Conservation of Ecosystems and Ecological Communities in Western Australia.

Discussion Paper No 2

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Summary

This is the second discussion paper for the project titled "*An interim framework for developing a comprehensive, adequate and representative protected areas system in Western Australia*". The main aim of the project is to compile a database that includes the known supratidal (but including mangroves and mudflats) ecosystems and ecological communities in Western Australia, an assessment of the conservation status of each entity, and to develop priorities for their protection. The database will include spatial data in a Geographical Information System (GIS) linked to descriptive data, and information on possible threatening processes. The project will include a review of current procedures for adding to the conservation reserve system, and proposals for enhancing these procedures using the newly developed database.

This discussion paper outlines the methods used to generate the draft List of Ecosystems and Ecological Communities in the State, and the draft List is attached.

The project database ECOSTATUS now contains over 350 ecosystems and ecological communities. These include the *c.* 60 Threatened Ecological Communities (TECs), plus ecosystems and ecological communities gleaned from interview and scientific literature following the circulation of Discussion Paper No. 1. In addition, the *c.* 900 vegetation associations throughout the State mapped by J S Beard, which are to be used as primary surrogates for ecosystems, have been downloaded to the database.

Comment is sought on the draft List of Ecosystems and Ecological Communities, and further input would be welcome.

1. Introduction

1.1 Background to the project

The State of Western Australia contains an enormous variety of environments that support a diverse biota. The southwest of the State is considered to be an important node of biodiversity on a world scale, because of the high number of species, and high degree of endemism. However, the biodiversity of the State is incompletely documented. This is partly a reflection of the vast area to be covered and the inaccessibility of many environments, coupled with a low population base. For example, rainforest and mangrove communities in the north of the State are of considerable importance for their nature conservation values but occur scattered over large, often remote areas, making comparative studies difficult. Invertebrates and other microorganisms are known to be diverse and to play an extremely important role in the functioning of most ecosystems, yet they are poorly known. Recent studies have uncovered some of the most significant invertebrate fauna communities in the world, living in caves and aquifers in Western Australia. Their contribution to the biodiversity of the State is obviously significant, but still not well understood.

At the same time as we are striving to understand this diverse biota, many of the State's environments are subject to threatening processes which have the potential to alter or completely destroy them. For example, much of the southwest of the State is affected by rising water tables, causing widespread salinity, as a result of clearing for agriculture. Other parts are severely affected by the presence of *Phytophthora* species, which cause dieback of plants. The north-west and arid interior of the State have high numbers of introduced herbivores such as sheep and cattle, goats, camels and donkeys which graze and trample vegetation, causing erosion which results in sedimentation, and nutrient enrichment of waterways. Introduced predators such as foxes and cats are a severe threat to native fauna in some areas. More localised threats include mining activities, tourism and urban development.

In-situ conservation of this rich and varied, but poorly known, biota in the face of substantial threats poses a great challenge. Preliminary assessments of the current conservation reserve system in Western Australia, conducted by the Department of Conservation and Land Management in collaboration with Environment Australia, have highlighted major gaps in the reserve system. Only four of the 26 bioregions of the State can be described as adequately reserved (Thackway and Cresswell 1995). At a more detailed level of assessment, only 163 of the 769 vegetation types mapped at a scale of 1:250, 000 by JS Beard are $\geq$ 10% represented in the existing conservation reserve system, 246 were poorly reserved, and 360 were not represented at all (Hopkins *et al.* 1996).

This project "An interim framework for developing a comprehensive, adequate and representative (CAR) protected areas system in Western Australia", funded by Environment Australia, aims to produce a framework for in-situ nature conservation in Western Australia. A computer database is being developed to bring together information on ecosystems and ecological communities throughout the State, threats to the nature conservation values of each one, and relevant land-use data, for the purposes of bioregional planning. The spatial attributes in the database will be analysed using Geographic Information System (GIS) computer software. Results of the spatial analysis will provide a sound basis for setting priorities for land acquisition and off-reserve management agreements and indigenous protected areas.

This paper presents a preliminary list of ecosystems and ecological communities (referred to as entities throughout the text) to be used for planning the protected areas system. The list has been developed from multiple sources that include existing databases, the scientific literature (including the so-called grey literature) and through broad consultation with members of the scientific community. It is acknowledged that the list is likely to be incomplete; it should be regarded as a first attempt, a foundation for future work.

Through this discussion paper, we invite constructive comment on the draft list, hoping that this process will refine and enhance the data. It is important to state from the outset that the development of a list of ecosystems and ecological communities in the State is in no way a substitute for continued biogeographic survey and research. This project is very much an interim one, drawing together existing information to improve the present reserve system, and designed with the expectation that survey results will be used as they become available.

1.2 Ecosystems and ecological communities

Discussion Paper No. 1 (Hopkins and Morgan 1999) provided a review of ecosystem and ecological community concepts, and then outlined the approach that the project would use to collate the data. The approach adopted in this project is based on the view that ecosystems and ecological communities are appropriate basic units to use in planning a comprehensive, adequate and representative protected area system for nature conservation.

The generally accepted concept of an ecosystem is an assemblage of organisms and their physical environment together with the processes that support them. There is, however, a need to define and map ecosystems if the concept is to be practical for land-use planning and nature conservation. For operational purposes, ecosystems can be regarded as synthetic ecological units derived from biotic and abiotic classifications, with functional aspects implied (see Discussion Paper No. 1).

Where species assemblages are found to occur in identifiable groupings that appear related to biotic and/or abiotic factors, the assemblages are described as ecological communities. Some ecological communities can be defined geographically and, therefore, incorporated into the land-use planning process. Once again, the term ecological community is a synthetic one, designed for use in an operational sense.

Because the overall objective of this project is to develop a database for use in land-use planning processes, the emphasis has been on identifying meaningful entities that can be located and mapped. It has been a challenge to identify ecosystems and ecological communities that are or can be defined geographically. We hope that the results of the project will inform the land-use planning process: at the same time we note the potential for those results to be used to inform the community about the natural environments of the State.

2. Sources of data for the project

In Discussion Paper No.1, we indicated the sources of data that we proposed to draw on to develop the database of ecosystems and ecological communities of Western Australia. The proposed sources of input were:

- vegetation associations as mapped by J S Beard at the scale of 1:250,000 over the whole State. This was to be the primary surrogate for ecosystems. Some of the map units would be refined as necessary;
- the Threatened Ecological Communities database. We proposed to incorporate all identified ecological communities, including those which were not deemed to be endangered in any way; and
- other ecosystems and ecological communities identified from the literature and/or through the community consultation process.

These data sources have been developed as anticipated. Considerable attention has been paid to consultation and literature searches. Discussion Paper No.1 was circulated to 66 individuals and organisations within the Western Australian community. Circulation of the Discussion Paper was followed by a series of over 35 personal interviews and other interactions. In addition, we scoured the literature, including the so-called grey literature, for information that could lead to the identification of ecosystems and/or ecological communities.

The sources for all the data are documented comprehensively in the database.

3. The database

A database was designed using Microsoft Access 97 software to organise the information. Data are entered into the database via a digital data entry form, and reports on each ecosystem and ecological community are printed from the form. An example of the report format is shown in Appendix D. The project database ECOSTATUS now contains over 350 ecosystems and ecological communities. These include the *c.* 60 Threatened Ecological Communities (TECs), plus ecosystems and ecological communities gleaned from interview and scientific literature following the circulation of Discussion Paper No.1. In addition, the *c.* 900 vegetation associations throughout the State mapped by J S Beard, which are to be used as primary surrogates for ecosystems, have been downloaded to the database.

Full reports for each of the ecosystems or ecological communities are available on request.

4. The draft list

Due to the diverse sources of data, the database is exceedingly heterogeneous in terms of the types of entities contained, and in terms of the variation in the scale of those entities. The ecosystems and ecological communities vary from the largest vegetation association in the State, which covers *c.* 26 million hectares, to a root mat community in a cave covering less than five square metres. In order to make some sense of these highly diverse entities, and to indicate some kind of relationship between the various types and scales, we are in the process of developing a hierarchical classification of ecosystems and ecological communities. The proposed classification scheme is given in Appendix C.

At present, the ecosystems and ecological communities are grouped into themes as a means of better organising the data, and emphasising the specific nature conservation values of particular groups of ecosystems and communities. An explanation of the themes is provided in Appendix B. The preliminary list of ecosystems and ecological communities, shown in Appendix A, is grouped according to these themes. Note that a few ecosystems and ecological communities have been assigned more than one theme, and will therefore appear more than once in the list. Note also that the *c.* 900 vegetation associations to be used as the surrogates for ecosystems are not included in the draft list, but are available upon request.

The process of gathering data and defining ecosystems and ecological communities has been selective. We have focussed on entities that have some kind of regional context, which have included:

- ecosystems and ecological communities regarded as "special" with respect to their nature conservation values, either because they are rare, threatened, or unusual in some way, and therefore require inclusion in the conservation reserve system;
- ecosystems and ecological communities recognised through regional or other broadscale surveys, both those regarded as "typical" and those considered to be unusual for the survey area.

There are a number of current studies, aimed at describing ecosystems or ecological communities and assessing their regional conservation status, which can be included in the database as more information comes to hand. For example, the biological survey of the southern Little Sandy Desert (S. van Leeuwen pers. com. 1999), the survey of the Carnarvon Basin (A.H. Burbidge pers. com. 1999), and the survey of the mound springs at Mandora marsh (G. Graham pers. com. 1999) are expected to provide valuable input in 2000.

5. Community input

There will be a further phase of community consultation following the circulation of this Discussion Paper. Members of the scientific community, Aboriginal communities, local natural history organisations, Landcare groups and individuals with relevant in formation are invited to contact the project Consultant. Comments on the draft list, and additional nominations for ecosystems and ecological communities will be actively sought throughout the first 3 – 4 months of 2000.

References:

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Thackway, R. and Cresswell, I.D. (eds.) (1995) An Interim Biogeographic Regionalisation for Australia: A framework for setting priorities in the National Reserves System Cooperative Program. Version 4.0. Reserves System Unit, Australian Nature Conservation Agency, Canberra.

Appendix A
The Draft List

Karst, Cave and Aquifer ecosystems and ecological communities

IBRA Region	*Community Name*
Carnarvon	
	* Subterranean karst wetlands of Lake MacLeod
	* Remipede Community of caves of the Cape Range area, north-western Australia (Bundera Sinkhole type)
	* Troglobitic Community of Cape Range area, north-western Australia (Cameron's Cave type)
	* Subterranean waterways and general groundwater on coastal plain and foothills of North West Cape Peninsula harbouring endemic and relictual invertebrate species
Central Kimberley	
	* Seasonal river and permanent pools of subterranean karst in Kimberley Region (Tunnel Creek type)
Dampierland	
	* Cave dwelling invertebrates of East Kimberley limestones
Nullarbor	
	* Troglobite and troglophile communities of caves of the Nullarbor Plain
Pilbara	
	* Invertebrate communities of groundwater calcretes
	* Stygofauna of fresh water aquifers (Millstream type): community characterised by Spelaeogriphaceans
Swan Coastal Plain	
	* Lake with subterranean waterways and caves - Loch McNess System (is this linked to root mat communities?) (Check against Bushplan communities!)
	* Aquatic root mat invertebrate community (Number 1) of caves of the Swan Coastal

IBRA Region	*Community Name*
Warren	
	* Aquatic root mat community (Number 3) of caves of the Leeuwin-Naturaliste Ridge
	* Aquatic root mat community (Number 4) of caves of the Leeuwin-Naturaliste Ridge
	* Aquatic root mat community (Number 2) of caves of the Leeuwin-Naturaliste Ridge
	* Aquatic root mat community (Number 1) of caves of the Leeuwin-Naturaliste Ridge
	* Cave ecosystems of the aeolian limestones fringing the south-west

Mangrove ecosystems and ecological communities

IBRA Region	*Community Name*
Carnarvon	
	* Inland, relictual mangrove community (sp?), Lake MacLeod
	* Mangrove community of Exmouth Gulf East tidal wetland ecosystem
	* Carnarvon Province mangrove zone
	* Mangrove communities of the Pilbara coast mangrove zone
	* Mangrove community of Shark Bay East tidal wetland ecosystem
Dampierland	
	* Mangrove communities of the King Sound Mangrove Zone
	* Mangrove communities of the Canning Coast mangrove zone
Geraldton Sandplains	
	* Carnarvon Province mangrove zone
Great Sandy Desert	
	* Inland, relictual Avicennia marina (White Mangrove) community in permanent saline creek (Salt Creek type)
Northern Kimberley	
	* Mangrove communities of the Kimberley Coast Mangrove Zone
	* Mangrove communities of the King Sound Mangrove Zone
	* Mangrove communities of the Cambridge Gulf Mangrove Zone
Pilbara	
	* Burrup Peninsula survey, community A1: Littoral Association of Avicennia marina and Rhizophora stylosa mangal
	* Mangrove communities of the Rowley Shelf Province mangrove zone
	* Mangrove communities of the Pilbara coast mangrove zone

Swan Coastal Plain

* Relictual Avicennia marina (White Mangrove) community in the Leschenault Estuary

Victoria Bonaparte

* Mangrove communities of the Cambridge Gulf Mangrove Zone

Microbial ecosystems and ecological communities

IBRA Region	*Community Name*
	* Benthic microbial mat community dominated by Lamprothamnium papulosum and Microspora sp. (Woody Lake type)
	* Benthic microbial communities of saline and hypersaline lakes
Avon Wheatbelt	
	* Microbial invertebrates and plant assemblages of natural saline seeps.
Carnarvon	
	* Hypersaline tidal stromatolite aragonite community number 2 (and benthic microbial
Esperance Plains	
	* Stromatolite Community Number 3 of Coastal Hypersaline Lakes (and benthic microbial communities)
Great Sandy Desert	
	* Microbial structures in permanent saline creek (Salt Creek type)
	* Microbial structures (stromatolites, tufa dams and related structures) and benthic microbial communities in freshwater springs of the Great Sandy Desert (McDonaldson Spring type)
Swan Coastal Plain	
	* Microbial community of coastal hypersaline lake (Rottnest Lakes type)
	* Stromatolite community of stratified hypersaline coastal lakes
	* Stromatolite-like microbialite community of coastal freshwater lakes
	* Stromatolite-like freshwater microbialite community of coastal brackish lakes
	* Thrombolites of hypersaline lake (Lake Preston type)
Warren	
	* Rimstone pools and cave structures formed by microbial activity on marine
	* "Algae biscuits" and benthic mats in swamps in the south-west region (Owingup Swamp System - data deficient)

Mound Spring ecosystems and ecological communities

IBRA Region	*Community Name*
	* Peat-based mound springs of Kimberley (Drysdale River Station type)
	* Peat based mound springs north of Kununurra, Kimberley (is this Point Springs?)
	* Peat-based mound springs supporting sedges and herbs in the Kimberley (Mt Elizabeth Station type)
Dampierland	
	* Mound spring community on mudflat, supporting dense, closed forest (Bunda-Bunda type)
	* Spring complex (including mound springs) in the north-west Kimberley, supporting diverse vegetation including dense rainforest dominated by Terminalia microcarpa over main seepage area (Big Springs type)
Great Sandy Desert	
	* Freshwater mound springs supporting open forest of Melaleuca argentea and/or Sesbania formosa, over ferns and/or sedges occurring on salt marsh in tropical desert environment (Mandora Marsh type)
	* Soaks in tropical desert environments, supporting Sesbania formosa over Baumea articulata (Dragon Tree Soak type)
Swan Coastal Plain	
	* Communities of Tumulus Springs (Organic Mound Springs), Swan Coastal Plain

Mudflat ecosystems and ecological communities

IBRA Region	*Community Name*
Dampierland	
	* Species-rich invertebrate community of intertidal mudflats of tropical Australia (Roebuck Bay type)
Victoria Bonaparte	
	* Mudflat community of tropical north-western Australia (Victoria-Bonaparte type)

Pools and Billabongs - ecosystems and ecological communities

IBRA Region	*Community Name*
	* Species-rich aquatic plant communities of river pools of Walcott Inlet area
Avon Wheatbelt	
	* Deep pools and natural braided sections of fresh to brackish rivers of the Avon Botanical District
Central Kimberley	
	* Seasonal river and permanent pools of subterranean karst in Kimberley Region (Tunnel Creek type)
	* Permanent pools in tropical gorges of northern Western Australia (Windjana Gorge)
Central Ranges	
	* Permanent rock pools of the Walter James Range
Gascoyne	
	* System of permanent to semi-permanent gorge pools (Kookhabinna Gorge)
Geraldton Sandplains	
	* Estuary systems with seasonal and permanent river pools in gorges (Murchison River (lower reaches) type)
Great Sandy Desert	
	* Rock Pools of the Breaden Hills
	* Major internal drainage system, including river pools and soaks fringed by stands of Melaleuca sp., Eucalyptus camaldulensis and E. microtheca, in a tropical desert environment (Lake Dora System)
Little Sandy Desert	
	* Semi-permanent gorge-pools of arid areas (Durba Hills type)
	* Major internal drainage system, including river pools and soaks fringed by stands of Melaleuca sp., Eucalyptus camaldulensis and E. microtheca, in a tropical desert environment (Lake Dora System)
Northern Kimberley	
	* Permanent rivers with large systems of river pools in the Kimberley region (Drysdale River type)

Pilbara

* River pools of the Pilbara region (De Grey River)
* Permanent river pools and springs of the Pilbara region (Millstream type)
* Permanent spring-fed gorge pools and streams in arid environments (Karijini Gorge)

Victoria Bonaparte

* Tropical floodplain with permanent billabongs, seasonal marshes and wooded swamps (Parry Floodplain type)

Rainforest ecosystems and ecological communities

IBRA Region	*Community Name*
	* Kimberley Rainforest survey community S: Rainforest patch on skeletal soils, lining a deep, narrow gorge in the Durack Range of the eastern Kimberley
	* Kimberley Rainforest survey community P: Small, very open-canopied rainforest patch in small scree gully incising the coastal margin of sandstone plateau, Kimberley
	* Permanent spring supporting rainforest community in tropical north-western Australia
	* Rainforest patches on the Devonian limestone ranges of the Nimbing Range and Oscar and Napier Ranges - "Savanna Rainforest"
	* Kimberley Rainforest survey community R: Rainforest patches on skeletal soils, sheltered in deep, narrow gorges of Saw and Osmond Ranges, in the drier parts of the eastern Kimberley (600-700mm annually)
	* Kimberley Rainforest survey community U: Narrow and discontinuous corridor of rainforest tree species along the floor of a precipitous (almost totally scoured by seasonal floods) gorge in the Osmond Range of the eastern Kimberley
	* Kimberley Rainforest survey community T: Rainforest patch on skeletal soils, lining the floor of a narrow gorge in the catchment of the Prince Regent River (high rainfall), Kimberley region
	* Kimberley Rainforest survey community X: Low, scrubby rainforest patch on isolated Quaternary sand dune towards the seaward edge of an extensive tidal mudflat in far northeastern Kimberley
	* Kimberley Rainforest survey community Q: Small, very open-canopied rainforest patch on scree-slope exposed on western side of an abrupt range in lower rainfall area of eastern Kimberley (800mm/year)
	* Kimberley Rainforest survey community J: Rainforest patches on the extensive floodplain that fringes the tidal mudflat at the easter end of Walcott Inlet, Kimberley
	* Kimberley Rainforest survey community F: Small, discrete and isolated patches of rainforest on the floor of small dolerite valleys, beside low duricrust breakaways
	* Kimberley Rainforest survey community L: Rainforest patches on the levee banks of major rivers: the Carson, King Edward, Ord and Sale Rivers, Kimberley region
	* Kimberley Rainforest survey community D: Diffuse or small patches of rainforest on sandstone or dolerite scree-slopes in the south near Walcott Inlet and its associated rivers in the Kimberley region
	* Kimberley Rainforest survey community C: Diffuse rainforest patches on sandstone

scree-slopes in the north-east and east Kimberley, but with denser vegetation (unless lower rainfall) than other patches on sandstone scree-slopes

* Kimberley Rainforest survey community H: Large, dense-canopied and more species-rich rainforest patches on sandy soils low in nutrients, on slopes covered with massive sandstone scree at the foot of sandstone cliffs in the Kimberley region

* Kimberley Rainforest survey community E: Small discrete and isolated patches of rainforest in small hollows in the sides of steep duricrusted and/or volcanic hills in the northern Kimberley region

* Kimberley Rainforest survey community I: Rainforest patches on protected alluvial deposit on floor of sandstone gorge in Kimberley region

* Kimberley Rainforest survey community G: Large, dense-canopied, species-rich rainforest patches on heavier soils in coastal and sub-coastal northwestern Kimberley, usually associated with volcanics and duricrusts

* Kimberley Rainforest survey, community B: Very small rainforest patches on sandstone scree-slopes under cliffs on the uplands between Walcott Inlet and Doubtful Bay in the Kimberley region

* Kimberley Rainforest survey community K: Rainforest patches on smally alluvial floodplain behind a tidal mudflat at the mouth of a valley in high rainfall area, Kimberley region

* Kimberley Rainforest survey community M: Rainforest patch around a soak on a floodplain beside Theda River, Kimberley region

* Kimberley Rainforest survey community N: Rainforest patches on alluvial floodplain in the drier eastern Kimberley region

* Kimberley Rainforest survey community A: Diffuse rainforest patches on coastal sandstone scree-slopes in the north-east Kimberley region

* Kimberley Rainforest survey community O: Small, very open-canopied rainforest patch in small gully on sandstone scree of Carson Escarpment, north-east

Dampierland

* Spring complex (including mound springs) in the north-west Kimberley, supporting diverse vegetation including dense rainforest dominated by Terminalia microcarpa over main seepage area (Big Springs type)

* Mound spring community on mudflat, supporting dense, closed forest (Bunda-Bunda type)

* Kimberley Rainforest survey community V: Rainforest patches fringing the rear slope of the steep Quaternary coastal sand dunes on the northern end of the Dampier

* Kimberley Rainforest survey community W: Fragmented, low scrubby rainforest among the Quaternary coastal dunes at Broome on the southern end of the Dampier

* Vine thicket communities on heavily ferruginised Emeriau Sandstone outcrops of the Dampier Peninsula

River ecosystems and ecological communities

IBRA Region	*Community Name*
	* Short to medium length rivers of the the Indian Ocean Drainage Division originating in areas of Acacia-Casuarina thickets and scrub-heath
	* Longer rivers of the Indian Ocean Drainage Division, originating in areas of mulga low woodland and scrub, flowing through other Acacia low woodland and scrub and to the coast, sometimes through Acacia-Casuarina thickets and scrub and/or scrub-heath
	* Short to medium length rivers of the Indian Ocean Drainage Division, flowing through mulga and other Acacia low woodland and scrub, but flowing into near coastal playa lakes (-) or disappearing into coastal sands without reaching the sea
	* Medium length and longer rivers of the Indian Ocean Drainage Division, flowing from the tree and shrub steppe of the Pilbara and through areas of short bunch-grass savanna along the river valleys and in coastal regions
	* Short to medium length rivers of the Timor Sea Drainage Division of WA, originating in, and keeping within, the Northern Botanical Province's high grass savanna woodland and flowing north to meet the coastline
	* Longer rivers of the Timor Sea Drainage Division of WA, originating in curly spinifex savanna woodland and tree savanna country and flowing north through the high grass savanna woodland to the coast
	* Longer westward flowing rivers of the Timor Sea Drainage Division of WA, traversing a number of vegetation areas including curly spinifex savanna woodland and tree savanna, semi-desert spinifex steppe, tall bunch-grass savanna and pindan
	* Longer northward flowing rivers of the Timor Sea Drainage Division, traversing vegetation areas from semi-desert spinifex steppe, through short and tall bunch-grass savanna, curly spinifex savanna woodland and tree savanna to high grass savanna woodland
	* Longer rivers of the Indian Ocean Drainage Division, flowing from areas of mulga low woodland and scrub and sometimes dwarf scrub of Cassia and Eremophila through tree and shrub steppe to the coast
	* Short ephemeral watercourses within mixed dry eucalypt woodlands of the WA portion of the Western Plateau Drainage Division
	* Short epehmeral watercourses within samphire and saltbush communities of halophytes in the WA portion of the Western Plateau Drainage Division
	* Ephemeral watercourses within tree and shrub steppe, spinifex with scattered eucalypts or shrubs of the WA portion of the Western Plateau Drainage Division
	* Ephemeral watercourses within mulga low woodland and scrub of the WA portion of the Western Plateau Drainage Division

* Shorter rivers of the Timor Sea Drainage Divison of WA, draining the pindan

Jarrah Forest

* River valleys in uplands of the Jarrah Forest bioregion (Avon River Valley type)

Northern Kimberley

* Permanent rivers with large systems of river pools in the Kimberley region (Drysdale River type)

Rock Outcrop ecosystems and ecological communities

IBRA Region	*Community Name*
	* Mountains of south-west survey, community 7a: Scrub and open herbs of granite exposures on uplands
	* Mountains of south-west survey, community 7b: Scrub and open herbs of quartzite exposures on uplands
Avon Wheatbelt	
	* Rock Pool communities of granite outcrops in the Wheatbelt Region (Yorkrakine Rock type)
	* Species-rich granite outcrops of the South West Botanical Province
Esperance Plains	
	* Species-rich granite outcrops of the South West Botanical Province
Gibson Desert	
	* Gnamma holes of the Gibson Desert
Jarrah Forest	
	* Northern Darling Scarp survey, Community 8: Heaths and low shrublands on shallow lithic soils around upper slope massive granite outcrops
	* Northern Darling Scarp survey, Community 5: Shrublands on granites of the central part of the northern Darling Scarp
	* Northern Darling Scarp survey, Community 1c: Northern granite shrublands and woodlands
	* Species-rich granite outcrops of the South West Botanical Province
	* Northern Darling Scarp survey, Community 2: Southern granite shrublands and woodlands
Mallee	
	* Species-rich granite outcrops of the South West Botanical Province
Swan Coastal Plain	
	* Calothamnus graniticus heath community on south-west coastal granites
	* Northern Darling Scarp survey, Community 1c: Northern granite shrublands and woodlands

* Northern Darling Scarp survey, Community 2: Southern granite shrublands and woodlands

* Northern Darling Scarp survey, Community 5: Shrublands on granites of the central part of the northern Darling Scarp

* Species-rich granite outcrops of the South West Botanical Province

* Northern Darling Scarp survey, Community 8: Heaths and low shrublands on shallow lithic soils around upper slope massive granite outcrops

Salt Lake ecosystems and ecological communities

IBRA Region	*Community Name*
Avon Wheatbelt	
	* Largest deep water lake in Western Australia, permanent and saline.
	* Intermittent saline lakes in upper drainage of the Avon River
	* Wetland in the upper part of the Coblinine River drainage system, with permanent saline/brackish lakes, and seasonal saline marshes
Coolgardie	
	* Biotic communities of inland salt lakes in the Goldfields region
Esperance Plains	
	* Systems of naturally-brackish/saline coastal lakes in the Esperance region (Lake Warden system)
Gascoyne	
	* Large intermittent saline lake systems in the Gascoyne Bioregion (Lake Carnegie system type)
Jarrah Forest	
	* Brackish/saline lakes in Jarrah Forest bioregion (Lake Muir type)
Mallee	
	* Naturally saline and brine lakes in the Mallee bioregion (Lake Grace system type)
Murchison	
	* Intermittent saline lakes of the Murchison Bioregion (Lake Barlee)
	* Intermittent saline lakes of the Murchison bioregion (Lake Ballard)
	* Intermittent saline lake of the Murchison bioregion
	* Seasonal/intermittent saline/brackish lake and marsh systems (Lake Anneen)
Swan Coastal Plain	
	* Naturally saline coastal lakes of the Swan Coastal Plain bioregion (Yalgorup Lakes system)
	* Salt lake complex on offshore island (exceeding 10ha in area) with seasonally meromictic lakes (Rottnest Island)

Yalgoo

* Salt lakes of the Yalgoo bioregion (Wagga Wagga Salt Lake)

Uplands/Unusual Geology - ecosystems and ecological communities

IBRA Region	*Community Name*
	* Bremer Range community 1: Eucalyptus rhomboidea and E. eremophila dominated woodlands on deeper soils of side slopes and low ridges of Bremer Range and Round Top Hill, Eastern Goldfields
	* Bremer Range community 2: Eucalyptus flocktoniae woodlands on deeper soils
	* Bremer Range community 3: Eucalyptus flocktoniae and /or E. longicornis dominated woodlands on deeper soils
	* Bremer Range community 4: Eucalypt woodlands dominated by E. longicornis and/or E. salmonophloia, (can also be dominated by E. georgei or subsp. Georgei or E. dundasii) on deeper soils
	* Bremer Range community 5: Floristic communities on lateritic breakaways dominated by either Eucalyptus livida woodland or Allocasuarina thicket
	* Bremer Range community 6: Floristic community on greenstone ridge
	* Parker Range community 2: Eucalyptus woodlands of broad flats within the greenstone belt
	* Parker Range community 5: Woodland dominated by Eucalyptus capillosa subsp. Polyclada and/or Eucalyptus loxophleba on more skeletal soils of lateritic and greenstone ridges
	* Parker Range community 1: Eucalypt woodlands on sandy soils at the base of ridges and low rises
	* Parker Range community 3: Eucalyptus salmonophloia and E. salubris dominated woodlands of the broad flats within the greenstone belt
	* Parker Range community 4: Community generally dominated by Allocasuarina acutivalvis and Allocasuarina corniculata (thicket?) on deeper sandy soils of lateritic and greenstone ridges
	* Parker Range community 6: Species-poor upland communities dominated by low trees of Callitris glaucophylla on massive greenstones of lateritic and greenstone
	* Plant assemblages of the Moonagin System: Acacia scrub on red soil on hills; Acacia scrub with scattered Eucalyptus loxophleba and Eucalyptus oleosa on red loam flats on the foothills
	* Kwongan communities of Mt Lesueur and surrounding uplands

* Mountains of south-west survey, community 7b: Scrub and open herbs of quartzite exposures on uplands

* Mountains of south-west survey, community 1a: Low woodland and Eucalyptus marginata shrub mallee-heath upland community

* Mountains of south-west survey, community 5: Scrub and mallee-heath of uplands

* Plant assemblages of the Koolanooka System: Eucalyptus ebbanoensis mallee over scrub; and Allocasuarina huegeliana low woodland on ranges; Acacia sp. Scrub on north-east flank of Koolanooka Hill and Eucalyptus loxophleba over scrub

* Mountains of south-west survey, Community 4: Heath and mallee-heath of uplands

* Mountains of south-west survey, community 7a: Scrub and open herbs of granite exposures on uplands

* Mountains of south-west survey, community 3: E. megacarpa mallee-thicket and heath of uplands

* Mountains of south-west survey, community 2b: Marri woodland-thicket of uplands

* Mountains of south-west survey, community 2a: Woodland, E. diversicolor (karri) forest and thicket of uplands

* Mountains of south-west survey, community 1c: Montane thicket and heath of the South West Botanical Province, above approximately 650m above sea level

* Mountains of south-west survey, community 1b: Mallee-heath, heath and thicket upland community

* Upland swamps of the Kimberley Region

* Mountains of south-west survey, community 6: Thicket and Scrub of uplands

Avon Wheatbelt

* Dense heath dominated by one or more of Regelia megacephala, Kunzea praestans, Allocasuarina campestris and Dryandra sessilis on the upper slopes of the chert (quartzite) hills of the Coomberdale floristic region

* Plant assemblages of the Wongan Hills (Plateaus and Uplands) system

Coolgardie

* Community 2 of Hunt Range, Yendilberin and Watt Hills, Eastern Goldfields: Eucalypt woodlands dominated by Eucalyptus ravida or E. longicornis on deeper

* Community 1 of Hunt Range, Yendilberin and Watt Hills, Eastern Goldfields: Eucalypt woodlands dominated by Eucalyptus clelandii, E. griffithsii or E.

longicornis on deeper, more fertile soils

* Community 3 of Hunt Range, Yendilberin and Watt Hills, Eastern Goldfields: Eucalypt woodlands dominated or co-dominated by Eucalptus transcontinentalis and E. clelandii on deeper, more fertile soils

* Mt Manning Range community 8: Chenopod rich Eucalypt woodlands of valleys and small rises

* Highclere Hills community 1: Eucalypt woodlands over chenopods

* Highclere Hills community 3: Acacia acuminata (jam) shrubland

* Mt Manning Range community 7: Casuarina pauper and/or Eucalyptus longicornis dominated woodlands on greenstone rises at base of Range

* Community 4 of Hunt Range, Yendilberin and Watt Hills, Eastern Goldfields: Eucalypt woodlands dominated or co-dominated by Eucalyptus capillosa subsp. capillosa or E. capillosa subsp. poyclada on deeper, more fertile soils

* Mt Manning Range community 6: Eucalypt woodlands on more fertile soils of slopes, valleys and small rises

* Community 6 of Hunt Range, Yendilberin and Watt Hills, Eastern Goldfields: Acacia dominated shrublands, occassionally with emergent Eucalypts, on less fertile soils

* Mt Manning Range community 5: Eucalyptus formanii dominated community at base of Range

* Mt Manning Range community 4: Eucalyptus capillosa subsp. capillosa dominated community on eroding breakaways

* Mt Manning Range community 3: Floristic community characteristic of yellow sand unit over laterite

* Mt Manning Range community 2: Community dominated or co-dominated by Eucalyptus ebbanoensis, Acacia ramulosa, A. aneura, A. quadrimarginea and/or Callitris glaucophylla occurring on the lower flanks of the range

* Community 7 of Hunt Range, Yendilberin and Watt Hills, Eastern Goldfields: Acacia dominated shrublands on deep yellow sands

* Highclere Hills community 4: Floristic community with characteristic species of Acacia tetragonophylla and Scaevola spinescens (dominants?)

* Mt Manning Range community 1: Species poor community occurring on skeletal soils over massive banded ironstone near the crest of Mt Manning Range

* Community 5 of Hunt Range, Yendilberin and Watt Hills, Eastern Goldfields: Acacia

and Allocasuarina co-dominated shrublands on sandy soils of laterite or banded

* Helena and Aurora range survey, community 2: Woodlands dominated by Eucalyptus ebbanoensis and/or E. corrugata or E. capillosa subsp. Capillosa with Alyxia buxifolia and/or Stenanthemum newbeyi in the understorey, occurring on the massive ironstone tops, slopes and breakaways

* Highclere Hills community 5: Allocasuarina campestris, Baeckea elderiana and Grevillea paradoxa dominated community on eroding lateritic breakaway

* Helena and Aurora range survey, community 5: Eucalypt woodland community over chenopod shrubland on the flats

* Helena and Aurora range survey, community 3: Midslope community dominated or co-dominated by Eucalyptus ebbanoensis and/or Eucalyptus corrugata, over Neurachne sp. Helena & Aurora, occurring on the open side slopes (chenopods

* Helena and Aurora range survey, community 1: Shrublands and woodlands largely restricted to ridge tops and upper slopes, dominated or co-dominated by Acacia quadrimarginea, Grevillea zygoloba, Allocasuarina acutivalvis, Melaleuca nematophylla, Dryandra arborea and Calycopeplus paucifolius

* Helena and Aurora range survey, community 4: Floristic community restricted to the lower slopes and flats, variously dominated by Acacia spp., or occassionally by Eucalyptus ebbanoensis and/or E. hypochlamydea subsp. Hypochlamydea

Esperance Plains

* Mountains of south-west survey, sub-community of community 1c: Montane Thicket and Heath of the South West Botanical Province, above approximately 900m above

Geraldton Sandplains

* Billeranga Hills plant assemblage, consisting of a scrub community dominated by Dodonaea inaequifolia on red loamy soils; Melaleuca filifolia - Allocasuarina campestris thicket; Acacia acuminata dominated thickets or open mallee over scrub on quartzitic with yellowish soils

* Melaleuca megacephala and Hakea pycnoneura thicket on stony slopes of Moresby Range

Jarrah Forest

* Eucalyptus rudis and Eucalyptus rudis / Melaleuca rhaphiophylla woodland communities of alluvial soils of foothills and valley floors of the northern Darling

* Northern Darling Scarp survey, Community 9: Upland Eucalyptus marginata forest

* Melaleuca preissiana woodland communities on perched winter-wet depressions on lateritic uplands of the northern Darling Scarp

* Northern Darling Scarp survey, Community 4: Woodlands on steep colluvial slopes of scarp face and upper valleys

* Northern Darling Scarp survey, Community 10: Upland Corymbea calophylla

* Northern Darling Scarp survey, Community 3: Corymbea callophylla woodlands on steep, loamy scarp and valley slopes

* Northern Darling Scarp survey, Community 7: Woodlands on poorly drained colluvial deposits

* Northern Darling Scarp survey, Community 1b: Eucalyptus wandoo - Corymbea calophylla woodlands on poorly-drained clay flats

* Northern Darling Scarp survey, Community 1a: Upper slope Eucalyptus wandoo woodlands

* Northern Darling Scarp survey, Community 11: Upland Corymbea calophylla - Eucalyptus marginata woodland

* Swan Coastal Plain community 10b: Shrublands on southern Swan Coastal Plain Ironstones (Busselton area)

Mallee

* Community 3 of Middle and Southern Ironcap, Digger Rocks and Hatter Hill of the Eastern Goldfields: Eucalypt woodlands dominated or co-dominated by Eucalyptus flocktoniae on more fertile soils

IBRA Region	*Community Name*
	* Community 2 of Middle and Southern Ironcap, Digger Rocks and Hatter Hill of the Eastern Goldfields: Species-poor, dense Allocasuarina - Melaleuca thickets on ridges and side slopes in the Hatter Hill area, Eastern Goldfields
	* Community 1 of Middle and Southern Ironcap, Digger Rocks and Hatter Hill, Eastern Goldfields: Species-rich shrublands and thickets with scattered eucalypt emergents
	* Community 5 of Middle and Southern Ironcap, Digger Rocks and Hatter Hill of the Eastern Goldfields: Floristic community dominated or co-dominated by Eucalyptus flocktoniae, E. salubris and E. annulata
	* Community 4 of Middle and Southern Ironcap, Digger Rocks and Hatter Hill of the Eastern Goldfields: Mallee community usually dominated by Eucalyptus calycogona on small colluvial flats of Middle and Southern Ironcap, Digger Rocks and Hatter Hill of the Eastern Goldfields
Pilbara	
	* Upland floristic communities of central Pilbara
Swan Coastal Plain	
	* Northern Darling Scarp survey, Community 11: Upland Corymbea calophylla - Eucalyptus marginata woodland
	* Northern Darling Scarp survey, Community 10: Upland Corymbea calophylla
	* Eucalyptus rudis and Eucalyptus rudis / Melaleuca rhaphiophylla woodland communities of alluvial soils of foothills and valley floors of the northern Darling
	* Melaleuca preissiana woodland communities on perched winter-wet depressions on lateritic uplands of the northern Darling Scarp
	* Northern Darling Scarp survey, Community 9: Upland Eucalyptus marginata forest
	* Perth to Gingin Ironstone Association
	* Northern Darling Scarp survey, Community 7: Woodlands on poorly drained colluvial deposits
	* Shrublands and woodland complex on Muchea Limestone of the Swan Coastal
	* Northern Darling Scarp survey, Community 3: Corymbea callophylla woodlands on steep, loamy scarp and valley slopes
	* Northern Darling Scarp survey, Community 1b: Eucalyptus wandoo - Corymbea calophylla woodlands on poorly-drained clay flats

IBRA Region	*Community Name*
	* Northern Darling Scarp survey, Community 1a: Upper slope Eucalyptus wandoo woodlands
	* Swan Coastal Plain community 10b: Shrublands on southern Swan Coastal Plain Ironstones (Busselton area)
	* Northern Darling Scarp survey, Community 4: Woodlands on steep colluvial slopes of scarp face and upper valleys
Victoria Bonaparte	
	* Diverse flora and fauna of the Cockburn Range, northwestern Australia
Warren	
	* Scott River Ironstone Association

Wetlands (other) - ecosystems and ecological communities

IBRA Region	*Community Name*
	* Invertebrate assemblages of freshwater wetlands with organically rich soils and impeded drainage, Southern Forest Region
	* High altitude peat swamps of the Stirling Range
	* Lake Tamworth peat swamp
	* Freshwater Swamp communities of the Dampier Peninsula
	* Ephemeral freshwater creeks of the Mitchell Plateau
	* Herbaceous plant communities dominated by a combination of Triglochin mucronata, Trichanthodium exilis, Angianthus tomentosus and Pucinellia stricta on bentonite lake beds of the Dandaragan Plateau.
	* Freshwater wooded swamp of the Esperance region dominated by Melaleuca (Nambarup West Swamp type)
	* Permanent freshwater lake with peaty marsh (Maringup Lake)
	* Upland swamps of the Kimberley Region
	* Moon springs - (peat-based?) springs where the water level fluctuates with the lunar
	* Burrow fauna of freshwater crayfish of the genus Engaewa in the Southern Forest
Avon Wheatbelt	* Perched fresh-water wetlands of the northern Wheatbelt dominated by extensive stands of living Eucalyptus camaldulensis (River Red Gum) across the lake floor (Morilla Swamp type)
	* Unwooded fresh to brackish water wetlands of the southern Wheatbelt, dominated by Muehlenbeckia horrida subsp. abdita and Tecticornia verrucosa across the lake floor (Lake Bryde and East Lake Bryde)
	* Perched wetland of the Wheatbelt region dominated by Canegrass (Eragrostis australasica) and Swamp Paperbark (Melaleuca strobophylla) across the lake floor
	* Perched wetlands of the Wheatbelt region with extensive stands of living Swamp Sheoak (Casuarina obesa) and Swamp Paperbark (Melaleuca strobophylla) across
Carnarvon	

* Coastal lake system including saline lakes and marshes, inland subterranean karst wetlands, and seasonal freshwater ponds

* Freshwater claypans in arid environment with extensive Lignum/Sesbania/sedge community in and around the claypans (McNeill Claypan type)

Central Kimberley

* Permanent freshwater lakes in Kimberley region (Gladstone Lake type)

Coolgardie

* Seasonal/intermittent freshwater lakes and ponds, with shrub swamps and shrub dominated freshwater marshes (Rowles Lagoon type)

Dampierland

* Permanent river pools in gorges (Geikie Gorge type, Fitzroy River)

* Floodplain comprising seasonal lakes / marshes and permanent billabongs in the Kimberley region

* Freshwater, almost permanent claypan of the Dampier Peninsula supporting disjunct populations of flora (Nimalaica Claypan)

* Roebuck Plains wetland system

Esperance Plains

* System of coastal lakes in the south-west region with a diversity of hydrological and vegetation characteristics (Mortijinup Wetlands)

* Naturally saline rivers, and undisturbed coastal lagoons (with protected catchments) that exhibit cycles of flooding and drying of variable length (Fitzgerald Inlet system

* Closed estuary systems with inflowing saline rivers (Culham Inlet system type)

* Naturally saline seasonal lake systems in inland southwestern Australia (Balicup Lake system type)

* Systems of saline coastal lakes of varied depth and salinity, which at times have extensive, associated brackish/saline marshes (Lake Gore system type)

* Wooded lakes/swamps of the south-west dominated by Yate (Yellilup Yate Swamp System)

Gascoyne

* Semi-permanent, freshwater springs with narrow fringing forest in desert environment (Windich Springs)

* Wooded freshwater claypan lake in Gascoyne region (Yadjiyugga Claypan - unique

to region)

* Seasonal and irregular rivers, streams and saline lakes - Lake Disappointment (Savory Creek) System

Geraldton Sandplains

* Estuary systems with seasonal and permanent river pools in gorges (Murchison River (lower reaches) type)

* Seasonal freshwater/brackish basins in Geraldton Sandplains region (Lake Logue/Indoon system type)

* Coastal brine lake systems (Hutt Lagoon System)

* Wetland and gorge system of the lower Murchison River

Gibson Desert

* Near permanent freshwater lake and wooded swamp in central eastern desert environment (Lake Gruszka type)

Great Sandy Desert

* Major internal drainage system, including river pools and soaks fringed by stands of Melaleuca sp., Eucalyptus camaldulensis and E. microtheca, in a tropical desert environment (Lake Dora System)

* Wooded swamps on the edge of the Great Sandy Desert (Bulka Swamp type)

Great Victoria Desert

* Lakes and associated claypans and ephemeral drainages in the Great Victoria Desert (Lake Yeo/Lake Throssell type)

Jarrah Forest

* Systems of stream-fed fresh and brackish lakes impounded by coastal sand (Moate's Lake system type)

* Natural wetland assemblage of lakes, swamps (including peat swamps) and flats in poorly drained area (Byenup Lagoon System)

* Freshwater wooded swamps dominated by paperbark (Chittering and Needonga Lakes type) - check!

* Near-permanent freshwater marshes with peat substrate (Lake Pleasant View

* Estuary with deep and permanent opening to the sea, and full tidal exchange (Oyster Harbour)

Little Sandy Desert

* Major internal drainage system, including river pools and soaks fringed by stands of Melaleuca sp., Eucalyptus camaldulensis and E. microtheca, in a tropical desert environment (Lake Dora System)

* Seasonal and irregular rivers, streams and saline lakes - Lake Disappointment (Savory Creek) System

Mallee

* Freshwater lake fringed with Melaleuca strobophylla tall shrublands

Murchison

* Seasonal/intermittent freshwater lakes that include woodland and shrubland, situated in arid country (Breberle Lake type)

* Major floodplain lakes in southern WA (Wooleen Lake)

Northern Kimberley

* Relatively small river systems and associated estuaries in the North Kimberley bioregion (Mitchell River system)

* Tropical estuaries and river systems incised in plateaus, with mangrove-fringed embayments typical of the west coast of the North Kimberley bioregion (Prince Regent River System)

* Galaxy Swamp (permanent swamp of biological interest), west of Drysdale River

* Freshwater swamps of the Mitchell Plateau (Airfield Swamp type)

Pilbara

* Coastal flats and associated tidal coast system in north- western Australia (Leslie (Port Hedland) Saltfields system)

* Extensive, inland floodplain system, which is irregularly inundated (Fortescue

* Burrup Peninsula survey, community C2d: Scirpus littoralis Aquatic Community in

Swan Coastal Plain

* Swan Coastal Plain community S17: E. rudis / Agonis linearifolia wetlands in Bassendean dunes

* Swan Coastal Plain community 8: Herb rich shrublands in clay pans

* Shallow estuarine system with significant remaining areas of tidal flats and marshes (Swan-Canning Estuary)

* Swan Coastal Plain community S3: Wet sedgelands on sandy clays

* Wooded swamp, typical of the Swan Coastal Plain bioregion (Spectacles Swamp)

* Remnant wetland system supporting remnant vegetation of the Southern Rivers vegetation complex on the Swan Coastal Plain (Perth Airport Woodland Swamps)

* Uncommon freshwater marsh dominated by low sedges and grasses in south-western Australia (Karakin Lakes)

* Permanent freshwater lake in the Perth Metropolitan Region (Lake Joondalup)

* Remnant lake/marsh in Perth Metropolitan Region (Herdsman Lake)

* Saline/brackish lake in the Swan Coastal Plain bioregion (Guraga Lake)

* Brackish seasonal lake with fringing sedgeland, typical of the Swan Coastal Plain bioregion (Forrestdale Lake)

* Wooded swamps typical of the Swan Coastal Plain bioregion (Chandala Swamp)

* Remnant wetland with extensive low closed-forest and closed- scrub in Perth Metropolitan Region (Booragoon Lake)

* Unique to WA system of small swamps exhibiting a continuum of development in geomorphology, hydrology and vegetation (Becher Point Wetlands)

* Brackish seasonal lakes with extensive fringing sedgeland, typical of the Swan Coastal Plain bioregion (Thomsons Lake type)

* Swan Coastal Plain community 5: Mixed shrub damplands

* Shallow estuaries of the Swan Coastal Plain with substantial areas of salt marsh (Peel Harvey Estuary type)

* Formerly estuarine basins functioning as seasonal brackish lakes, including tall samphire community, seasonally covered by Bolbaschoenus caldurelli

* Wooded Swamps on the Swan Coastal Plain (McCarley's Swamp type) (check against Bushplan communities!)

* Seasonally inundated wooded shrub swamps dominated by paperbark in the Perth Metropolitan Region (Gibbs Road Swamp Systems type)

* Perched, winter-wet clay-based swamps of the Swan Coastal Plain (Ellen Brook Swamps System type)

* System of sedge-dominated marshes and wooded swamp fringing a major estuary system in the Swan Coastal Plain bioregion.

* Swan Coastal Plain community S5: Acacia saligna wetlands

* Aquatic plant community of seasonal shrub swamps of the Swan Coastal Plain (Brixton Street Swamps type)

* Swan Coastal Plain community 10a: Shrublands on dry clay flats

* Swan Coastal Plain community 2: Southern wet shrublands

* Wooded swamps of the Swan Coastal Plain bioregion (Barraghup Swamp)

* Swan Coastal Plain community 7: Herb rich saline shrublands in clay pans

* Swan Coastal Plain community 11: Wet forests and woodlands

* Swan Coastal Plain community 9: Dense shrublands on clay flats

* Swan Coastal Plain community 12: Melaleuca teretifolia and/or Astartea aff. fascicularis shrublands of seasonal wetlands

* Swan Coastal Plain community 13: Deeper wetlands on heavy soils

* Swan Coastal Plain community 14: Deeper seasonal wetlands on sandy soils

* Swan Coastal Plain community 15: Forests and woodlands of deep seasonal

* Swan Coastal Plain community 16: Highly saline seasonal wetlands

* Swan Coastal Plain community 17: Melaleuca rhapiophylla - Gahnia trifida seasonal wetlands

* Swan Coastal Plain community S4: Regilia ciliata Dandaragan Plateau wetlands

Tanami

* Near-permanent lake in desert environment (Lake Gregory type)

Victoria Bonaparte

* Tropical floodplain with permanent billabongs, seasonal marshes and wooded swamps (Parry Floodplain type)

* Estuary system of tropical north-west Australia including the most extensive mudflat and tidal waterway complex in WA (Ord River System)

Warren

* Extensive acid peat flats subject to inundation, in the south-west region (Doggerup Creek System)

* System of freshwater lakes, marshes and shrub swamps (Gingilup-Jasper Wetland System)

* Permanently waterlogged freshwater swamps of the Warren bioregion (Mt Soho

* Permanent freshwater lakes and marshes with well developed lake delta and outflow River in the south-west region (Owingup Swamp System)

* Freshwater river and estuary/inlet system with associated floodplain (Broke Inlet

Yalgoo

* Lignum-canegrass swamp community (Thundelarra Lignum Swamp type)

Not yet assigned - ecosystems and ecological communities

IBRA Region	*Community Name*
Avon Wheatbelt	
	* Dense thickets of Melaleuca spp. with emergent Eucalyptus erythronema var. marginata and Eucalyptus transcontinentalis
	* Wheatbelt Mottlecah (Eucalyptus macrocarpa subspecies macrocarpa) dominated heathland on deep white sands
	* Eucalyptus aff. incrassata mallee over low scrub on gypsum dunes (at Lake Chinocup)
Geraldton Sandplains	
	* Acacia rostellifera low forest with scattered Eucalyptus camaldulensis on Greenough Alluvial Flats
	* Sedgelands and grasslands with occassional emergent Eucalyptus loxophleba and scattered E. camaldulensis over Acacia acuminata and A. rostellifera shrubland on clay flats of the Irwin River (presumed totally destroyed)
Jarrah Forest	
	* Northern Darling Scarp survey, Community 6: Talbot Road Corymbea calophylla - Eucalyptus wandoo woodlands and heaths
Northern Kimberley	
	* Palm communities on lateritic surfaces in tropical north-west
	* Fauna-rich communities of sandstones in the Prince Regent River Reserve
Nullarbor	
	* Nullarbor survey community 2: Woodland communities
	* Nullarbor survey community 11: Beach dune community
	* Nullarbor survey community 8: Treeless Plain community
	* Nullarbor survey community 4: Hampton Range Mallee community
	* Nullarbor survey community 1: Southwest woodlands community
	* Nullarbor survey community 7: Treeless plain community of the southern central Nullarbor region
	* Nullarbor survey community 10: Coastal mallee and woodland community

* Bungle Bungle survey, community 9: Eucalyptus collina Woodland with Acacia tumida and Pletrachne pungens, Purnululu area

* Bungle Bungle survey, community 17: Acacia spp. Tall Shrubland with Triodia spicata, Purnululu area

* Bungle Bungle survey, community 16: Eucalyptus cliftoniana Low Open Woodland with Acacia sp. and Triodia spicata, Purnululu area

* Bungle Bungle survey, community 15: Eucalytpus aspera Low Woodland with Acacia eripoda and Triodia microstachya, Purnululu area

* Bungle Bungle survey, community 14: Eucalyptus cliftoniana Low Woodland with Cajanus sp. and Pletrachne pungens, Purnululu area

* Bungle Bungle survey, community 13: Eucalyptus brevifolia Low Open Woodland with Acacia retivenia and Triodia intermedia, Purnululu area

* Bungle Bungle survey, community 12: Eucalytpus opaca Low Open Woodland with Grevillea pyramidalis and Triodia pungens, Purnululu area

* Bungle Bungle survey, community 10: Eucalyptus brevifolia Open Woodland with Cassia venusia and Pletrachne pungens, Purnululu area

* Bungle Bungle survey, community 1: Livistona sp. Open Forest with Acacia holosericea and Germania truncatiglumis

* Bungle Bungle survey, community 7: Acacia farnesiana Open Shrubland with Aerva javanica and Aristida spp., Purnululu area

* Bungle Bungle survey, community 6: Lysiphyllum cunninghamii Low Woodland with Acacia holosericea and Cenchrus ciliaris, Purnululu area

* Bungle Bungle survey, community 5: Lysiphyllum cunninghamii Woodland with Carissa lanceolata, Purnululu area

* Bungle Bungle survey, community 4: Melaleuca leucadendra Open Forest with Acacia eriopoda and Aristida hygrometrica, Purnululu area

* Bungle Bungle survey, community 3: Melaleuca leucadendra/Eucalyptus camaldulensis Open Forest with Aerva javanica and Aristida spp., Purnululu area

* Bungle Bungle survey, community 2: Eucalyptus ptychocarpa Forest with Pandanus spiralis and Heteropogon contortus, Purnululu area

* Bungle Bungle survey, community 8: Eucalyptus collina Woodland with Acacia stipuligera and Triodia spicata, Purnululu area

* Bungle Bungle survey, community 11: Hakea arborescens Low Woodland with Dodonaea polyzyga and Triodia wiseana, Purnululu area

Pilbara

* Burrup Peninsula survey, community B1a: Acacia coriacea community of coastal

* Burrup Peninsula survey, community A2e: Littoral community of Trianthema triquetra and Sesuvium portulacastrum

* Burrup Peninsula survey, community A2d: Littoral community of Enchylaena tomentosa and Threlkeldia diffusa

* Burrup Peninsula survey, community A2c: Littoral community dominated by Frankenia ambita and Limonium salicorniaceum

* Burrup Peninsula survey, community A2b: Sporobolus virginicus community in littoral areas

* Burrup Peninsula survey, community A2a: Succulent low shrubland ("samphire") community dominated by Arthrocnemum halocnemoides and Arthrocnemum leiostachyum in littoral areas

* Burrup Peninsula survey, community C2a: Community of Terminalia canescens and Rhynchosia minima in valleys

* Burrup Peninsula survey, community B1b: Community of Acacia coriacea and Acacia bivenosa on coastal sands

* Burrup Peninsula survey, community D1c: Triodia pungens community on rocky soil, rocky flats and lower slopes

* Burrup Peninsula survey, community E2: Shrubland associations of Brachychiton australe and Terminalia supranitifolia on rocks and very rocky soil

* Themeda grasslands of Pilbara Region

* Open tussock grasslands of Astrebla pectinata, A. elymoides, Aristida latifolia, in combination with Astrebla squarrosa and low scattered shrubs of Sida fibulifera, on cracking-clay loam depressions and flowlines

* Woodland or forest of Eucalyptus victrix (coolibah) over thicket of Muehlenbeckia florulenta (lignum) on red clays in run-on zones

* Burrup Peninsula survey, community C1d: Triodia angusta community in valleys

* Burrup Peninsula survey, community B1c: Community of Pittosporum phylliraeoides and Acacia coriacea on coastal sands

* Burrup Peninsula survey, community D1d: Acacia inaequilatera over Triodia pungens Community on rocky soil, rocky flats and lower slopes

* Burrup Peninsula survey, community D1b: Community of Acacia bivenosa and Triodia pungens on rocky soil, rocky flats and lower slopes

* Burrup Peninsula survey, community D1a: Eucalyptus dichromophloia over Triodia pungens on rocky soil, rocky flats and lower slopes

* Burrup Peninsula survey, community C2c: Community of Sesbania cannabina, Eleocharis atropurpurea and Stemmodia sp. In valleys

* Burrup Peninsula survey, community C2b: Community of Terminalia canescens and Cyperus vaginatus in valleys

* Burrup Peninsula survey, community B2d: Community of Eragrostis falcata and Swainsona pterostylis on coastal sands

* Burrup Peninsula survey, community C1c: Community of Eucalyptus dichromophloia and Chrysopogon fallax in valleys

* Burrup Peninsula survey, community C1b: Community of Tephrosia rosea var. clementii and Indigofera monophylla in valleys

* Burrup Peninsula survey, community C1a: Community of Eucalyptus microtheca and Triodia angusta in valleys

* Burrup Peninsula survey, community B2e: Plechtrachne sp. Community of coastal

* Burrup Peninsula survey, community B3b: Ehretia saligna and Pittosporum phylliraeoides Depression Complex of coastal sands

* Burrup Peninsula survey, community B3a: Psoralea pustulata and Scaevola spinescens Valley Complex on coastal sands

* Burrup Peninsula survey, community E1: Triodia wiseana Grass Steppe on rocks and very rocky soil

* Burrup Peninsula survey, community B2c: Paspalidium sp. Tussock Grass community of coastal sands

* Burrup Peninsula survey, community B2a: Spinifex longifolius community on coastal sands

* Burrup Peninsula survey, community C1e: Community of Acacia bivenosa and Triodia angusta of valleys

* Burrup Peninsula survey, community B2b: Community of Triodia sp. cf. pungens

and Scaevola globulifera on coastal sands

Swan Coastal Plain

* Swan Coastal Plain community S20: Northern shrublands on sandy clays

* Swan Coastal Plain community 20a: Banksia attenuata woodlands over species rich dense shrublands

* Swan Coastal Plain community S19: Dense tall shrublands

* Swan Coastal Plain community S6: Northern dense low shrublands

* Swan Coastal Plain community 20b: Banksia attenuata woodlands over species rich dense shrublands

* Swan Coastal Plain community 21a: Central Banksia attenuata - E. marginata

* Swan Coastal Plain community 21c: Lowlying Banksia attenuata woodlands or

* Swan Coastal Plain community 22: Banksia ilicifolia woodlands

* Swan Coastal Plain community 23a: Central Banksia attenuata - Banksia menziesii woodlands

* Swan Coastal Plain community S2: Pericalmmya ellipticum dense low shrublands

* Swan Coastal Plain community 3a: Eucalyptus calophylla - Kingia australis woodlands on heavy soils

* Swan Coastal Plain community 23b: Northern Banksia attenuata - Banksia menziesii woodlands

* Swan Coastal Plain community 20c: Banksia attenuata woodlands over species rich dense shrublands

* Swan Coastal Plain community S1: Astartea aff. fascicularis / Melaleuca species dense shrublands

* Swan Coastal Plain community 19b: Woodlands over sedgelands in Holocene dune swales

* Swan Coastal Plain community 19a: Sedgelands in Holocene dune swales

* Swan Coastal Plain community 18: Shrublands on calcareous silts

* Swan Coastal Plain community 4: Melaleauca preissiana damplands

* Swan Coastal Plain community S7: Northern woodlands to forests over tall sedgelands alongside permanent wetlands

* Swan Coastal Plain community 1b: Corymbea calophylla woodlands on heavy soils

* Swan Coastal Plain community 3b: Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils

* Swan Coastal Plain community 21b: Southern Banksia attenuata woodlands

* Swan Coastal Plain community 23c: North-eastern Banksia attenuata - Banksia menziesii woodlands

* Swan Coastal Plain community S8: Eucalyptus wandoo woodlands (Scarp)

* Swan Coastal Plain community 3c: Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands

* Swan Coastal Plain community 1a: E. haematoxylon - E. marginata woodlands on Whicher foothills

* Swan Coastal Plain community 30a2: Callitris preissii and/or Melaleuca lanceolata forests and woodlands of the Quindalup Dunes

* Swan Coastal Plain community S9: Banksia attenuata woodlands over dense low shrublands

* Northern Darling Scarp survey, Community 6: Talbot Road Corymbea calophylla - Eucalyptus wandoo woodlands and heaths

* Swan Coastal Plain community S13: Northern Olearia axillaris - Scaevola crassifolia shrublands of Quindalup Dunes

* Swan Coastal Plain community S12: Rottnest Island Melaleuca lanceolata and/or Callitris preisii forests and woodlands

* Swan Coastal Plain community S11: Northern Acacia rostellifera - Melaleuca acerosa shrublands of the Quindalup Dunes

* Swan Coastal Plain community 30c2: Woodlands and shrublands on Holocene dunes (Quindalup Dunes)

* Swan Coastal Plain community S14: Spinifex longifolius grassland and low shrublands of Quindalup Dunes

* Swan Coastal Plain community 29b: Acacia shrublands on taller Quindalup Dunes

* Swan Coastal Plain community 29a: Coastal shrublands on shallow sands of the Quindalup Dunes

* Swan Coastal Plain community 28: Spearwood Banksia attenuata or Banksia attenuata - Eucalyptus woodlands of the Spearwood Dunes

* Swan Coastal Plain community S18: Eucalyptus marginata / Corymbea calophylla woodlands on laterites

* Swan Coastal Plain community 26b: Woodlands and mallee on limestone of the Spearwood Dunes

* Swan Coastal Plain community 20d: Dandaragan Plateau shrublands and

* Swan Coastal Plain community 26a: Melaleuca huegelii - M. acerosa shrublands on limestone ridges of the Spearwood Dunes

* Swan Coastal Plain community 25: Eucalyptus gomphocephala - Agonis flexuosa woodlands on the southern Spearwood dunes

* Swan Coastal Plain community 24: Shrublands and woodlands on northern Spearwood dunes

* Swan Coastal Plain community 27: Species poor shrublands and mallees on limestone of the Spearwood Dunes

* Swan Coastal Plain community 30b: Eucalyptus gomphocephala and/or Agonis flexuosa woodlands of the Quindalup Dunes

* Swan Coastal Plain community S16: Mixed dense shrublands on yellow brown

* Swan Coastal Plain community S10: Calothamnus sanguineus dense low shrublands on sandy laterites

Appendix B
Explanation of Themes

Explanation of Themes

The ecosystems and ecological communities in the ECOSTATUS database have been categorised according to a list of general themes (Table 1). The groupings are reflected in the draft list. Ecosystems and ecological communities may be categorised according to more than one theme. For example, pools of granite rock outcrops may be grouped under "Rock Outcrops" or "Wetland (other)". The process of grouping ecosystems and ecological communities according to themes will be refined during the course of the project.

The themes may be thought of as habitats with significant nature conservation values, and which require special management. They are usually areas of high biological diversity and often contain rare or threatened communities. The list of themes includes, and adds to, the "significant habitats" listed in DCALM (1992). Some of these habitats, such as uplands, may cover extensive areas and incorporate many communities. Others, such as mound springs, usually have a more patchy distribution and are typically only a few hectares or less in area.

Table 1. Themes used to group ecosystems and ecological communities in the ECOSTATUS database.

Theme
Karst, Caves and Aquifers
Rainforest
Rock Outcrops
Uplands and Areas of Unusual
Wetlands (other)
Mangroves
Aquatic Microbial Communities
Mound Springs
Mudflat
River Pools and Billabongs
Rivers
Salt Lakes

1. Karst, Caves and Aquifers (in limestone):

Karst and other forms of limestone occur in a number of regions in Western Australia. Most of the areas are characterised by the presence of caves below the ground surface. Subterranean wetlands occur in many of the caves, fed by aquifers contained in karst and porous or fissured rock. The caves of Western Australia are very old, with the youngest being those of the aeolian limestone fringing the southwest (2 million to 10,000 y.o.) and the oldest being found in the Oscar and Napier Ranges in the Kimberley region (350 million y.o.). Many caves have acted as refugia during times of changing climatic conditions and contain relic species from more humid times.

Western Australia contains a rich cave fauna with a high number of endemic species and communities. Some of the caves contain troglobites (animals completely dependent on caves, often with specialised adaptations for cave existence), including the only known vertebrate troglobyte species in Australia (Humphreys 1991). These species require the specialised cave conditions for existence and are susceptible to even minor changes to the cave environment. Other species are less cave-dependent, and may use the cave only for special purposes (eg. roosting and breeding by bats).

Cave ecosystems are particularly susceptible to disruptive processes. Humidity, temperature and other conditions in caves remain relatively constant due to the lack of external climatic influence on most of the cave environment. However, human visits to caves can cause permanent physiochemical changes to the system, including changing the gaseous composition of the air through expired CO_2, trampling cave surfaces, or changing ventilation by blocking or opening cave entrances (see Humphreys 1991).

Developments associated with industrial or residential developments in the vicinity of cave systems and associated aquifers can also pose threats to the ecosystem by causing drawdown of aquifers and pollution of the caves and waterways. Thus, management of caves needs to consider the surface (epigean) environment, catchment areas of streams or watercourses that enter caves, and groundwater systems with which caves are associated (DCALM 1992). Humphreys (1991) concludes that habitat protection is more important than the protection of individual species for the persistence of cave fauna.

In addition to cave fauna, the stygofauna (fauna of aquatic groundwater) in karst and calcrete aquifers of the Pilbara region is currently being studied, and is proving to contain one of the world's most diverse subterranean faunas, as well as many ancient lineages (Humphreys 199*). An example is the Millstream aquifer on the Fortescue River, which contains a relict freshwater stygofauna with clear Gondwanan affinities. Evidence suggests that pockets of groundwater calcretes in the Pilbara may contain distinct faunas, and thus substantial biodiversity. The groundwater calcretes are vulnerable to pollution, water abstraction and dewatering operations associated with mining.

2. Mangroves

Mangrove is the term used to refer to the perennial trees and shrubs that grow in the intertidal region of the tropical and sub-tropical coasts of the world. Mangal refers to an association of mangrove species. Mangals are best developed along the Kimberley coast, and extend along the northwest coast as far south as Shark Bay, with small stands occurring on islands of the Abrolhos and in the Leschenault Estuary near Bunbury. Mangals occur in a wide range of habitats in Western Australia, which Semeniuk (1993) has subdivided into nine major mangrove regions based on climate and geomorphic-sedimentary setting.

Mangals provide an important interface between marine and terrestrial species. Certain species of crustaceans, molluscs and mudskippers are found resident in the mangals, in the mud or on the mangroves themselves. At high tide the mangals are inhabited by fish and crustaceans, and provide an important nursery and feeding ground for these animals. At low tide, terrestrial species such as birds, reptiles and mammals, such as bats, feed on the invertebrates of the mudflats, and leaves, fruits and flowers of the mangroves. Mangroves also provide important habitat for the Salt-water Crocodile (*Crocodylus porosus*).

The nature conservation values of mangals are considerable. They form important fish nursery habitat, because of the protection they afford and because of the supply of detritus. Mangals provided an important source of food, timber and recreational areas for Aboriginal people in the past and in some areas today (Kenneally, 1982). Mangals also help to stabilise the coast by providing a buffer for wave action.

The mangroves of northern Australia support the richest mangrove bird fauna in the world (Johnstone, 1990). In Western Australia, 16 species of birds are virtually confined to mangal, and another 6 species are confined to it in at least part of their range. Some of the birds found in mangroves in Western Australia are also found in structurally similar habitats such as semi-deciduous vine forest and paperbark swamps. In Western Australia, the Kimberley is the only place where these similar habitats occur in close proximity to mangroves. The mangroves, therefore, provide a linkage between these habitats that is important for bird migration (Johnstone 1990).

Threats to mangroves in Western Australia include the use of mangals for dumping rubbish, cutting for timber, and clearing and large scale dredging of extensive intertidal areas for industrial or residential development, particularly along the Pilbara coast (Lear and Turner 1977; Kenneally 1982). The degradation of mangrove ecosystems that may include the destruction of vegetation can lead to a severe decline in estuarine productivity, loss of water quality and impoverishment of fauna.

Although part of tidal ecosystems, mangroves have been included in this project: because of their nature conservation values it is crucial that they be taken into account in terrestrial reserve planning, recognising the fact that terrestrial reserves can be extended to low water mark.

3. Aquatic Microbial Communities

The aquatic microbial communities included in the database are benthic microbial communities (BMCs) and microbialites. BMCs are "complex ecological associations of photosynthetic prokaryotes (ie. cyanobacteria), eukaryotic microalgae (eg. diatoms), and 'true' bacteria" (Moore 1993). "Microbialite" is a recent term used to refer to all organosedimentary structures produced by the growth and metabolic activity of benthic microbial communities (Moore 1993). Microbialites may form by mechanical trapping and binding of sediment particles by the BMC; biologically-influenced precipitation of a mineral phase within the BMC; inorganic calcification that encrusts the BMC; or a combination of these processes. The microbialite structure that is formed depends on the structure of the associated BMC, and may include laminated structures (stromatolites), structures with clotted internal framework (thrombolites), and structures with less defined internal framework (eg. tufa, travertine, algal nodules and algal biscuits).

Throughout the preCambrian (3.5 billion to 600 million Years BP) stromatolitic microbialites dominated the shorelines of lakes and seas globally. Today, however, living stromatolites are restricted in distribution to a few, relatively small areas, probably due to the evolution of grazing and burrowing marine animals that disturbed the BMCs. Stromatolites and other microbialite structures are extremely important scientifically, as they provide an opportunity to study both fossil and living forms, and thereby aid interpretation of past environments. Geologically they provide a record of life from a time for which few other fossilised forms are available (Moore *et al.* 1983).

Western Australia has the largest and most varied living microbialite formations in the world, as well as the world's oldest fossil microbialites. The stromatolites at Hamelin Pool, Shark Bay, are the most well-known living examples in the world. Although restricted in abundance, living microbialites in Western Australia are found in a wide range of wetland types and climates, including fresh, marine and hypersaline waters in sub-tropical to cool temperate environments.

Living BMCs and microbialites are fragile and vulnerable to damage. Management strategies, such as building boardwalks and providing information to visitors in tourist destinations such as Hamelin Pool and Lake Clifton, are extremely important to ensure that these ancient communities are not adversely affected by tourism. Other threats to microbialites are changes in water quality and hydrology, such as nutrient enrichment or groundwater drawdown, and trampling by livestock.

4. Mound Springs

Mound springs are defined as "points of groundwater discharge, characterised by mounds of peat or calcarenite about the spring boil" (Knott and Jasinska 1998). The springs may discharge from a central vertical channel or seep from the total surface of the mound. In Western Australia, mound springs are found in the Ellenbrook area near Perth and in several locations in the northwest of the State. They range in size from only a few metres in diameter to several hectares, and they vary in height.

Mound springs have significant conservation value as mesic refuges for plants and animals in an arid landscape, and they support both endemic species and isolated outliers (Knott and Jasinska 1998). The mound springs at Ellenbrook have been well studied, and have been found to have a unique mound spring faunal assemblage including rare and restricted species of Gondwanan origin. The permanently moist peat mound provides important habitat for these species which lack resistant stages and are not found in temporary water bodies on the Swan Coastal Plain (Jasinska, 1998). Mesic plants such as liverworts, bog clubmosses and sundews, usually found only in permanently wet swamps of the lower south-west, are found in the moist environment of the Ellenbrook mound springs.

Little is known of the fauna and flora of the mound springs of northwestern Australia. A current study of mound springs in the Mandora area in the Great Sandy Desert will provide more information (G Graham pers. com. 1999). In South Australia, each major group of the 90 mound spring complexes has its own unique characteristics and a distinct fauna and flora (Ponder 1985).

Mound springs are also important watering points for terrestrial animals from surrounding areas. In the northwest, mound springs supporting dense closed forest occur, providing oases in desert environments. In the past, mound springs provided an important permanent water source for Aboriginal people. The peat formations of most mound springs are very old, and are therefore valuable for the study of past environments.

Mound springs were formerly widespread in the Ellenbrook area near Perth; all but three have been destroyed to create farm dams or pastures. The major threats to mound springs are groundwater abstraction from their source aquifers, physical destruction either by land-clearing or cattle-grazing, fire, and invasion of exotic plant and animal species.

5. Mudflats

Mudflats are an ecosystem associated with, but distinct from, mangal. They are expanses of bare mud in the intertidal zone, usually situated on the seaward side of the dunes or mangal. Mudflats contain the highest diversity and density of many invertebrates in the mangrove system (Carr and Livesey 1996). Large numbers of waterbirds utilise the mudflat as feeding grounds, and areas such as Roebuck Bay mudflats have been recognised as internationally important for migratory shorebirds.

Little is known of the fauna communities of mudflats in Western Australia, but there are studies underway by the Netherlands Institute for Sea research in collaboration with Birds Australia to document the invertebrates of Eighty Mile beach, Roebuck Bay and King Sound .

The major threats to the Roebuck Bay mudflats are possible changes to ground water flows and pollution by agricultural chemicals, and vehicle traffic, which may disturb shorebird roosts. Threats to mangroves may impact on mudflats too due to the integrated nature of these habitats.

6. River pools and billabongs

River pools and billabongs provide an important source of permanent or semi-permanent water in semi-arid areas, and act as refugia for the river's aquatic life in the dry season. Billabongs are thought to be far more productive than the main stream of the river. They provide a breeding and nursery area for a range of organisms, and can provide nutrient cycling and pollutant removal services (Water and Rivers Commission 1997). They are a contained ecosystem, but have connections to the river system itself. Little is known of the ecological processes and organisms of most pools and billabongs.

The major threats to river pools and billabongs are those which increase siltation and sedimentation which can smother stream-bed flora and fauna, thereby reducing benthic food supply, lowering the water's oxygen supply and smothering microhabitat such as submerged logs. Furthermore, the temperature of the water increases as the pool becomes shallower due to sedimentation build-up, changing the composition of the flora and fauna. Siltation and sedimentation are caused by increased runoff due to high rainfall, trampling in areas where stock congregate around pools and billabongs, and clearing. These processes cause erosion and encourage weed growth.

Changes to water quality also occur through nutrient enrichment due to stock or agricultural fertilisers. Direct filling and dam building are problems in some areas. Spraying for mosquitoes in some areas may kill other organisms in the pools and billabongs.

The condition of pools and billabongs can be an important indicator of river health.

7. Rainforest

The presence of rainforests in Western Australia was not formally recognised until 1965. It is now known that more than 1500 patches of rainforest are located throughout the sub-humid Kimberley region. However, few patches exceed 20 hectares in area, and the total area of rainforest in the Kimberley is only about 8000 hectares. Most patches are located in the shadow of gorges and sheer cliffs, or among massive rock scree, often in fire-protected areas. Due to the inaccessibility of most rainforest patches, only one major survey of rainforest in Western Australia has been conducted (McKenzie *et al.* 1991).

Rainforest patches in Western Australia are highly significant in terms of their conservation values, containing approximately 25% of known Kimberley flora and 45% of land-bird fauna of the Kimberley. The rainforest canopy provides an important habitat for insects, birds and bats, including migratory birds. The migratory bird species often utilise the corridor provided by mangroves to travel between rainforest parches in the Kimberley (*see* **Mangroves** above). Evidence suggests that

the patches contain a rich and diverse invertebrate litter fauna, with many undescribed species (McKenzie and Dyne, 1991; Solem, 1991). However, rainforest patches are inadequately represented in the Western Australian reserve system due to their wide distribution, small patch size and heterogeneous composition.

The major threats to rainforest patches are trampling by cattle and inappropriate fire regimes. Trampling of the patches by cattle, particularly in swampy areas, results in opening of the canopy, allowing invasion by savannah grasses, increasing the risk of fire (DCALM 1992). In addition, excessive hot fires burn into rainforest patches, causing a gradual retreat at the margins.

8. Rivers

Rivers are vital components of the landscape and must be managed carefully in order to preserve their nature conservation values. River systems are closely integrated with terrestrial and other wetland ecosystems, and river health is immediately linked to the health of the land (Water and Rivers Commission 1997). They are highly diverse in their physical and biological characteristics, ranging from saline to fresh, and seasonal to permanent, with nature conservation values are too numerous to list here. While their major function is to drain the landscape, they also provide a great number of important habitats, both riparian and aquatic.

Major threats to rivers in Western Australia are salinity, nutrient enrichment, and erosion causing increased runoff and occlusion of the streambeds, destruction of riparian habitat and changes in flow due to damming. Lesser threats include water harvesting and waste disposal associated with mining operations.

9. Rock Outcrops

Outcrops of the preCambrian Great Western Shield, which covers much of the south west of WA, occur in the jarrah forest, karri forest, wheatbelt and neighbouring regions. They appear either as hills up to 60m above the surrounding plain, or as flat sheets of rock on eroded slopes (DCALM 1992). Significant nature conservation values are attributed to rock outcrops. They contain a variety of microhabitats, including bare rock, rock pools, exfoliating rock sheets and crevices, caves/tafoni/shade of boulders, cryptogamic crusts, lichens and mosses, herbfields and shrublands and woodlands (Hopper *et al.* 1997). Rock outcrops may be of granite (or metaigneous granitioid rock types), quartzite and related rock substrates, but are generally referred to as granite outcrops or sometimes as monadnocks.

The granite outcrops of the southwest of Western Australia are recognised as being important areas of biodiversity. Main (1997) states that granite outcrops in the southwest have a characteristic assemblage of plants and animals comprising relictual genera and/or species, and widespread taxa from the surrounding environment. The moisture-retaining habitats associated with granite outcrops, such as caves and rock pools, provide refuge for the relictual taxa. Conversely, arid-adapted taxa persist on the drier parts of granite outcrops even in high rainfall areas. Rainfall, geoclimatic history and the configuration and topography of the rocks determine the composition of granite rock communities (Main 1997).

The plant life of granite outcrops is extremely diverse in the context of the mega-diverse South West Botanical Province, with up to 200 plant species, including many endemics, found on individual outcrops (Hopper *et al.* 1997). Few animals are restricted to granite outcrops (Withers and Edward 1997), although there is an

enormous range of terrestrial animals found associated with them. The fringing apron of granite outcrops forms specialised edge habitats and must be included in the boundary of the outcrop for conservation purposes.

Granite outcrops in the southwest appear to be extremely susceptible to weed invasion, especially following disturbance. Outcrops in the wheatbelt have mostly been severely disturbed, with clearing for agriculture to the base and stock grazing on the outcrops themselves. Dieback is also common and widespread, frequent fire has caused the loss of a shrub layer in the understorey, stock and feral animals are grazing to the detriment of many native species, and salinisation affects waterways associated with outcrops. Water harvesting from granite rocks by building dam walls at the base of the rocks has been common practice in wheatbelt areas in the past, and causes hydrological changes and alters the composition of rock communities. Many granite outcrops are used as recreational areas due to their scenic value. Trailbike riding, trampling and graffiti are common problems, and recreational use of outcrops must be monitored and managed.

10. Salt Lakes

Salt lakes are hydrologically closed basins, where evaporation exceeds inflow, but inflow is sufficient to sustain a standing body of water (Eugster and Hardie 1978). Salt lakes as part of larger chains of lakes occur within the wheatbelt of Western Australia as remnants of paleo-drainage channels.

In the eastern wheatbelt, the wetlands are generally naturally saline or hypersaline. Landscape features associated with salt lakes include large playa lakes, gypsum dunes around the immediate lake edge, and extensive series of lunettes varying in their sand, clay and gypsum content.

Salt lakes are biologically interesting, in that they provide an opportunity to study ecosystem functioning in a less complex system (Bayly and Williams, 1966). Their physiologically stressing conditions preclude many biological groups from inhabiting them. An inverse correlation between salinity and species diversity has long been recognised, and salt lakes have greatly reduced species diversity compared with freshwater ecosystems as a result. However, numerous plants and animals, especially diatoms, algae and crustaceans, have adapted to the highly saline and ephemeral nature of salt lakes in Western Australia.

Little is known of the ecology of salt lakes in Western Australia. Evidence to date suggests that salt lakes in Western Australia contain a greater number of species in certain genera than salt lakes in eastern Australia (Handley 1991; Geddes *et al.* 1982 and Williams 1981 in Handley 1991). Little is known too of threats to salt lake ecosystems. Mining operations may impact on salt lakes, by removing gypsum deposits and, in some, cases, by pumping waste water into them. Communities within salt lakes, such as benthic microbial communities (see above) are affected by the types of hydrological changes now very prevalent in the wheatbelt. The current systematic survey of wheatbelt salt lake fauna and flora by the Department of Conservation and Land Management will provide greater insight into the communities of salt lakes.

11. Uplands and Areas of Unusual Geology

Uplands and areas of unusual geology appear to be centres of diversity and provide habitat for restricted endemic species (DCALM 1992). Hopkins et al. (1983) suggest

that landscape dissection, in concert with climatic and microclimatic factors, has provided geographical isolation and thereby facilitated taxonomic divergence. Furthermore, uplands often have features which create microhabitats that act as refugia. Areas of unusual geology on flat plains, such as the wet ironstone heaths of the Swan Coastal Plain, often support restricted endemic species and communities (DCALM 1992).

There are at least six upland groups in Western Australia defined on the basis of physical and biological characteristics (Hopkins *et al.* 1983). Studies of the Mt Lesueur upland area and the Stirling Range have shown these upland groups to be floristically rich areas with restricted endemic species and outlying populations with generally more mesic distributions. Studies of ranges in the Eastern Goldfields region have shown that although there are many shared species between ranges, each range has a unique assemblage of communities (M. Lyons pers. com. 1999). Uplands in the northwest of the State, although well known for their spectacular scenic attractions, are generally poorly known in terms of their biology. Features associated with uplands in the north, such as gorges and scree slopes, often provide habitat for restricted species, and communities such as rainforest (see above).

Despite their obvious nature conservation values, uplands in the southwest are not well conserved – they have been exploited for water catchment purposes, mining, agriculture and recreation. Many of the remnants are the only remaining locations of certain species and communities. Threats to uplands and areas of unusual geology include clearing for agricultural and pastoral use, impacts of stock, weed invasion and intense fires. In agricultural areas, upland vegetation may remain intact in an otherwise cleared landscape due to the unsuitability of slopes for cropping. It is important to protect these remnant patches as examples of once more widespread vegetation.

12. Wetlands (Other)

Wetlands are generally defined as "areas of permanent seasonal or intermittent inundation, whether natural or otherwise, fresh, brackish or saline, static or flowing, and include estuaries, rivers, streams, lakes, springs, intertidal sandflats, mudflats and mangroves" (DCALM, 1992). The definition does not include marine areas (other than intertidal flats and mangroves) and water bodies that do not support aquatic life.

"Wetlands (other)" refers to wetland types other than those already listed. Wetlands and their catchments are integrated systems consistent with the ecosystem concept, and may contain a wide range of community types.

Wetlands are highly diverse ecosystems and occur on all land types. Many important communities, such as microbialite and mangrove communities, depend on wetlands for their survival. Many wetlands are protected for their value to waterbirds, providing habitat for feeding, breeding and roosting, and a network of wetlands for migration. Wetlands provide essential water resources, and many have significance to Aboriginal heritage. They are also often a focal point of recreational areas and have great aesthetic appeal.

Wetlands require special management as they are highly vulnerable to change, not only due to alteration of the wetland itself, but also to the surrounding terrestrial environment. Rising saline groundwaters as a result of land clearing is the most serious problem affecting wetlands in the southwest of Western Australia today. Other major threats include impacts of feral animals and livestock, weed invasion of

waterways and erosion. Few wetlands in Western Australia are in pristine condition, and it is important to protect those that are. Integrated management involving landholders and conservation organisations is required to maintain wetland ecosystems, and to rehabilitate wetlands where necessary.

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Appendix C
Proposed hierarchical classification of ecosystems and ecological communities

Proposed hierarchical classification

The ecosystems and ecological communities in the ECOSTATUS database can be considered to make up nine different but related data types. In GIS terminology, these can be referred to as data layers in the database. We have designed a preliminary ordering of those data layers to imply a hierarchy, as described below:

Ecosystem Type 1: the 1:250,000 scale vegetation map units (Associations) as mapped by J S Beard throughout the whole State.

Ecosystem Type 2: more finely discriminated vegetation units (eg Sub-associations) defined through larger-scale mapping, or through subdivision of Beard's units.

Ecosystem Type 3: other ecosystems defined on the basis of biophysical data eg a lake containing algal mats that are at least partially documented.

Ecosystem Type 4: other entities that are defined on the basis of physical parameters only eg a sub-catchment or a lake with a little-known biota.

Ecological Community Type 1: biotic assemblages defined using classification/ ordination procedures of comprehensive biological data following survey.

Ecological Community Type 2: floristic assemblages defined using classification/ ordination procedures of floristics-only data following survey.

Ecological Community Type 3: faunal assemblages defined using classification/ ordination procedures of faunal data following survey.

Ecological Community Type 4: assemblages of fungi, plants or animals or any combination that are well documented from at least one site.

Ecological Community Type 5: assemblages of fungi, plants or animals or any combination, that are not well documented (data deficient) but considered important.

For the purposes of this project, we are considering an ecosystem to be, in general, a broadscale unit, whereas an ecological community is likely to be smaller, or restricted in area. An ecosystem may include several ecological communities; for example, a lake may include within its boundaries a fringing vegetation community, an aquatic invertebrate community and a fish community. Furthermore, the same fish community may occur in several related lakes as well as in some streams.

The different types of ecosystems and also of ecological communities have been distinguished on the basis of data type and quality. As knowledge about the State's environments and biota improve, individual entities will be able to be reclassified from one type to another. For example, results from fauna surveys in a region where floristically defined communities are already documented will provide the basis for defining new communities, or redefining the floristic communities in a holistic way.

The hierarchical classification scheme above represents a first attempt, and is being applied to the data at present. Guidelines for assigning ecosystems and ecological communities to a particular data layer will be developed and trialed.

Comments on the classification scheme shown above are welcome.

Appendix D
Example of report from the ECOSTATUS database

Mound spring community on mudflat, supporting dense, closed forest (Bunda-Bunda type)
Ecological Community
Themes: Mound Springs/Rainforest

Conservation Status

Original area in WA:	*ha*
Existing area:	22 *ha*
No. of occurrences:	1
Extent in IUCN reserves:	*ha*
% in IUCN reserves:	
Extent in CALM managed reserves:	*ha*
% in CALM managed reserves:	

Threats
Grazing by native or introduced species

CALM Location(s)
District **Region**

IBRA Region(s)
Dampierland

Biological significance
Bunda-Bunda mound springs are an excellent example of rainforest around a natural mound spring in the Dampierland bioregion. Bunda-Bunda is an isolated refuge for rainforest and riparian plant species, and a freshwater refuge for birds, including mangrove birds, in an arid setting. Although the rainforest species found at Bunda-Bunda are common to rainforest areas of northern Australia, they are unusual in such a seasonally arid environment. This and other spring-fed rainforest patches in the Dampierland bioregion are the most southerly occurrences of rainforest in Western Australia. However, comparative studies of spring-fed rainforest are required to delineate community types. Although Bunda-Bunda is similar to Big Springs (a mound spring complex located in King Sound) in its near-tidal setting, it has an entirely different physiography and flora (T. Willing, pers. comm.).

Community description and threats
Two areas of mound springs, characterised by raised peat mounds, are located on tidal mudflats in Carnot Bay, Dampier Peninsula, and are known by Aboriginal people as "Bunda-Bunda". The peat mounds rise approximately 2-3m above the surrounding tidal flats. The large mound is about 20ha in area, while the small mound is about 2ha.

The mounds are heavily vegetated, while the surrounding mudflats are bare. The springs support a closed forest (rainforest) of *Melaleuca cajuputi, Carallia brachiata, Timonius timon* and *Sesbania formosa,* with an understorey of of the fern *Cyclosurus interruptus.* The climbing maidenhair fern (*Lygodium microphyllum*) forms dense trailing columns into the tree canopy. The mangrove fern *Acrostichum speciosum* forms clumps at the outer edge of the swamp. Both the mound springs are fringed by mangroves in places. However, the two mounds differ somewhat in their vegetation,

and the smaller mound is dry in the centre, where it supports a wattle shrubland of mainly *Acacia neurocarpa* over grasses and sedges.

The springs are fed by a major unconfined freshwater aquifer in the Broome Sandstone, which meets a saltwater wedge along the coast. Although the groundwater is fresh, the channels surrounding the peat islands are saline and occasionally inundated during large tides.

Bunda-Bunda spring is also referred to as "Fern Island" or "Carnot Bay spring".

Bunda-Bunda is currently part of Beagle Bay Aboriginal Reserve, and is used for free-range cattle grazing. The vegetation has been grazed and trampled in places, and some of the pools have been heavily churned. However, the vegetation on the mounds appears to be in good condition. Dense leaf litter covers the surface of the mounds. Fire is also a potential threat.

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