aridity (ibid). Most of the birds found in southwest Australia are either habitat generalists or tend to be widespread.

ECOLOGICAL PROCESSES

Soule and colleagues (2004) highlight the importance for conservation of understanding and accommodating large-scale and long-term ecological processes that sustain natural systems. They review seven categories of ecological phenomena that:

> require landscape permeability and that must be considered when planning for the maintenance of biological diversity and ecological resilience in Australia: (1) trophic relations at regional scales; (2) animal migration, dispersal, and other large scale movements of individuals and propagules; (3) fire and other forms of disturbance at regional scales; (4) climatic variability in space and time and human forced rapid climate change; (5) hydroecological relations and flows at all scales; (6) coastal zone fluxes of organisms, matter, and energy; and (7) spatially dependent evolutionary processes at all scales.

In most Mediterranean woodlands in Australia and globally, landscape permeability—necessary for exchanges of energy, water and nutrients, and plant and animal interchange, between both contiguous and distant locations at diverse scales—has been greatly compromised by gross disturbance.

Here we briefly consider aspects of the seven categories of ecological processes to demonstrate their relevance to designing conservation approaches for the one Mediterranean focus area. There is still much to understand about these systems.

CRITICAL SPECIES INTERACTIONS

Critical species have a major impact on the habitat in which they live —those major ecological players referred to as 'keystone' or 'strongly interacting' species. Their decline or disappearance is often felt in the ecosystem at large, and may initiate ecological chain reactions or trophic cascades (Soule et al. 2004).

Some of the critical species in the Mediterranean biome include:

- Pollinators, such as honeyeaters, parrots, possums and insects, and seed dispersers, such as birds and ants
- Dingoes, which suppress cat and fox populations
- Cavity creators, such as termites, that create habitat for other species

- Termites and ants, for energy flow and nutrient recycling.
- Plants that provide food—nectar, fruit and seeds—during resource bottlenecks, such as eucalypts flowering during autumn
- Burrowing animals, such as bilbies, bettongs, and malleefowl, that influence water infiltration and nutrient distributions in soil

LONG DISTANCE BIOLOGICAL MOVEMENT

It is important to conserve the capacity in Mediterranean woodlands for large-scale biological movements. Because of the variability in productivity of most Australian biomes, a large proportion of species must migrate or disperse during at least part of their life-cycle. For example, a large proportion of the birds is nomadic and track ephemeral or seasonal resources. The conservation of such species requires protection of each of their required habitats as well as patches that serve as 'stepping stones' for long-distance movements (Soule et al 2004). It is also critical to protect ecological refugia that provide resources for mobile species during times of stress (Morton et al. 1995).

Key long-distance movements in Mediterranean biomes in Australia include those of:

- Nectarivorous birds tracking different nectar resources in time and space.
- Waterbirds following heavy rainfall events.
- Arid zone birds moving into the more mesic Mediterranean ecosystems during times of drought in semi-arid and arid areas.

DISTURBANCE

Disturbance is natural and inevitable, and important for maintaining species diversity in Mediterranean woodlands. However, anthropogenic disturbance is often damaging because it "exceeds the historic range of variability and intensity of natural disturbance regimes" (Soule et al. 2004). For example, changed fire regimes can disrupt processes and connections and cause local and regional extinctions.

Key natural disturbances in Australian Mediterranean systems are:

- Fire regimes, which have probably become much more frequent and destructive since European colonization.
- Flood events, which recharge aquifers, provide key regeneration events for some long lived plants, and provide breeding opportunities for waterbirds.

CLIMATE CHANGE & VARIABILITY

Natural and human induced climate variability and change affects species, their distributions, and their habitats. Global warming will exert considerable pressure on all biomes, and many species are likely to go extinct, particularly when climate change is combined with other anthropogenic pressures, such as those

caused by invasive species, fire and grazing, and due to the loss or degradation of climate refugia. Some of the potential detrimental impacts of human-induced climate change in the Mediterranean woodlands include:

- Range contractions for some native species
- Range expansions for some invasive species and diseases
- Altered fire regimes and more extreme weather events
- Reduced fertility in leaves used by herbivores
- Disruption of key relationships such as pollination

HYDROECOLOGY

Hydroecology refers to the links between water, vegetation and wildlife, including water flows below and above the ground. Moisture underpins landscape productivity, and its significance is amplified where rainfall is as seasonal and variable as it is in many Mediterranean woodlands. In particular, because of the almost total lack of permanent water in the Great Western Woodlands, the spatially and temporally variable availability of water is highly significant in determining whether various fauna persist.

Some of the key hydroecological features in the Mediterranean woodlands are:

- Lack of drainage and permanent water in drier areas, such as the Great Western Woodlands
- Highly saline soils especially in south-west Western Australia, making salinisation of ground water and wetlands a key threat in many areas (Coates & Atkins 2001).

COASTAL ZONE FLUXES

Australian Mediterranean regions are largely remote from the coast. Where they do abut the coast, fluxes are often minimal due to the absence or low level of run-off from the drier land areas.

SPATIALLY DEPENDENT EVOLUTIONARY PROCESSES

Effective conservation must protect landscapes to allow for long term changes in the range of species, and the movement of genes across land and seascapes.

In Mediterranean woodlands maintaining permeability requires protecting, for example:

- Landscape scale connectivity to allow gene flows of plants across landscapes over time.
- Habitat heterogeneity at different scales
- Fire and climate refugia, and geologically stable regions which have been less affected by climatic changes over deep time.

GREAT WESTERN WOODLANDS

GENERAL DESCRIPTION

The Great Western Woodlands focus area covers 140 000 km^2 in Western Australia. It encompasses two IBRA bioregions—Coolgardie (COO) and Hampton (HAM)—and is equivalent to The Coolgardie Woodlands ecoregion delineated by WWF (Hopkins 2001a).[38]

The focus area overlaps the Southwest Australian Floristic Region in the southwest part of the Coolgardie bioregion. It also overlaps a large portion of the Jindaburra area (described in Watson et al. in press).

FIGURE GWW.1: LOCATION OF GREAT WESTERN WOODLANDS

Source: modified from Morgan (2001)

BRIEF BIOPHYSICAL DESCRIPTION[39]

Most of the focus area sits on a very ancient piece of the earth's surface—the 2.4-3.7 billion year old Yilgarn Craton. The geology is predominantly granite-based, with intruding low hills and ranges of greenstone in parallel belts. The Mardabilla subregion is an Eocene marine limestone plain. The Hampton bioregion is mainly of quaternary marine dune systems, with a limestone scarp backing onto the karst system of the Nullarbor Plains.

Having had a stable geological history, much of the focus area is flat or undulating, and highly eroded. There are large sandplains, relieved by laterite breakaways and saline lake playas. The soils are infertile and in a complex mosaic of different types.

There is almost no permanent water in the focus area. An old drainage system is now occluded.

Biologically, the focus area is a rich interzone area, in transition from the Mediterranean climate of the southwest to the arid climate of central Australia. The transition is reflected in the vegetation shifts from shrublands rich in endemic proteaceae in the west to shrublands with endemic acacias in the east. Overall, the vegetation is dominated by eucalypt woodlands and open woodlands, with large areas also of acacia shrublands (see Table GWW.1). The Hampton bioregion is dominated by mallee.

The climate is arid to semi-arid and Mediterranean, with warm, dry summers and cool, wet winters. The predominantly winter rainfall averages 200-300 mm, but is highly variable and unpredictable.

[38] However, there is ambiguity in WWF's designation, with Hampton included in the Coolgardie Woodlands ecoregion on the map, but not in the text.

[39] Sources: NLWRA (2002) database; McKenzie et al. (2002)

GWW.1: DOMINANT VEGETATION GROUPS (KM^2)

Bioregion	Eucalypt woodland	Eucalypt open woodland	Acacia shrublands	Other shrublands	Mallee	Chenopod groups
COO	64,829	16,692	12,138	10,746	1,528	6,186
HAM	-	-	-	-	7,849	2,973
Total	**64,829**	**16,692**	**12,138**	**10,746**	**9,377**	**9,159**

Source: NLWRA (2001)

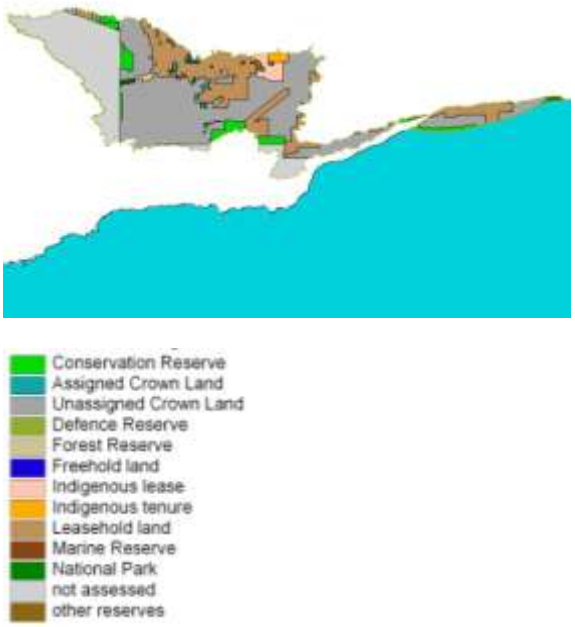
LAND USES, PEOPLE & INSTITUTIONS[40]

About three-quarters of the focus area is vacant crown land. The other major tenure is grazing leasehold, used mostly for sheep-grazing on native pastures (see Figure GWW.2). Some smaller areas have been cleared for dryland cropping and introduced pastures. Conservation is a minor land use.

The most economically significant land use is mining, mostly for gold and nickel. The gold triggered a rush in the late 1880s, which brought 50,000 people and infrastructure development, and also resulted in large-scale logging. Although occupying significant areas, pastoral activities, some only developed since the 1960s, are mostly of marginal economic value. Some pastoral stations have been abandoned, due to the lack of water and also, possibly, the presence of native plants toxic to stock (the gastrolobiums).

The area is sparsely populated, with most of the 30,000 or so people living in towns. There are large areas in the focus area (including in Jindaburra) with very few or no residents.

FIGURE GWW.2: LAND USE



The focus area is the traditional country of at least four major Indigenous language groups—the Ngatjumay, Malpa, Kalaamaya and Mirning Peoples. Much of the focus area is under native title claim. Aboriginal people in the focus area are represented by the Goldfields Land Council.

CONSERVATION VALUES

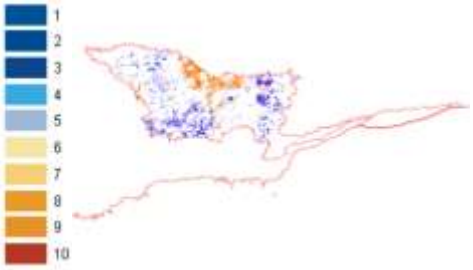
With limited water resources having prevented widespread grazing and intensive development, apart from mining and logging, this focus area has a largely semi-natural landscape with ecological processes functioning at the landscape scale. There is outstanding plant diversity and endemicity. Apart from its intrinsic biodiversity values, the Great Western Woodlands focus area has high global significance for its size and relative intactness. It is the largest and most intact remaining area of Mediterranean woodland and heathland left on earth (Watson et al. in press; M. Looker pers. comm).

[40] Sources: Grant et al. (2002), Gilfillan et al. (2001), Watson et al. (in press), AIATSIS (2005), NNTT (2006)

FIGURE GWW.3: VEGETATION CONDITION (VAST)

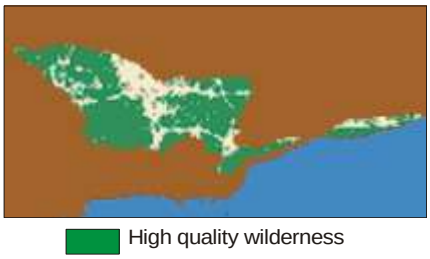
Source: Thackway & Lesslie (2005)

FIGURE GWW.4: RIVER CONDITION



Source: Stein (2006), Stein et al. (2002)
Class 1 is least disturbed.

FIGURE GWW.5: WILDERNESS QUALITY (NWI)



Source: Lesslie & Masslen (1995)

In the assessment of landscape health by Morgan (2001), the Great Western Woodlands rated variably, with Hampton ranked in the highest class, and the Coolgardie subregions in lower classes (see Table GWW.2). However, McKenzie et al. (2002) consider that the Southern Cross subregion (rated in class 4) should in fact be rated 2 (due to grazing, agriculture and emerging salinity problems). Note that the assessment did not include the effects of fire.

Minimal vegetation has been cleared, but vegetation condition (again without reference to fire) is also variable, with close to half rated 'transformed' (see Figure GWW.3).

There are no permanent rivers, but the headwaters of the now occluded drainage system are predominantly in good condition, apart from those in Southern Cross subregion (COO2) (see Figure GWW.4). The few riparian habitats associated with these headwaters are also in good condition (see Table GWW.2) and would recover "if feral herbivores and stock, exotic weeds, changed fire regimes, feral predators and firewood collection could be controlled" (McKenzie et al. 2002). The condition of the one nationally significant wetland is only fair, with recovery requiring significant intervention (ibid).

Finally, in the National Wilderness Inventory, more than half of the focus area was assessed as having high wilderness quality (see Figure GWW.6).

TABLE GWW.2: LANDSCAPE HEALTH, VEGETATION CLEARANCE & RIPARIAN CONDITION

Subregions	Continental Stress Class (1-6, with 6 lowest stress)	% cleared native vegetation	Riparian condition (1-4, with 4 best)
COO 1/2/3	5/4/5	2	5/3/3
HAM 1	6	0	5

Sources: Morgan (2001), NLWRA (2001), NLWRA (2002) database

BIODIVERSITY VALUES

The Great Western Woodlands are indeed great, with outstanding botanical richness and endemicity.[41] As explained in the biome introduction, an array of factors—including geological stability, isolation from eastern Australia, complex soils, antiquity of lineages –have resulted in extremely high plant richness and endemicity in the southwest of Western Australia. The focus area overlaps on its southwest edge with the well-recognised centre of plant richness and endemism in southwest Australia, which is listed among 25 global biodiversity hot spots (Myers et al. 2000).

The other major factor contributing to the area's plant species diversity is that it spans two climatic zones—the wetter southwest and the arid zone. The ranges of many species from the southwest, including some of the endemics, overlap with the ranges of desert species.

There is high diversity of ecological communities, including a number of ecosystems unique to the focus area. Endemic vegetation communities include banded-ironstone hill communities, 21 eucalypt woodland associations, three succulent steppe associations and two acacia associations (McKenzie et al 2002).

More than 40 regional ecosystems are considered threatened (NLWRA 2002 database), and need significant management intervention for recovery. They include (McKenzie et al 2002):

- Ephemeral wetland communities, threatened by exotic herbivores and mining.
- Bluebush, saltbush, and samphire communities on calcareous plains, threatened by grazing, weeds and feral predators, and declining with the spread of Wards weed.
- Granite outcrops, including apron woodlands, herbfields, moss sheet communities, Jam-Sheoak thickets, ephemeral pools aquatics, declining under pressures from human recreation, and rabbits.
- 12 flora complexes of banded ironstone, greenstone and other isolated ranges, grazed by rabbits and subject to mining.
- Valley-floor woodlands of species such as York and salmon gum, which are decimated across most of their West Australian range, and threatened by fire and feral predators.
- Melaleuca scrubs
- 3 mallee formations, threatened by fire and feral predators

There are no threatened regional ecosystems identified in Hampton, but chenopod communities are at risk due to accelerating colonization by Wards weed (Gilfillan et al. 2001).

For the Jindaburra portion alone, there are records of 2 473 flowering plant species from 103 families, and over 2860 different taxa (subspecies, hybrids, varieties and possible new species), representing about one-sixth of Australia's flowering plant species (Watson et al. in press).

Plant diversity and endemicity are particularly high in the eucalypts and acacias. The Eastern Goldfields subregion alone has up to 170 eucalypt species, and is one of three top subregional sites for eucalypt endemism (NLWRA 2002; NLWRA 2002 biodiversity database). The area is also very rich in acacias—COO2 and COO3 each have >100 species.

Other special botanical features are the coastal dune communities of the Roe Plain (Hampton), with a number of endemic species, and the diverse ephemeral flora communities of Tertiary sandplain scrubs and of valley flood woodlands (NLWRA 2002 database).

[41] Note that some of the information comes from a report on the Jindaburra Wilderness (Watson in press), which encompasses only part of the Coolgardie bioregion as well as part of the Mallee bioregion.

TABLE GWW.3: SIGNIFICANT SPECIES

Group	Endemic taxa	Threatened taxa: federal & territory / federal listings	Comments
Plants	COO: 31-50 eucalypts & acacias HAM: 3	22 10 endangered 12 vulnerable	Threatened plants include 6 eucalypts, 2 acacias. There are >40 threatened regional ecosystems.
Birds		3 1 endangered 2 vulnerable	Threatened birds include 1 cockatoo, 1 malleefowl, 1 thornbill. Bird diversity is considered quite low. Coolgardie bioregion has a high proportion of Australian endemics.
Reptiles	At least 7		
Mammals		7 1 endangered 6 vulnerable	Threatened mammals include 1 bandicoot, 3 dasyurids, 3 rodents
Invertebrates	many	3	3 cave invertebrates (2 spiders, 1 isopod) are listed under WA legislation. Many cave invertebrates would be endemic, but are unknown.
Regionally extinct species	Greater stick-nest rat (*Leporillus conditor*) Lesser stick-nest rat (*L. apicalis*) from COO Long-tailed hopping-mouse (*Notomys longicaudatus*) from COO Desert mouse (*Pseudomys desertor*) from COO Western mouse (*P. occidentalis*) from both Djoongari (*P. fieldi*) from COO Plains mouse (*P. australis)* from HAM Western chestnut mouse (*P. nanus)* from COO Pale field-rat (*Rattus tunneyi*) from COO Greater bilby (*Macrotis lagotis*) from both Western barred bandicoot (*Perameles bougainville*) from HAM		Numbat (*Myrmecobius fasciatus*) from COO Western quoll (*Dasyurus geoffroii*) from both Burrowing bettong (*Bettongia lesueur*) from COO Woylie (*B. penicillata*) from both Crescent nail-tail wallaby (*Onychogalea lunata*) from COO Diel's Wattle (Acacia prismifolia) from COO Short-leaved Frankenia (Frankenia parvula) from COO Masked Owl (*Tyto novaehollandiae*) from HAM
Various statistics	COO: 34 mammals / 126 reptiles / 13 frogs / 191 birds / 55 WA endemic mammals, reptiles, frogs HAM: 15 mammals / 46 reptiles/ 0 frogs / 204 birds / 7 WA endemic mammals, frogs, reptiles		

Sources: NLWRA (2002) database, How & Cowan (2006), Birds Australia (2002) database, Menkhorst & Knight (2001)

Note: In some cases the former existence of a species in the focus area may be speculative.

The vertebrate fauna has standout reptile diversity with at least 126 species in the Coolgardie bioregion (How & Cowan 2006). But a large proportion of the original mammal fauna is regionally extinct—>40% of Coolgardie's and about 70% of Hampton's (McKenzie et al 2002). Of 43 original species (this tally is based on evidence from subfossil material and early collections) there are now thought to be just 13 in Hampton (ibid). However, there may be more mammals in the focus area than officially recorded, with Watson et al. (in press) compiling a list of 50 mammal species for Jindaburra based on a range of sources, 14 more than recorded by the Western Australia Museum.

The largely unknown invertebrate fauna is likely to be very rich. Watson (ibid) notes that a recent survey of the Wheatbelt found 800 new spider species. Caves in the Mardabilla subregion and Hampton are known as, or likely to be, centres of endemism for stygofauna (Gilfillan et al. 2001, Grant et al. 2002). See Table GWW.3.

SIGNIFICANT REFUGIA & LANDSCAPE FEATURES

Evolutionary refugia include caves, where invertebrates have evolved in isolation. Given the endemic and relictual plants in the focus area, much of it must be considered refugial, particularly sites of endemism in the ranges.

Ecological refugia include the Rowles Lagoon system of wetlands—the largest semi-permanent freshwater complex in the area, providing habitat for 41 species of waterbirds (more than any other southern arid zone wetland in WA)—and Swan Lake, a semi-permanent freshwater lake that often persists when other water bodies have dried up (Cowan 2001).

Human-induced refugia include all the woodland areas for fauna. The adjacent wheatbelt areas to the west and south have been almost entirely cleared. As the largest remaining temperate woodland in Australia, the Great Western Woodlands have large and intact populations of many species which are regionally extinct or declining elsewhere on the continent (Duncan et al. 2006).

Significant wetlands: There is one wetland rated as nationally significant—the Rowles Lagoon System. It is threatened by feral rabbits, goats, foxes, cats, stray stock, weeds and uncontrolled recreational use (McKenzie et al. 2002). Most of the 14 wetlands of regional significance are salt lakes and intermittent or seasonally inundated.

ECOLOGICAL PROCESSES

Key ecological processes for the Mediterranean biome in Australia have been identified and exemplified in the biome introduction. One of the values of the Great Western Woodlands is that large-scale ecological processes still function. Because of large scale clearing these ecological processes are now compromised in all other temperate woodlands in Australia. Because they are diffuse and landscape-based, and have received only limited scientific and conservation focus, their status is not easily catalogued and assessed. Therefore, we make just the following coarse qualitative judgments about ecological processes in the Great Western Woodlands, exemplifying where processes have been compromised.

Strongly interactive species: Compromised in some areas by destruction of dingos (who have a keystone predator function) and in unknown ways by loss of mammals (burrowers, for example, are likely to have played keystone roles in water and nutrient distributions).

Long distance movement: Compromised where productive 'stepping stone' patches or refugia have been degraded by grazing, mining or fire.

Hydroecology: Compromised where clearing has occurred—salinity is a problem in the Southern Cross subregion and surrounding areas.

Disturbance regimes: Compromised to a significant extent with changed fire regimes. Climate change is expected to further compromise disturbance regimes.

Climate: Largely intact, but significant compromise looming with global warming.

Coastal fluxes: Largely intact.

Spatially dependent evolutionary processes: Largely intact, except where evolutionary refugia have been degraded, and permeability impeded due to degradation of productive areas by grazing and altered fire regimes. The area functions as an important biogeographic corridor.

THREATS

The major threats across this focus area are feral animals (foxes, cats, donkeys, rabbits, goats); changed fire regimes (with extensive wildfires now apparently more common than previously); stock grazing and weeds (see Table GWW.4).

In some districts with underlying greenstone geology, mining has damaged and fragmented native vegetation and acted as a pathway for invasive species. The area remains a very large and active mining province.

In recent years there was a proposal to resume intensive logging of some woodland areas.

TABLE GWW.4: MAJOR THREATS

Threats	Impacts	Comments
Grazing & agriculture	▪ Grazing has caused extensive degradation in the Mardabilla and Eastern Goldfields subregions, and the north eastern part of the Southern Cross subregion (McKenzie et al. 2002). ▪ The western third of the Southern Cross subregion is cleared for dry-land agriculture, with salinity problems emerging (ibid). ▪ Reduced productivity of landscapes for some wildlife, ▪ Changes in vegetation, eg. loss of palatable species, weed invasion	
Altered fire regimes	▪ Fires have become more frequent, causing damage particularly in scrubs and mallees on duplex, sandy and laterite surfaces (McKenzie et al. 2002).	Howe et al. (1988) suggest the natural fire interval was ~100 years for woodlands, 25-30 years for shrublands. Aboriginal burning regimes are unknown (Watson et al. in press). Currently, frequent burning—eg. about 25% of Jindaburra burnt in past 5 years (ibid)
Feral animals	▪ Degradation of vegetation by rabbits, goats, cattle—eg. degradation of chenopod shrublands (also due to weed invasion and fire). ▪ Declines in mammal fauna due to predation by cats & foxes	Ferals include rabbits, cats, foxes, mice, rats, goats. There has been reduced rabbit damage due to Calicivirus, but that is likely to be temporary.
Weeds	▪ Displacement of native species & degradation of wildlife habitats ▪ Ward's weed is a major transformer of habitats.	Ward's weed has spread over large areas.
Mining **&** **logging**	▪ Cutting of woodlands for fuel and building material for mining operations ▪ "Some highly restricted environments, such as outcrops of ultramaric rocks, supporting localised and endemic plant species have been (and continue to be) particularly favoured for mining activity, to the detriment of those species" (McKenzie et al. 2002) • Waste disposal and sulphur dioxide emissions (ibid)	There are gold and nickel mining operations in the area. There was extensive damage during gold rushes that started in the 1890s, including large-scale logging. Impacts of previous large-scale logging are still evident. Recent proposals for logging.

EXISTING CONSERVATION ACTIVITIES

PROTECTED AREAS

There are 46 reserves, some large, in the focus area. Because of the relative extensiveness of this reserve system, each of the bioregions is a relatively low priority for the National Reserve System (see Table GWW.5). However, there is limited management in the reserves, with no predator control and only limited fire control (McKenzie et al. 2002). Some reserves in the Mardabilla subregion are becoming saline (ibid). Due to the very high number of localised endemic species, current reserves do not support all plant species. Areas that have been identified as a high priority for reservation include wetland communities, succulent steppe, ironstone and greenstone range and valley-floor woodland communties (Sattler & Glanznig 2006).

TABLE GWW.5: COMPREHENSIVENESS, EXTENT AND MANAGEMENT OF PROTECTED AREAS

Bioregion	Area (ha) & extent reserved IUCN I-IV	Area (ha) & extent reserved IUCN V-VI	Comprehensiveness I-IV (%)	Comprehensiveness V-VI (%)	Manag't Standard	NRS priority
COO	1,339,065 (10%)	453,029 (4%)	53	?	Fair/good	3
HAM	134,486 (12%)	0	67	0	Poor/fair	4
Focus area	1,473,551 (11%)	453,029 (3%)	--	--	--	

Source: Sattler & Glanznig (2006)

POLICIES, PLANS & PROGRAMS

There has been little active conservation or land management in the region. In recent years a major collaborative community conservation project, Gondwanalink, has commenced in the broader region of the south coast of Western Australia. This has been an active and successful project involving several NGOs and many local community groups. Great Western Woodlands forms the eastern part of the Gondwanalink area (see Table GWW.6).

TABLE GWW.6: PLANS, POLICIES & PROGRAMS

Plan/policy/program
Conservation plans: The South Coast Regional Management Plan (1992)—but does not provide information or strategies specific to the area / South Coast Macro Corridor Project—identifies some areas where improved landscape connectivity will benefit biodiversity conservation / Nature Conservation Reserves in the Eastern Goldfields (Henry-Hall et al 1990)—recommendations on a nature conservation reserve system for the southern and central Goldfields / Current assessment by DEC in eastern Jindaburra, likely to recommend expansion of reserve system.
Fire: Bushfire control program.

CONSERVATION CAPACITY

Indigenous Conservation: Native title claims in the region have been largely unresolved in the region. However, the Goldfields Land and Sea Council has an active Land unit which is working with Traditional Owners on access and land management issues, including potential joint management of lands.

Advocacy conservation groups: The Wilderness Society has an active advocacy campaign seeking protection for the Great Western Woodlands. There is one permanent position dedicated to the work. A new report by The Wilderness Society on the values of the region is due for publication shortly.

Private land conservation groups: In the south-east of the focus area Greening Australia, Bush Heritage Australia and several local groups are active members of Gondwanalink and are carrying out on-ground work that connects with fragmented bushland to the west of the Great Western Woodlands.

Other institutional capacity: In all except one subregion there is no identified natural resource management capacity to integrate conservation (NLWRA 2002 database).

ADEQUACY OF INFORMATION

Fine- scale vegetation mapping is lacking. There is little understanding of the habitat requirements of invertebrate species, ephemeral plants, persisting critical weight range mammals, and uncommon vertebrate and plant species (McKenzie et al. 2002). There is inadequate information about life-history of species and the effects of exotic predators, weed colonisation, and fire on biodiversity, and the effect of mineral-extraction on greenstone communities (ibid). There is also the need for better understanding of Indigenous management practices.

DISCUSSION

Thus far in this paper we have selected and described 12 focus areas which meet a defined threshold of land condition. In this section, we summarise and compare the conservation attributes of these focus areas, and broadly outline conceptual and practical factors that will determine which projects are funded under the Pew-TNC Wild Australia Program.

Note that our aim here is not to identify a hierarchy of priority areas or projects. There are practical constraints in making prioritisation decisions, especially the 3-year timeframe for implementation that will narrow attention to a subset of potential projects. The relative value of these options can be assessed best in a qualitative way.

In the first section, we explain the conceptual framework for conservation in these largely natural landscapes, based on recent recognition of the importance of protecting ecological processes as well as values. In the second section, we examine conservation priorities in terms of The Nature Conservancy's global goals, and then summarise and compare values, threats and conservation capacity in the 12 focus areas, drawing together information from each of the snapshots. Finally, we explain the primary considerations that will apply in determining which projects are funded under the Pew-TNC Wild Australia Program.

CONSERVATION APPROACHES IN LARGE NATURAL AREAS

Conservation in Australia has been largely shaped by the focus on the 'intensive' landscapes of the east coast and temperate south subjected to considerable fragmentation and degradation. In those landscapes conservation has primarily been about protecting the best remaining pieces of natural or semi-natural habitat, restoration and damage mitigation. In the 'extensive' landscapes, which include the very large natural areas considered in this paper, there are fewer barriers to a more comprehensive landscape approach which aims to conserve both natural values and ecological processes, as identified by Soule et al. (2004).

Stafford-Smith and Ash (2006), reporting on a workshop on how to prioritise high conservation values in the extensive 'rangeland' landscapes, make a similar distinction between:

1. conservation of particular site-specific or focal-specific values, such as can be contained within national parks, and

2. maintenance of diffuse ecosystem processes across large areas, such as genetic flow, the integrity of water distribution and the spatio-temporal dynamics of disturbance regimes.

They note that while ecosystem processes are important in both fragmented and semi-natural to natural landscapes, in fragmented landscapes the importance of focal areas for conservation greatly outweighs the importance of diffuse processes, whereas in large natural areas, the significance of each is relatively more even. However, as they discuss, while there are tools for priority setting based on focal and site-specific values (although there are often data limitations in the extensive landscapes), there are not yet good tools for priority setting that account for diffuse ecological processes. Stafford Smith and Ash (2006) recommend an approach based around IBRA bioregions, which involves the following:

1. Identify differential intrinsic values represented by each IBRA bioregion in a pristine condition[42]

2. Identify differential values represented by each IBRA bioregion in their current condition[43]

3. Identify management interventions appropriate to maintaining the diffuse processes in that IBRA bioregion, and their costs; and

4. Identify the degree of benefit to be achieved by making those management interventions.[44]

In developing an approach to prioritising for diffuse processes they note there are "some parallels to current reserve design methodologies, [but] it is conceptualised at a far larger scale of geographic unit (not generally amenable to excision), and the issues of representativeness, geographic relationships and perhaps irreplaceability are not so meaningful." They suggest the diverse values and weightings can only be handled using some form of Multi-Criteria Analysis, yet to be developed. We note that the University of Queensland Ecology Centre is currently developing modeling approaches to incorporate some consideration of ecological processes.

Below, for descriptive purposes, we compare some of the diverse values that should be considered in such analysis—without seeking to weight and integrate them in a list of priorities. There is no one or even few surrogates that can be relied upon to represent the spectrum of values and ecological processes considered significant for conservation in these regions.

COMPARISON OF CONSERVATION VALUES

In this section we summarise and compare some of the values of the focus areas in response to the following questions:

- How might conservation projects in these focus areas contribute to addressing global biome conservation priorities, as well as National Reserve System priorities?
- Which focus areas are in the best condition—in terms of continental stress ratings, vegetation condition, river and riparian condition, and wilderness quality (conditions that contribute to maintenance of ecological processes)?
- Which focus areas have the most significant biodiversity values—in terms of species richness, endemicity, and threatened species?
- What are the key threats in these focus areas?

[42] They recommend that initially each IBRA bioregion be accorded equal value even though there are "strong conceptual reasons to imagine that the intrinsic pristine differences between IBRAs exist", because there is limited evidence about the differences.

[43] They further explain that the "current condition values of IBRAs would be assessed in terms of historical damage, both in terms of degree and, as importantly, longevity. Longevity of impact is important: although some processes that create local genetic diversity … might be reinstated quite easily, if they have been absent for long enough, the diversity has been lost (as in many fragmented landscapes) and will not be re-instated until genetic drift is reestablished, probably over centuries." They note that this sort of description of IBRAs has been carried out in various projects, but "not with a specific eye to these diffuse processes which support biodiversity."

[44] Stafford Smith and Ash note that the costs and benefits of conservation action with respect to "invasive species control, maintenance of water-remote areas, maintenance of landscape function in terms of water flows, re-establishment of wetland networks, etc, have also been summarised for many IBRAs, but again without a focus on diffuse processes – in general these have been discussed in terms of maintaining processes at the far less critical level required for production."

CONSERVATION TENURE GOALS

Here, we consider the global situation for each of the three biomes represented in the 12 focus areas and the contribution that increasing conservation tenure in these areas can make to The Nature Conservancy's 2015 global conservation goals.

As Table D.1 shows, of the three global biomes represented, the Mediterranean habitats are most highly threatened. They rank second in the global Conservation Risk Index, with more than eight times as much habitat converted as is protected (Hoekstra et al. 2005). The Great Western Woodlands focus area consequently has high global significance as the largest remaining relatively intact Mediterranean woodland (Watson et al. in press, CIESIN & WCS 2003).

Globally, the tropical/subtropical grasslands, savannas & shrublands rank moderately highly in the Conservation Risk Index with more than twice as much habitat converted as is protected. The Australian tropical savannas also have global significance for their relative intactness, as the largest intact examples of this biome remaining in the world (Woinarski et al. *in press*; CIESIN & WCS 2003).

Although poorly conserved, the desert biome is lower in the Conservation Risk Index with proportionately much less habitat conversion than other biomes. As noted already, Australia has the largest remaining relatively intact deserts/xeric scrubs in the world (on a country basis, although the Sahara Desert, which lies across several countries, is the largest single contiguous desert region) (CIESIN & WCS 2003).

As noted in the Introduction, The Nature Conservancy has a goal to ensure the effective conservation of at least 10% of every Major Habitat Type on Earth by 2015. In the Australasian biogeographical realm, their goal is to work with others to effectively conserve 10% of each of the eight major biomes that exist here (M. Looker pers. comm.). Currently, that goal is met in just two Australasian biomes—Montane Grasslands and Temperate Broadleaf Forests (M. Looker pers. comm.). Table D.1 shows the proportion of the three biomes considered in this paper already effectively conserved in Australasia (in IUCN protected area categories I-IV), and the extent of further reservation required to meet the 10% goal in Australasia.

TABLE D.1: GLOBAL & AUSTRALASIAN PRIORITIES (THE NATURE CONSERVANCY)

Biome / Major Habitat Type	Habitat converted globally	Habitat protected globally	Conservation Risk Index	Global crisis ranking (1-13)	Area effectively conserved Australasia (minimum)	Area required to meet TNC 2015 goal (km^2)
Mediterranean Forests, Woodlands & Scrub	41.4%	5%	8.2	2nd	9.84%	1286
Tropical/ Subtropical Grasslands, Savannas & Shrublands	23.6%	11.9%	2.0	7th	5.22%	103,619
Deserts & Xeric Shrublands	6.8%	9.9%	0.7	9th	6.6%	118,128

Source: Hoekstra et al. (2005), M. Looker (pers. comm.)

Note: the area effectively conserved is based on IUCN I-IV categories of protected areas. The TNC 2015 goal is to ensure effective conservation of 10% of the area of each of the Australasian major habitat types (biomes).

In Australia, one form of well-recognised prioritization for reserves is that based on the CAR (comprehensive, adequate and representative) criteria used by the National Reserve System. Table D.2 identifies the current highest priority bioregions in the focus areas for the National Reserve System (NRS priorities 1 and 2—ie. those bioregions most poorly reserved). As well as being able to contribute to improving the reservation status of different ecosystems, the program may be able to enter funding partnerships with the Australian Government in high priority NRS bioregions.

TABLE D.2: NATIONAL RESERVE SYSTEM PRIORITY BIOREGIONS

Reserve priorities	Priority focus areas (bioregion)
NRS priority 1	Daly Basin-Arnhem Land (DAB), Carpentaria (GUC), Kimberley (DL), Victoria Plains (STU)
	Central Ranges (CR, FIN)
NRS priority 2	Daly Basin-Arnhem Land (ARC, CA, TIW), Kimberley (CK)
	Great Sandy-Tanami (TAN, DMR, GSD, LSD)

Source: Sattler & Glanznig (2006)

LAND CONDITION

It was on the basis of land condition that the 12 focus areas were selected, so all of them have met a condition threshold. However, there is considerable variation in condition indices within and among them. Land condition values do not correlate tightly with biodiversity values but, as explained, they are indicative of conditions under which ecological processes will still function and long-term conservation security can be achieved. High land condition values also indicate the potential for cost-effective prevention strategies which minimize the future necessity for much more expensive mitigation and restoration.

The value in preventing degradation is starkly illustrated with river health in Australia, where it has been recognised far too late for many systems the extremely high environmental, social and economic costs associated with degradation. The value of protecting natural rivers has recently been recognised in the Wild Rivers program in Queensland.

TABLE D.3: LAND CONDITION

Condition/ qualities	Best condition focus areas
Land health (stress condition): bioregional average or median stress class >5	Kimberley
	Gibson Desert, Great Sandy-Tanami Deserts, Great Victoria Desert, Nullarbor Plains
Vegetation condition: bioregions with >90% 'high quality' vegetation	Daly Basin-Arnhem Land (ARP, ARC, CA, TIW), Kimberley (NK)
	Gibson Desert, Great Sandy-Tanami Deserts, Great Victoria Desert, Simpson-Strzelecki Desert, Central Ranges (CR)
River condition: bioregions with least disturbed rivers	Cape York Peninsula, Daly Basin-Arnhem Land (ARP, ARC, CA, TIW), Kimberley (NK), Carpentaria (GUC)
	All deserts except Finke (Central Ranges)
Riparian condition: at least 75% of subregions rated at least 3 (good condition)	Kimberley, Cape York Peninsula, Daly Basin-Arnhem Land, Carpentaria
	Simpson-Strzelecki Desert, Central Ranges, Great Sandy-Tanami Deserts
	Great Western Woodlands
Wilderness quality: bioregions with at least 75% high wilderness quality (NWI)	Cape York Peninsula, Daly Basin-Arnhem Land (ARP, ARC, CA, TIW), Kimberley (NK)
	All deserts, except Central Ranges

Table D.3 shows the highest value focus areas in each biome in each of five categories of land condition. Note that they do not capture all threats to land condition, in particular altered fire regimes.

BIODIVERSITY VALUES

The focus areas represent the opportunity to conserve areas of high biodiversity values, many of which have been recognised as globally and nationally significant. Table D.4 shows the highest-value focus areas in various categories of species-focused biodiversity values.

While we acknowledge the importance of ecosystemic and phylogenetic diversity as other conservation values, the information to make such comparisons is not available for these focus areas. In general, there is a lack of even species-focused information about biodiversity in many of these focus areas. In many areas, no comprehensive biological surveys have been conducted, and recorded biodiversity values will undoubtedly increase with further surveys. For example, How and Cowan (2006) in an analysis of Western Australian vertebrates note that recent surveys have discovered new species in the pastoral and central desert regions, and that biodiversity values there are probably richer than recognised.

TABLE D.4: BIODIVERSITY VALUES

BIODIVERSITY FEATURES		HIGHEST VALUE FOCUS AREAS
Species richness: Savanna: >2000 plants, >500 vertebrates; Desert: >1500 plants, >400 vertebrates; Mediterranean: >2500 plants, >400 vertebrates		Cape York Peninsula, Daly Basin-Arnhem Land, Kimberley
		Central Ranges
		Great Western Woodlands
Richness in particular assemblages	Plants	Cape York Peninsula, Daly Basin-Arnhem Land, Central Ranges, Great Western Woodlands
	Reptiles	Cape York Peninsula, Daly Basin-Arnhem Land, Kimberley, Victoria Plains, Great Victoria Desert, Great Sandy-Tanami Deserts, Simpson-Strzelecki Desert, Great Western Woodlands
	Birds	Cape York Peninsula, Daly Basin-Arnhem Land, Kimberley
	Mammals	Cape York Peninsula, Daly Basin-Arnhem Land, Kimberley
	Fish	Cape York Peninsula
	Amphibians	Cape York Peninsula, Kimberley
Endemicity in particular assemblages	Plants	Cape York Peninsula, Daly Basin-Arnhem Land, Kimberley, Great Western Woodlands
	Reptiles	Cape York Peninsula, Daly Basin- Arnhem Land, Kimberley, Great Victoria Desert, Great Sandy-Tanami Deserts, Simpson –Strzelecki Deserts, Great Western Woodlands
	Birds	Cape York Peninsula
	Mammals	Cape York Peninsula
	Fish	Cape York Peninsula, Kimberley
	Amphibians	Kimberley
	Invertebrates	Cape York Peninsula (butterflies), Daly Basin-Arnhem Land (isopods & shrimps), Kimberley (snails & earthworms), Central Ranges (snails), Nullarbor Plains (cave invertebrates)
Threatened plant & vertebrate species Savanna: >50, Desert: >30, Mediterranean: >50		Cape York Peninsula, Daly Basin-Arnhem Land
		Central Ranges, Great Victoria Desert, Simpson-Strzelecki Desert
		Great Western Woodlands
Fewest bioregional extinctions: <5		Cape York Peninsula, Daly Basin-Arnhem Land

THREATS

In Table D.5, we summarise the major threats to conservation values and ecological processes in each of the biome areas encompassed within the focus areas. Noteworthy is the similarity of threats across these areas. Most of the threats are diffuse and pervasive rather than locale-specific. However, there is increasing threat of development which will transform ecosystems at a local and regional scale. A major looming threat, which is not noted but applies to all biomes, is global warming.

TABLE D.5: SUMMARY OF KEY THREATS IN EACH BIOME

Key pervasive threats	Key focal threats
Altered fire regimes, Invasive species, Grazing	Clearing for agriculture, Mining
Altered fire regimes, Invasive species, Grazing	
Altered fire regimes, Invasive species, Grazing	Mining

CONSERVATION CAPACITY

As discussed below, the Pew-TNC Wild Australia Program will support projects capable of achieving on-ground results within 3 years, and which will therefore require existing conservation capacity.

There is considerable variation between the focus areas in existing capacities for advocacy and private land conservation and in Indigenous conservation (see box describing each of these sectors). With the relative scarcity of conservation resources currently available in the large, remote regions in Australia, the variation is often due to one or two groups, active in one region, but not in an adjacent region. Consequently there are no particular comparisons on capacity that can be made across different focus areas. The details of these are given in the capacity section for each area. Some generalisations can be made, however, about the differences between different biomes. These generalisations may be useful in focusing decisions on priority work and they are summarised in Table D.6.

Another facet of conservation capacity is the economic cost of achieving conservation outcomes—for example, conservation is typically hindered when the cost of land is high, as demonstrated by the bias of reservation

TABLE D.6: EXISTING CONSERVATION CAPACITY

Biome	Advocacy environment NGOs	Private land conservation NGOs	Indigenous conservation
Tropical savannas	Strong current focus & generally good capacity in a range of groups	Strong current focus & generally good capacity in national groups	Strong & increasing focus by many groups, some tenure issues unresolved
Deserts	Limited & patchy current focus & capacity	Patchy current focus	Patchy capacity, some tenure issues unresolved
Mediterranean	Strong existing focus & generally good capacity in some groups	Strong existing focus & good capacity in national & local groups	Limited capacity by groups, tenure issues largely unresolved

towards less productive or less usable areas. One of the practical benefits of working in the focus areas identified is that compared to land in the intensive zone, costs are relatively cheaper. In addition, stewardship agreements tend to be more cost-effective when profitability is lower. Figures D.1 and D.2 show the relative value of unimproved land and profitability across Australia (see Carwardine et al. (2006) for explanation of their derivation).[45]

FIGURE D.1: PROFITABILITY

Source: UQ Ecology Centre
Focus areas are outlined in red

FIGURE D.2: UNIMPROVED LAND VALUE

Source: UQ Ecology Centre

PROJECT PRIORITIES FOR THE PEW-TNC WILD AUSTRALIA PROGRAM

As discussed, the Pew-TNC Wild Australia Program is a 3-year funded collaboration between Pew and TNC. The goal is broadly to achieve conservation tenure and associated good management for large natural areas in Australia, both on land and sea.

The conservation principles that will guide the program work are those that recognise the need for landscape approaches to conservation. Establishing large conservation reserves is a key part of what is required to effectively conserve these large natural areas. However, as emphasised in this paper, and as demonstrated by the latest conservation science, long-term conservation outcomes require more than just reserves. Protecting ecological processes and connections requires that country be managed in a way that is compatible for conservation across all tenures. Given these goals and principles, there are three broad criteria that will be applied in assessing priority projects for the Pew-TNC Wild Australia Program.

(1) The projects will achieve long-term protection of significant ecological values and processes in large natural areas (ie. in one or more of the 12 focus areas). This requires conservation tenure that is coupled with a management regime that mitigates key threats.

(2) The projects will achieve on-ground results within the 3-year program timeframe.

[45] We note also that there are differences in the cost-effectiveness of securing conservation tenure and funding stewardship arrangements. For example, WWF analysis found that the federal government reserve (NRS) program cost on average $10.61/hectare (or <$24/hectare in high-priority states) compared to $258/hectare for stewardship type projects funded by Envirofund (Natural Heritage Trust) (WWF supplementary submission to Senate Inquiry into Australia's national parks, conservation reserves and marine protected areas, 2006).

(3) The projects will be integrated wherever possible with region-wide conservation programs and planning that provide the basis for maintaining ecological processes.

The program will work wherever possible across all tenures to achieve secure conservation reserves, and conservation-compatible management of land around those reserves.

The focus will therefore be work with Traditional Owners on Indigenous lands, such as through Indigenous Protected Areas; private land conservation work on other tenures, such as through acquisitions and covenants; and advocacy to achieve secure state-owned conservation reserves. Wherever possible this will be done in conjunction with and provide support for regional conservation planning and natural resource management planning to ensure long term protection of areas.

The program will not set up a separate bureaucracy, but will work through a range of partner Australian organisations.

Conservation sectors in Australia

Initial nature conservation work in Australia focused particularly on advocacy to protect public lands and seas and to prevent destructive exploitation of such areas, in campaigns such as those to protect the Great Barrier Reef from oil drilling, and achieve national parks in south-west Tasmania and the Blue Mountains. The voluntary organisations conducting those campaigns have developed into a major network of local, state and national environment groups that work on environment issues through advocacy.

Conservation work on private lands in Australia was for decades far more limited in scope, especially compared to the work of more sophisticated and well resourced private land trusts in the USA and Europe. However, since the early 1990s, through NGOs such as Trust for Nature, Greening Australia, Bush Heritage Australia, Australian Wildlife Conservancy, and The Nature Conservancy, there has been far greater focus and resources to establish conservation covenants and privately owned sanctuaries in all states. There have also been major natural resource management initiatives such as Landcare, and salinity action plans, much of it funded through government programs, especially the Natural Heritage Trust.

Often overlooked is the rapid development in the past decade of a third major sector relevant to nature conservation in Australia—conservation work led by Indigenous people or with significant involvement of Indigenous people. In part this has been a natural progression as increasing areas of Australia have been successfully claimed under Indigenous freehold title, and as traditional rights of access and use have been legally recognised over pastoral leases and other tenures. Currently, over 20% of the continent is under Aboriginal freehold title, and this is likely to increase in the next decade. Most of these lands are in Central, Northern and Western Australia, where European settlement has been sparsest and where Indigenous links to country remain strongest. Much of this Aboriginal-owned land is of very high conservation value, having suffered the least degradation since European settlement.

For these reasons Indigenous involvement is now at the forefront of most conservation work in remote areas in Australia. Many Traditional Owners are seeking support for land management work on country they now hold title to. The Indigenous Protected Area program, started in 1997, already has 22 different areas registered covering 14.9 million hectares (Gilligan 2006). Conservation groups are increasingly seeking support from Indigenous bodies and Traditional Owners for conservation work across tenures, and seeking protection of specific areas and conservation management on Indigenous freehold lands they regard as having nationally or internationally important conservation values.

But this positive work for conservation comes at a time when Traditional Owners in remote areas face increasing and understandable pressures to use the land and its resources as economic assets to improve their often very poor social and economic conditions. Indigenous support for conservation will be greatly strengthened if there are economic and employment opportunities associated with conservation outcomes. Such support is beginning—a recent review of the Indigenous Protected Areas program found that as well as conservation outcomes strong social benefits flowed from the funding and involvement of communities and individuals in Indigenous Protected Areas and associated land management (Gilligan 2006). However, programs are relatively new, and funding and support systems are patchy.

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