

# **Advice on Conservation Values and Review of Nature Reserve Proposals in the Lake Cronin Region**

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**Advice of the Environmental Protection Authority to the Minister for  
Environment under Section 16(e) of the *Environmental Protection Act 1986***

**Environmental Protection Authority  
Perth, Western Australia  
Report 1329  
June 2009**

### **Strategic Advice Timelines**

<b>Date</b>	<b>Progress stages</b>
<b>10/11/04</b>	<b>Request for advice from Minister for the Environment</b>
<b>10/04/06</b>	<b>First stakeholder group meeting</b>
<b>15/05/06</b>	<b>Second stakeholder group meeting</b>
<b>20/02/07</b>	<b>Third stakeholder group meeting</b>
<b>02/06/09</b>	<b>EPA section 16(e) advice released</b>

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There is no appeal period on s16(e) advice.

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## Executive Summary

This document was developed as a result of advice requested in November 2004 by the (then) Minister for the Environment, Dr Judy Edwards, from the EPA under Section 16(e) of the *Environmental Protection Act (1986)*.

In 1975, the EPA recommended “that Lake Cronin and an adequate area around the lake should be made a Class “A” reserve for the Conservation of Flora and Fauna, to be vested in the WA Wild Life Authority” (recommendation 11.10, EPA 1975).

Due to competing interests, only a small area consisting of 1015 hectares (ha) around the lake was gazetted as a formal Nature Reserve in 1980. Henry-Hall (1990) reviewed the values of the area and recommended that the values could best be protected by the establishment of a large reserve consisting of approximately 113,250 ha.

Lake Cronin is a semi-permanent freshwater lake located in the south western region of the Eastern Goldfields and is the largest freshwater lake in the region. Despite a relatively dry climate with variable rainfall, the Lake Cronin Region (LCR) has diverse vegetation patterns which are regulated by geology and a long history of erosion in an ancient landscape (Newbey and Hnatiuk 1988, Beard 1990).

The LCR supports extensive shrubland, sandplain and woodland environments, including excellent representation of a range of vegetation types that are now extensively cleared in the Wheatbelt. These areas provide very important habitats for fauna species that are now largely absent or suffering declining populations in the Wheatbelt. Creation of nature reserves in the LCR provides an opportunity to conserve a portion of this extensive and contiguous environment representing the full catena of landscape elements in this biologically diverse region.

The LCR possesses significant values in terms of wetland, flora and fauna habitat, however the area also contains mineral wealth and exploration and mining leases have claim to the majority of Unallocated Crown Land (UCL) within the Coolgardie IBRA Region. The potential for large scale clearing for mineral exploration and extraction is the most significant threat in the LCR. Threats may include management issues such as the introduction of weeds and pathogens from vehicle movement and introduced materials, and hydrological changes that may occur from dewatering.

In preparing this advice, the EPA was mindful that the areas surrounding Lake Cronin provides a contiguous representation of environments that are now extensively cleared in the adjacent Wheatbelt Region and, at a wider scale, provides a potential for conservation management at a whole-of-region level in an environment that represents the transition from the higher rainfall South West Australia to the arid areas of central Australia

These values have recently been recognised in the Great Western Woodlands conservation strategy, which the Government has committed to support. The advice provided places the Lake Cronin Region into the wider context of the Great Western Woodlands region.

## Summary of recommendations

Based on the values identified in this report, it is recommended that:

1. The Great Western Woodlands conservation strategy, which provides a basis for whole-of-region scale recognition of conservation and heritage values, and management priorities, is strongly supported.
2. The proposed expanded Lake Cronin conservation proposals (as outlined in Map 1) be implemented through the Great Western Woodlands conservation strategy. Highest priority in this process should be to establishing:
  - a. The proposed “C” Class Nature Reserve to protect the catchment of Lake Cronin;
  - b. The proposed “A” Class Nature Reserve to protect North Ironcap Banded Ironstone Formation; and
  - c. The proposed “C” Class Nature Reserve representing extensive sandplain and woodland vegetation located immediately east of the Wheatbelt, which represents vegetation communities and fauna habitats that have been extensively cleared and fragmented in the adjacent Wheatbelt.
3. The Great Western Woodlands conservation strategy should be used to review the potential to:
  - a. Expand the “A” Class Nature Reserve around North Ironcap; and
  - b. Upgrade the recommended “C” Class Nature Reserve protecting the Lake Cronin catchment and the “C” Class Nature Reserve representing extensive sandplain and woodland vegetation located immediately east of the Wheatbelt to “A” Class status.

# Contents

	Page
<b>1. Overview .....</b>	<b>1</b>
<b>2 Introduction.....</b>	<b>4</b>
<b>3 Methodology Developed to meet Objectives for Section 16(e) Advice .....</b>	<b>8</b>
<b>4 Regional Values.....</b>	<b>9</b>
4.1 Interim Biogeographic Regionalisation of Australia (IBRA) Values.....	11
4.2 Botanical Region Values.....	12
4.3 Comprehensive, Adequate and Representative (CAR Assessment .....	15
<b>5 Lake Cronin Region Values .....</b>	<b>18</b>
5.1 Rare, Endemic and Poorly Known Flora .....	23
5.2 Floristic Communities.....	24
5.3 Fauna and Fauna Habitats .....	25
5.4 Wetlands .....	27
<b>6 Key Threats to Biodiversity in the LCR .....</b>	<b>28</b>
<b>7 Conclusions.....</b>	<b>30</b>
<b>8 Recommendations .....</b>	<b>32</b>
<b>9 Further advice .....</b>	<b>33</b>

## Figures

- Figure 1 Lake Cronin (photo Mark Brundrett, March 2007).  
Figure 2 Catena of landform/vegetation units seen from North Ironcap (photo Mark Brundrett, March 2007).  
Figure 3 North Ironcap (photo Mark Brundrett, March 2007).  
Figure 4 Lake Cronin waterbirds (photo Mark Brundrett, March 2007).

## Maps

- Map 1 Lake Cronin Proposed Nature Reserve and Management Area.  
Map 2 Proposed Lake Cronin Reserve Locality Map.  
Map 3 Lake Cronin Region Study Area.  
Map 4 Botanical Provinces and IBRA Regions.  
Map 5 Pre-European Vegetation and Declared Rare Flora.  
Map 6 Mining Activity.  
Map 7 Proposed Lake Cronin Reserve and Great Western Woodlands.

## Tables

Table 1	Areas of existing and proposed Lake Cronin Reserves. ....	2
Table 2	Sources of information concerning flora, vegetation, fauna and landscape significance, as well as criteria for designation of nature reserves. ....	9
Table 3	Native plant taxonomic diversity in selected regional biodiversity hotspots in WA. ....	10
Table 4	% Remaining and Protected Native Vegetation Amounts in Local Government Areas in and surrounding the Lake Cronin Region. ....	10
Table 5	IBRA Regions intersected by the proposed Lake Cronin Reserve, level of reservation and extent of clearing.....	12
Table 6	Representation of Vegetation Associations and Protection Areas.....	17
Table 7	Geographic features and sources of flora, fauna and vegetation information in or near the Lake Cronin Nature Reserve.....	18
Table 8	Rare, priority, apparently endemic and other flora of conservation concern by location, endemism and substrate located in the Lake Cronin Region. ....	19
Table 9	Summary of Declared Rare Flora (DRF), extinct (X) priority (P1-4), potentially rare (PR) and apparently endemic flora (SRE) of conservation concern by endemism and substrate (BIF shaded brown, sandplains and other soil types shaded yellow) within the Lake Cronin Region. ....	23
Table 10	Rare vertebrate fauna recorded from or expected to occur in the area. ....	26

## Appendices

Appendix 1	References.
Appendix 2	Definitions.
Appendix 3	Acknowledgements.

**Abbreviations/Acronyms (see Appendix 2 for definitions)**

BIF	Banded Ironstone Formation
CALM	Department of Conservation and Land Management
CAR	Comprehensive, Adequate and Representative
DEC	Department of Environment and Conservation (includes former CALM and DoE).
DoE	Department of Environment
DRF	Declared Rare Flora listed in Western Australia
EPA	Environmental Protection Authority
Eremaean	Inland arid Botanical Province of Western Australia (Beard 1990)
FCT	Floristic Community Type
Interzone	Botanical region of intermediate rainfall between the Wheatbelt (SWAFR) and Goldfields (Eremaean zone) (Beard 1990)
IBRA	Interim Biogeographic Regionalisation for Australia
P1, P2, P3, P4	Categories of Priority Flora, Fauna and Communities listed in Western Australia
PEC	Priority Ecological Community
SRE	Short Range Endemic fauna (or flora)
SWAFR	South Western Australian Floristic Region (formerly South West Botanical Province of WA).
Taxa	Taxonomic entity - species, subspecies, etc.
TEC	Threatened Ecological Community
WAherb, herbarium	Western Australian Herbarium

## 1. Overview

This document was developed as a result of advice requested in November 2004 by the (then) Minister for the Environment, Dr Judy Edwards, from the EPA under Section 16(e) of the *Environmental Protection Act* (1986). This request followed Ministerial approval of the Flying Fox Nickel Mine in Forrestania without formal assessment by the Environmental Protection Authority (EPA). Relevant paragraphs of the letter from the Minister are reproduced below.

### **Requested information in letter to the EPA Chairman from the Minister for the Environment, November 2004**

Your assistance is however sought with respect to one key matter which was highlighted in the appeals.

The Class "A" Lake Cronin Nature Reserve (Reserve number 36526) was created in 1980 for the Conservation of Flora and Fauna. This reservation followed recommendations by the Conservation Through Reserves Committee in 1974 (the "Green Book") and the EPA in 1975 (the "Red Book") that "Lake Cronin and an adequate area around the lake should be made a Class "A" reserve for the purpose of Conservation of Flora and Fauna".

A further report to the EPA Red Book Task Force in 1990 (*Nature Conservation Reserves in the Eastern Goldfields, Western Australia*, N. Henry-Hall) recommended that the existing Lake Cronin Nature Reserve be extended to cover an area of 113,250 hectares, with the main extension primarily to the west of the existing reserve.

I understand from the Department of Conservation and Land Management (CALM) that since these developments, further negotiations have been held with the Department of Industry and Resources (DoIR) with a view to agreeing the boundaries and a management regime for the land surrounding the existing reserve. This has led to the development of a proposal for the area within the ironstone belt to be unreserved but managed by CALM under the auspices of Section 33(2) of the *Conservation and Land Management Act* 1984. The remaining areas identified in the 1990 report to the Red Book Task Force are recommended to be gazetted as conservation reserves under the care, control and management of the Conservation Commission of Western Australia.

It is apparent from the above review that the status of the Lake Cronin Nature Reserve has been the subject of lengthy deliberations by a number of government authorities since at least the mid-1970s. In my view, it is appropriate to finalise this process through the creation of an adequate reserve (or reserves) to protect the Lake and the surrounding environment.

With this object in mind and given the EPA's past involvement in the issue, it would be appreciated if the EPA could review the current proposals for reserves in the Lake Cronin area, and provide me with a recommendation on establishing a conservation reserve (or reserves) which adequately protect the nature conservation values of this area.



The Lake Cronin area has been formally recognised for conservation since 1975 when the EPA recommended “...that Lake Cronin and an adequate area around the lake should be made a Class A reserve for the Conservation of Flora and Fauna, to be vested in the WA Wild Life Authority. Specifically EPA recommends to the Department of Mines that conditions should be placed on mining tenements including and surrounding Lake Cronin to provide the maximum protection of the environment and furthermore recommends to the Departments of Lands and Surveys that until further notice no land within a 10 km radius of Lake Cronin should be alienated” (recommendation 11.10, EPA 1975).

Due to competing interests, only a small area consisting of 1015 ha around the lake was gazetted as a formal Nature Reserve in 1980. Henry-Hall (1990) reviewed the values of the area and recommended that the values could best be protected by the establishment of a large reserve consisting of approximately 113,250 ha. This recommendation included a portion of the Forrestania greenstone belt of mineralised rock with significant prospectivity and its implementation was not supported by the (then) Department of Mines.

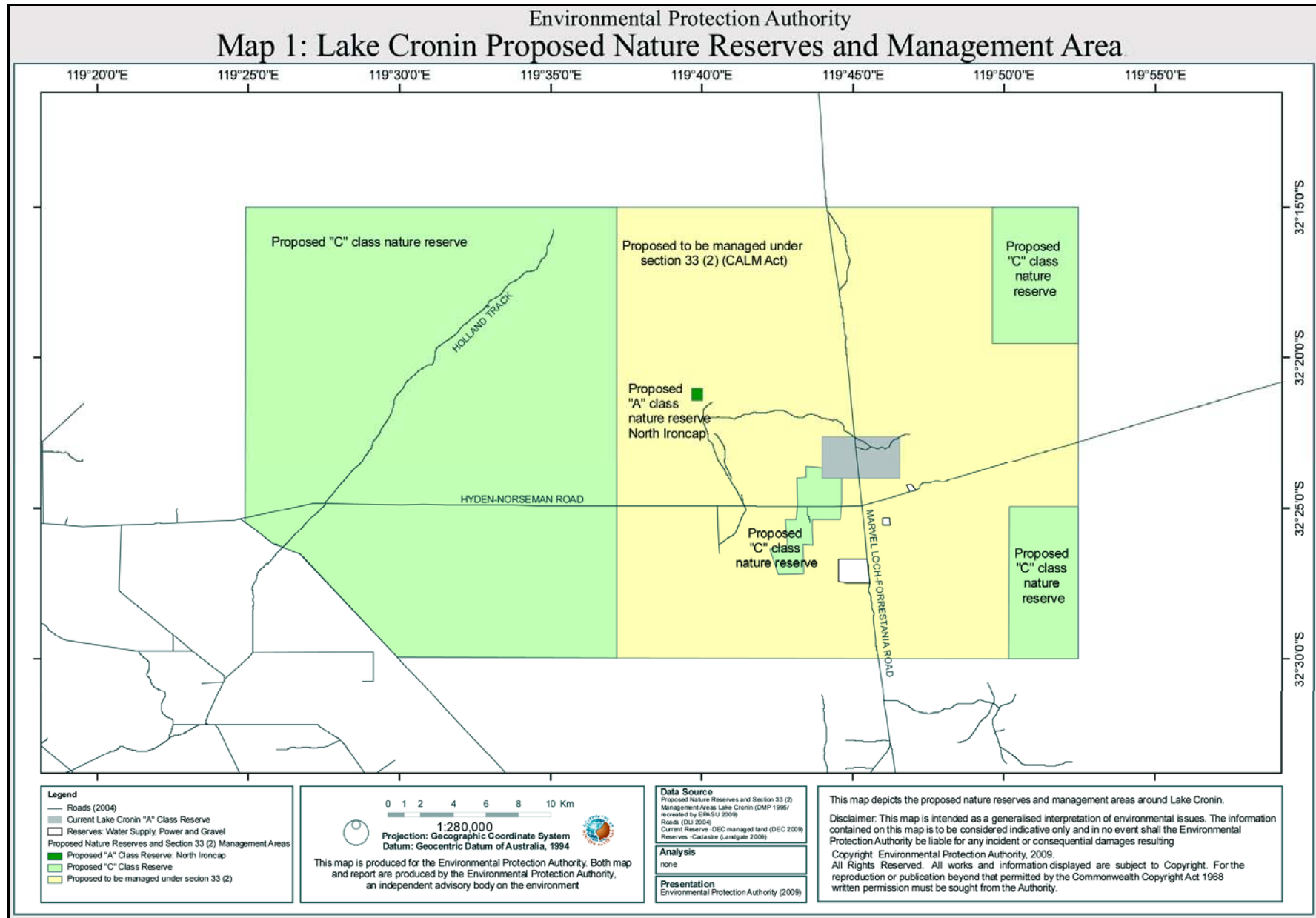
A subsequent modified proposal (detailed in Map 1) for the proposed Lake Cronin Reserve was that:

- A small “A” Class Nature Reserve be established to protect core area of highest conservation priority being the North Ironcap Banded Ironstone Formation.
- The majority of the mineralised greenstone belt be managed under Section 33(2) of the *Conservation and Land Management Act 1984* but not formally reserved; and
- A “C” Class Nature Reserve to protect the drainage catchment that feeds into Lake Cronin; and
- The remaining low prospectivity portions of the area proposed by Henry-Hall be reserved in a “C” Class Nature Reserve.

The revised proposal was supported by the (then) Department of Minerals and Energy. This recommendation has not been enacted to date due to the need to obtain Native Title clearances. The enacting of the proposal is estimated to represent the following area of protection in the Lake Cronin area.

**Table 1.** Areas of Existing and Proposed Lake Cronin Reserve.

<b>Reserve</b>	<b>Area (ha)</b>
Lake Cronin Nature Reserve – existing A Class Reserve	~1,000
Proposed Interim Protected Area - Lake Cronin Reserve (EPA 1975)	~100,000
Expanded Lake Cronin Reserve proposal (Henry-Hall 1990)	<50,000
Reserves to adequately protect rare endemic flora, vegetation communities and maintain connectivity (Great Western Woodlands)	~1,000,000



*Map 1: Location Map showing location of Lake Cronin Nature Reserve and proposed Lake Cronin Reserve.*

In preparing this advice the EPA was mindful that the areas surrounding Lake Cronin provides a contiguous representation of environments that are now extensively cleared in the adjacent Wheatbelt Region and, at a wider scale, provides potential for conservation management at a whole-of-region level in an environment that represents the transition from the higher rainfall South West Australia to the arid areas of central Australia

These values have recently been recognised in the Great Western Woodlands conservation strategy which the Western Australian Government has committed to support. The advice provided places the Lake Cronin Reserve into the wider context of the Great Western Woodlands region.

## 2 Introduction

The Lake Cronin Region study area (LCR) as discussed in this report is centred on Lake Cronin, approximately 86 kilometres east of Hyden at the intersection of Hyden-Norseman and Forrestania-Southern Cross Roads (Maps 2 and 3). The LCR occurs near the eastern boundary of the Wheatbelt and encompasses the proposed expanded reserve area identified by Henry-Hall (1990). It is in the southern part of the Yilgarn Craton and immediately to the east of the limit of agricultural land clearing demarcated by the vermin-proof fence.

Lake Cronin is a semi-permanent freshwater lake located in the south western region of the Eastern Goldfields and is the largest freshwater lake in the region. It is located in a region where extensive areas of woodlands, mallee and shrublands are relatively intact compared to further west where agricultural clearing has reduced the original vegetation to scattered small remnants.



**Figure 1.** Lake Cronin (photo Mark Brundrett, March 2007).

The climate of the LCR is semi-arid with cool winters, hot summers and reliable winter rainfall. No local rainfall readings are available, however Henry-Hall (1989) estimated the average rainfall at about 350mm with some seasonal and annual variability.

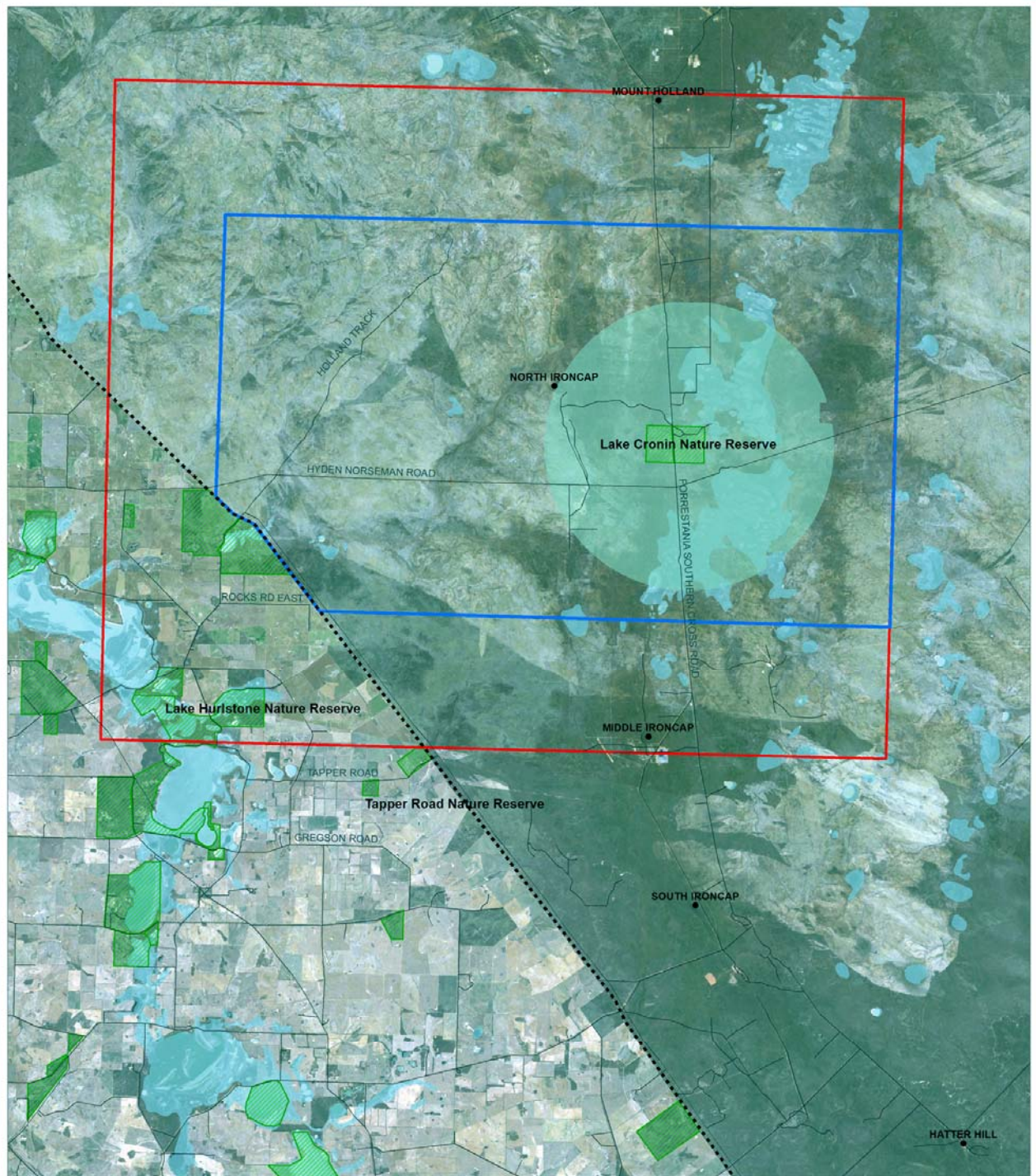
Environmental Protection Authority  
**Map 2: Proposed Lake Cronin Reserve Locality Map**



<p><b>Legend</b></p> <ul style="list-style-type: none"> <li><span style="border: 1px solid blue; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Proposed Lake Cronin Reserve (1990)</li> <li><span style="background-color: cyan; border: 1px solid blue; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Current Lake Cronin Nature Reserve</li> <li><span style="background-color: cyan; border: 1px solid cyan; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Proposed Interim Protected Area (1975)</li> <li><span style="border-bottom: 1px solid black; display: inline-block; width: 20px; margin-right: 5px;"></span> Main Road</li> <li><span style="display: inline-block; width: 5px; height: 5px; background-color: black; border-radius: 50%; margin-right: 5px;"></span> Town</li> </ul>	<p style="text-align: center;">0 10 20 40 60 80 100 km</p> <p style="text-align: center;"><b>1:1,200,000</b></p> <p style="text-align: center;">Projection: Map Grid of Australia Zone 50 Datum: Geocentric Datum of Australia, 1994</p> <p><b>Data Source</b></p> <p>Proposed Lake Cronin Reserve (Department of Environment and Conservation 1990)          DEC Managed lands (Department of Environment and Conservation 2006)          Proposed Interim Protected Area (Environmental Protection Authority 1975)          Major Rivers (Water and Rivers Commission 1995)          Towns (AUSLIG 1995)          Main Roads (AUSLIG 1995)</p> <p><b>Analysis</b> none</p> <p><b>Presentation</b> Environmental Protection Authority (2008)</p>	<p>This map is produced for the Environmental Protection Authority. Both map and report are produced by the Environmental Protection Authority, an independent advisory body on the environment.</p> <p>This map depicts the location of the proposed Lake Cronin Reserve.</p> <p><small>Disclaimer: This map is intended as a generalised interpretation of environmental issues. The information contained on this map is to be considered indicative only and in no event shall the Environmental Protection Authority be liable for any incident or consequential damages resulting from use of the material.</small></p> <p style="text-align: right;"><small>© Copyright Environmental Protection Authority, 2008. All Rights Reserved. All works and information displayed are subject to Copyright. For the reproduction or publication beyond that permitted by the Commonwealth Copyright Act 1968 written permission must be sought from the Authority.</small></p>
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**Map 2: Proposed Lake Cronin Reserve Locality Map**

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**Map 3: Lake Cronin Region Study Area**



Legend	
—	Road
....	Extent of Clearing
□ (Blue)	Proposed Lake Cronin Reserve (1990)
□ (Red)	Study Area
□ (Green)	DEC managed land
□ (Light Green)	Proposed Interim Protected Area (1975)
□ (Light Blue)	Water Body

0 2 4 6 8 10 km	
1:130,000	
Projection: Map Grid of Australia Zone 50	
Datum: Geocentric Datum of Australia, 1994	
<b>Data Source</b>	
Proposed Lake Cronin Reserve (Department of Environment and Conservation 1990)	
DEC Managed Lands (Department of Environment and Conservation 2008)	
Proposed Interim Protected Area (Environmental Protection Authority 1975)	
Water Bodies (Landgate 1996)	
Roads (AUSLIG 1995)	
Satellite Imagery (2007)	
<b>Analysis</b>	<b>Presentation</b>
none	Environmental Protection Authority (2008)

This map is produced for the Environmental Protection Authority. Both map and report are produced by the Environmental Protection Authority, an independent advisory body on the environment.

This map depicts the proposed Lake Cronin Reserve.

Disclaimer: This map is intended as a generalised interpretation of environmental issues. The information contained on this map is to be considered indicative only and in no event shall the Environmental Protection Authority be liable for any incident or consequential damages resulting from use of the material.

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**Map 3: Lake Cronin Region Study Area**

Despite a relatively dry climate with variable rainfall, the LCR has diverse vegetation patterns which are regulated by geology and a long history of erosion in an ancient landscape (Newbey and Hnatiuk 1988, Beard 1990). These patterns (Figure 2) include a sequence (catena) of alternating sandplains, breakaways, woodlands, and internally-draining salt lakes in valley floors similar to the adjoining Wheatbelt (Beard 1990).



**Figure 2.** Catena of landform/vegetation units seen from North Ironcap (photo Mark Brundrett, March 2007).

Chin *et al.* (1984) provided a detailed description of the geology of the LCR. The region has gently undulating topography with broad valleys containing salt lake systems (internal drainage) and a relict duricrust peneplain partly covered by a sandplain, with hills and ranges associated with a greenstone belt and isolated granite monoliths.

A major greenstone belt, running in a north-south direction, crosses the region and there are localised areas of Banded Iron Formation (BIF) including the North, Middle and South Ironcaps. These are relatively small features compared to BIF ranges elsewhere in the Yilgarn Craton, but the soils and landforms of the greenstone belt support endemic plant species and communities (Section 5.2 and 5.3). The LCR study area has been subject to intense prospecting following the discovery of gold and other minerals in the Forrestania Greenstone Belt (Chin *et al.* 1984, Henry-Hall 1989).

Little is known of the local groundwater levels, however hydrological investigations approximately 20 kms east determined that the water table is deep (~ 20 – 40 metres below the surface) with high salinity recordings between 36,000 – 117,000 mg/litre total dissolved salts (TDS) (Frost *et al.* 2004).

Local hydrology studies have determined that Lake Cronin remains fresh with historical readings between 185 – 1300 mg/litre TDS, despite being in a region where

most lakes are hypersaline. The study found that the lake floor was slightly porous, resulting in water and associated salts held in the lake slowly draining into the substrates rather than concentrating and accumulating in the lakebed (Henry-Hall 1989).

Situated near the borders of both north-south and east-west biogeographical and floristic regions (Map 4), the transitional nature of this region has an intrinsically high conservation value. The value of being within a transitional zone is further increased when examined within the context of the region's anticipated climate change impacts (Dunlop and Brown 2008, CSIRO and Australian Bureau of Meteorology 2007).

### **3 Methodology Developed to meet Objectives for Section 16(e) Advice**

The key objectives of this report is to assess the capacity of the current reserve proposal to adequately protect biodiversity in the LCR, particularly rare endemic flora, fauna and vegetation communities which have been extensively cleared in the adjoining Wheatbelt, and to provide context to enable the LCR to be considered within the values of the wider Great Western Woodlands region.

The methodology utilised to deliver the objectives were:

1. Compile information from existing flora, vegetation and fauna data about the distribution of rare, priority and other significant taxa.
2. Assess significance of rare or possibly endemic fauna and identify key fauna habitats as best possible from existing data.
3. Assess significance of unique plant community types with the potential to be recognised as Threatened Ecological Communities (TECs).
4. Identify plant communities (associations), landforms and animal habitats that are not well represented in other conservation reserves.
5. Review effectiveness of proposed reserve boundaries for protection of biodiversity and propose additional areas for inclusion if appropriate.
6. Assess appropriate conservation mechanisms for areas of high conservation value, while recognising the existence of mines and mineral leases in the Forrestania Greenstone Belt.
7. Propose a strategy to manage biological values (especially rare, priority and endemic flora and fauna) in areas of high mineralogical value.

The framework for recognising essential biodiversity and other heritage assets is summarised in Table 2. The area searched for flora, TECs and fauna in the LCR was **32° 10' to 32° 35' and 119° 20' to 119° 55'** (Map 3). A supplementary geographic names search in Florabase used locality names in Table 7. Flora and vegetation data were also obtained from Florabase, published and unpublished survey reports and consultation with botanists (Table 2).

**Table 2.** Sources of information concerning flora, vegetation, fauna and landscape significance, as well as criteria for designation of nature reserves.

<ul style="list-style-type: none"> <li>• Historical proposals for protection of Lake Cronin including EPA (1974), CTRC (1975) and Henry-Hall (1989 and 1990).</li> </ul>
<ul style="list-style-type: none"> <li>• Lists of species protected under WA legislation in the CALM Act (DRF, P1-P4) available from Durell and Buehrig (2001), Florabase (florabase.dec.wa.gov.au) and WAherb database searches.</li> </ul>
<ul style="list-style-type: none"> <li>• DEC Database of Declared Rare Flora and Priority Flora locations (DEFL).</li> </ul>
<ul style="list-style-type: none"> <li>• Protected flora and fauna listed under the <i>Commonwealth Environment Protection and Biodiversity Conservation Act 1999</i> (<a href="http://www.environment.gov.au/biodiversity/threatened/index.html">http://www.environment.gov.au/biodiversity/threatened/index.html</a>).</li> </ul>
<ul style="list-style-type: none"> <li>• Local and regional flora and vegetation, and fauna surveys.</li> </ul>
<ul style="list-style-type: none"> <li>• Recognition of flora and fauna which are endemic to a restricted range or known from very few records.</li> </ul>
<ul style="list-style-type: none"> <li>• Recently recognised flora likely to be endemic to a confined area (Florabase and pers. comm. by botanists).</li> </ul>
<ul style="list-style-type: none"> <li>• Knowledge of genetic structure and isolation of populations of rare species (Bussell and James 1997, Coates 2000, Butcher <i>et al.</i> 2007).</li> </ul>
<ul style="list-style-type: none"> <li>• Update of Beard's vegetation maps showing the distribution of broad-scale vegetation types (Shepherd <i>et al.</i> 2002, Department of Agriculture 2005) and other more detailed maps for smaller areas (Newbey and Hnatiuk 1988).</li> </ul>
<ul style="list-style-type: none"> <li>• List of poorly reserved vegetation types within the Coolgardie 2 bioregion (CALM 2002).</li> </ul>
<ul style="list-style-type: none"> <li>• Interim Biogeographical Regionalisation of Australia (IBRA) (Thackway and Cresswell 1995)</li> </ul>
<ul style="list-style-type: none"> <li>• DEC search of database of Threatened and Priority Ecological Communities (PEC, TEC) and other records of habitats of rare species (English and Blyth 1999).</li> </ul>
<ul style="list-style-type: none"> <li>• Descriptions of vegetation associations and their relationships with landforms and soils (Newbey and Hnatiuk 1988, Beard 1990).</li> </ul>
<ul style="list-style-type: none"> <li>• Structural diversity of landscapes and habitats (topographic and geology and satellite imagery).</li> </ul>
<ul style="list-style-type: none"> <li>• Geology, geomorphology and mineral exploitation (Chin <i>et al.</i> 1984).</li> </ul>
<ul style="list-style-type: none"> <li>• EPA principles, especially avoiding environmental harm and the precautionary principle, are relevant when potential rare species are not well studied (EPA 2004).</li> </ul>
<ul style="list-style-type: none"> <li>• Criteria for Comprehensive, Adequate and Representative (CAR) reserves (<a href="http://www.environment.gov.au/parks/nrs/science/scientific-framework.html">http://www.environment.gov.au/parks/nrs/science/scientific-framework.html</a>).</li> </ul>
<ul style="list-style-type: none"> <li>• Recognition of biodiversity hotspots with the highest levels of endemism, species richness and rare species in WA (Hopper and Gioia 2004).</li> </ul>
<ul style="list-style-type: none"> <li>• Significant geological, landscape and heritage features (Sharples 2002).</li> </ul>

## 4 Regional Values

The South West of Australia is recognised as a global biodiversity hotspot and one of five Mediterranean climate systems in the world. The criteria for international biodiversity hotspot is to support at least 1,500 endemic species and be more than 70% cleared (Conservation International 2007).

The Government of Australia also recognises 15 national biodiversity hotspots, eight of which are in Western Australia (Commonwealth of Australia 2008). Table 3 illustrates the high level of endemism found in some of these areas. Exceptionally diverse geology, soils, topography and hydrology with granite and sandplain areas



similar to the Wheatbelt, as well as more typical goldfields habitats, BIF ranges and wetlands are represented by the Ironcaps/Lake Cronin Region. High diversity has been linked to highly infertile soils and a long history without major tectonic or glacial disturbance (Hopper and Gioia 2004).

**Table 3.** Native plant taxonomic diversity in selected regional biodiversity hotspots in WA.

<b>Biodiversity Hotspot</b>	<b>Area (ha)</b>	<b>Total</b>	<b>Endemic</b>	<b>DRF</b>	<b>Priority listed</b>	<b>Reference</b>
Stirling Range National Park	116,000	1615	88	26	134	Keighery 1993
Fitzgerald River National Park	330,000	1230+	75	12	96	Chapman and Newbey 1995
Lesueur National Park	27,000	900+	9	7	54	EPA Bulletin 424
Mount Manning Region	821,000	1000+	32	9	72	EPA 2007
Southern Swan Coastal Plain	1,334,000	2082	18+	42	164	Keighery unpublished data
Ironcaps, Lake Cronin Region	>100,000	343+	<b>31</b>	<b>5</b>	<b>79</b>	Gibson 2004

The LCR is located within the Shire of Kondinin which has a thin north-south area but an extended east-west boundary. As a result of the boundary, the Shire of Kondinin encompasses Wheatbelt and Goldfields Region areas, including significant areas to the west of the vermin-proof fence. Significant clearing has occurred to the west of the vermin-proof fence and the Shire of Kondinin retains 50.5% native vegetation. Significantly, the Shire has the lowest percentage of native vegetation in secure conservation estate when compared to surrounding Local Government Areas.

**Table 4.** % Remaining and Protected Native Vegetation Areas in Local Government Areas in and surrounding the Lake Cronin Region

<b>Local Government Area</b>	<b>Pre-European Extent of Native Vegetation</b>	<b>Current Extent of Native Vegetation</b>	<b>% Remaining of Native Vegetation</b>	<b>% Protected in DEC Estate</b>
Kondinin	741927.0	374477.9	50.5	6.0
Lake Grace	1188347.9	384698.7	32.4	41.8
Kulin	471813.6	55702.2	11.8	45.6
Yilgarn	3042768.9	2476612.8	81.4	25.9
Dundas	9303336.9	9296484.0	99.9	9.7

Greater community interest in protecting vegetation to the east of the vermin-proof fence has occurred as the values of the Region are understood in context of the botanical interzone, BIF diversity and loss of extensive areas of native vegetation. Two regional biodiversity conservation initiatives currently in development encompass the LCR. These are the South West Ecoregion Initiative (Gole 2006) and the Wilderness Society's Great Western Woodlands plan (Watson et al. 2008).

The South West Ecoregion Initiative is a partnership of business, government and communities groups which undertakes a variety of projects within the South West of Australia. One of the projects is known as the Gondwana Link, which aims to restore

the natural environmental link in the disturbed South West biodiversity hotspot from the Jarrah Forest in Margaret River, following the South Coast Region past Albany and through to Kalgoorlie by strategic protection and restoration. The stated aim of the project is to “*Reconnect[ed] country across south-western Australia, from the karri forest of the SW corner to the woodlands and mallee bordering the Nullarbor plain, in which ecosystem function and biodiversity are restored and maintained*” (<http://www.gondwanalink.org/index.html>).

The Wilderness Society is promoting increasing scientific research within the Gondwana Link project in an area defined as the “Great Western Woodlands”. The Great Western Woodlands includes the LCR and encompasses the native vegetation to the east of the vermin-proof fence generally utilising the boundaries of the Coolgardie and Mallee IBRA Regions and clearing boundaries. The Society aims to study and ultimately protect the Great Western Woodlands as the last relatively undisturbed temperate woodland in the world (Watson *et al.* 2008).

The Western Australian Government has committed to supporting the conservation and management of the Great Western Woodlands. The current direction of the Great Western Woodlands conservation strategy is to provide a framework identifying priorities for management; outline management plans and on ground actions including weed and feral animal control as well as fire management, and provide direction for capital works programs.

#### **4.1 Interim Biogeographic Regionalisation of Australia (IBRA) Values**

The system of bioregion classification and mapping (bioregionalisation) currently used as the geographic basis for conservation planning in Australia is the Interim Biogeographic Regionalisation of Australia (Thackway and Cresswell, 1995). The term ‘bioregion’ or ‘biogeographic region’ has been extensively used in Australian conservation literature and has been defined as “*a land area composed of a cluster of interacting ecosystems that are repeated in similar form where region descriptions seek to describe the dominant landscape scale attributes of climate, lithology, geology, landforms and vegetation*” (Thackway and Cresswell 1995).

Western Australia is a large and ecologically diverse land area encompassing 85 IBRA bioregions with widely varying climate, lithology, vegetation, evolutionary history, and human disturbance history.

Lake Cronin Region study area is situated across the boundary of the Mallee and Coolgardie IBRA regions (Map 4). Thackway and Cresswell (1995) described this area as the interzone between the South West and Eremaean Botanical Provinces. The transitional rainfall zone (interzone) between the South Western Australian Floristic Region and Eremaean Botanical Province contains the limits of distribution patterns for many plants and plant communities of the Goldfields and Wheatbelt Regions (Section 4.2).

This is particularly relevant in relation to the largely-cleared Wheatbelt on the western side of the interzone and as refugia where relictual taxa have escaped from a drying climate. These taxa are isolated pockets of the landscape unlinked by effective corridors for long-range seed or pollen dispersal. Additionally, specialised interzone species have narrow distributions in a band running from Geraldton to east of Esperance.

The Coolgardie IBRA Region is known to have high species and ecosystem diversity with banded ironstone ranges, ephemeral flora communities of Tertiary sandplain scrubs and valley floor woodlands (CALM 2002). The Mallee IBRA Region supports a large number of rare species and communities due to widespread clearing in the agricultural section of the region, west of the vermin-proof fence.

**Table 5.** IBRA Regions intersected by the proposed Lake Cronin Reserve, level of reservation and extent of clearing

<b>IBRA Region Code</b>	<b>IBRA Region Name</b>	<b>Pre-European Extent of Native Vegetation (ha)</b>	<b>Current Extent of Native Vegetation (ha)</b>	<b>% Native Vegetation Remaining</b>	<b>% Current Native Vegetation Extent in All DEC Managed Lands</b>
COO	Coolgardie	12912204.2	12707619.6	98.4	15.5
MAL	Mallee	7395897.6	4040547.0	54.6	31.2

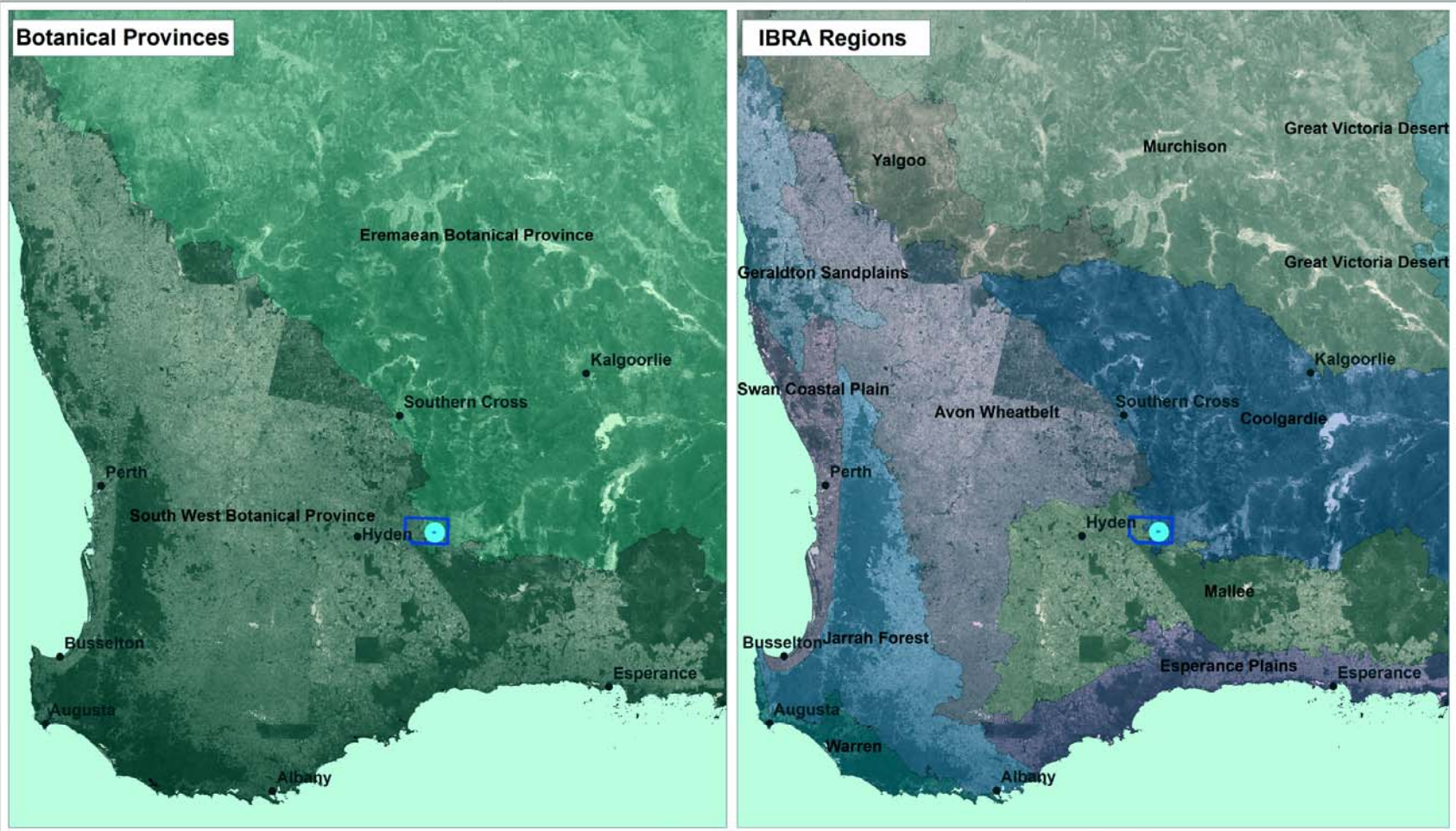
Assessment at a subregional scale found that the Mallee 1 (Western Mallee) Subregion and Coolgardie 2 (Southern Cross) Subregion are high priorities for nature reserve creation (CALM 2002, Commonwealth of Australia 2002). The priorities for conservation differ given the Southern Cross Subregion has 98.4% remaining while the Western Mallee Subregion retains only 54.6% native vegetation.

Creation of consolidated and secure nature reserves in the LCR provides an important opportunity to conserve extensive and contiguous environments representing the full catena of landscape elements in this biologically diverse region.

## **4.2 Botanical Region Values**

The proposed Lake Cronin Reserve is situated in the transitional zone between the South Western Australian Floristic Region and Eremaean Botanical Province as defined by Beard (1980) (Map 4). As such, the LCR is recognised as containing geological, climatic and biological characteristics of surrounding botanical and biogeographical regions. The transition zone, in particular, demarcates the climatic gradient between the winter rainfall dominated South West Botanical Province and the low and variable rainfall of the Eremaean Botanical Province.

Environmental Protection Authority  
**Map 4: Botanical Provinces and IBRA Regions**



**Legend**

- Town
- Current Lake Cronin Nature Reserve
- Proposed Interim Protected Area (1975)
- Proposed Lake Cronin Reserve (1990)

**Data Source**  
 Proposed Lake Cronin Reserve (Department of Environment and Conservation 1990)  
 DEC Managed Lands (Department of Environment and Conservation 2006)  
 Proposed Interim Protected Area (Environmental Protection Authority 1975)  
 IBRA Regions version 6.1 (Department of Environment and Heritage 2004)  
 Botanical Provinces (Beard 1960)  
 Towns (AUSLIG 1998)  
 Satellite Imagery (2007)

**Analysis**  
 none

**Presentation**  
 Environmental Protection Authority (2008)

0 25 50 100 150 200 250 km

1:2,000,000

Projection: Map Grid of Australia Zone 50  
 Datum: Geocentric Datum of Australia, 1994

This map is produced for the Environmental Protection Authority. Both map and report are produced by the Environmental Protection Authority, an independent advisory body on the environment.

This map depicts Lake Cronin area of interest in relation to botanical provinces and IBRA regions.

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**Map 4: Botanical Provinces and IBRA Regions**

Harrison (1993) states that transitional/hybrid zones are of extremely high value to nature conservation in that:

- Ecological assemblages in transitional zones tend to contain elements and biota from surrounding regions, for this reason ecological assemblages in transitional zones are often unusual, and sometimes unique, in composition.
- Many species and ecological assemblages found within transitional zones exist at the edge of their normal range and therefore tend to differ both genetically and characteristically from those residing within their normal range.
- Transitional zones provide refuge for species that have declined through disturbances within their normal range, thereby facilitating the recolonisation of depleted species back into surrounding areas post disturbance.
- Through genetic variation and a tendency for communities to become isolated during disturbance, transitional zones facilitate speciation and therefore act as important evolutionary drivers.
- Transitional zones provide important habitat and linkage resources for migratory species and metapopulations.

These characteristics of transitional zones also underline the importance of the LCR in regard to ecological resilience within the context of foreseeable climate change impacts. A series of climate change scenarios compiled by the CSIRO and the Australian Bureau of Meteorology (2007) all show that the LCR will be subjected to reducing rainfall, increasing temperature and an increase in the frequency of extreme weather events over the next 60+ years. This in turn will result in an increase in the frequency and intensity of wild fires, a lowering of water tables, a diminished flow within water courses, structural changes in vegetation communities, species translocations and migrations, localised extinctions, and significant changes in human land use practices (Dunlop and Brown 2008).

Within the context of these circumstances, the transitional landscape attributes evident in the LCR will enable it to provide refuge, facilitate migration, maintain the structure of ecological assemblages and facilitate the retention of a high level of species diversity. Therefore, by virtue of its transitional nature and in regard to climate change, the LCR will be of significant value in conserving South Western Australia's biodiversity.

Regional mapping of Western Australia (Beard 1980) defines the area as lying within the Roe Botanical District of the South West Australian Floristic Region. Vegetation within the Roe Botanical District is characterised by mallee vegetation with some *Eucalyptus* woodland in lower valleys and scrub heath and *Allocasuarina* thicket on the residual plateau soils (Beard 1980).

The Lake Cronin Nature Reserve is located within the Forrestania system as described by Beard (1972). The Forrestania system is a greenstone belt stretching from Mt Holland (approximately 22kms north of the Lake Cronin Nature Reserve) to Hatter Hill. The Forrestania system encompasses a variety of communities in a mosaic form, relating to underlying geology (Beard 1972).

Newbey and Hnatiuk (1988) undertook regional surveys in the Lake Johnston-Hyden area which developed regional vegetation mapping following a land system approach.

The survey noted that vegetation structure of the ironstone formations in the area (known as North Ironcap, Middle Ironcap and South Ironcap) finely differ while diversity was more notably different. Newbey and Hnatiuk (1988) also found that the Ironcap structures differed widely from other banded ironstone formations.

Gibson (2004) found that the Forrestania belt was much richer in endemic species while displaying a similar floral richness to other goldfields ranges. The study however did not support the Newbey and Hnatiuk (1988) finding of the different diversity of the Ironcap systems. Gibson (2004) noted that “*almost none of the Forrestania greenstone belt is currently in conservation reserve system*”.

The creation of the proposed Lake Cronin Reserve would protect a number of critical vegetation associations. Beard’s (1972) vegetation mapping of the Hyden area shows that two vegetation associations are represented within the boundaries of the Lake Cronin Nature Reserve, while eight vegetation communities would be represented within the Henry-Hall (1990) recommendation area (Map 5). As illustrated in Table 6, most vegetation associations located within the LCR are not securely reserved within the Southern Cross and Western Mallee IBRA Subregions.

### **4.3 Comprehensive, Adequate and Representative (CAR) Assessment**

The reserve system plays a pivotal role in conserving Western Australia’s biodiversity, which is both rich and exhibits a high degree of endemism (i.e. plants and animals occurring nowhere else). The terms ‘comprehensive’, ‘adequate’ and ‘representative’ (CAR) together describe the attributes of an ideal reserve system (CALM 2002).

The objective of establishing a CAR conservation reserve system is reflected in a range of national and State policies and strategies, including the National Strategy for the Conservation of Australia’s Biological Diversity (1996), the National Objectives and Targets for Biodiversity Conservation 2001-2005 (June 2001) and the Western Australian State Sustainability Strategy (2003). CALM (2002) describes CAR as defined in the Australian and New Zealand Environment and Conservation Council Guidelines for Establishing the National Reserve System (1999) as:

- *“comprehensiveness – inclusion of the full range of ecosystems recognised at an appropriate scale within and across each bioregion;*
- *adequacy – the maintenance of the ecological viability and integrity of populations, species and communities; and*
- *representativeness – the principle that those areas that are selected for inclusion in reserves reasonably reflect the biotic diversity of the ecosystems from which they derive.”*

In addition to using the scientifically based CAR criteria, spectacular landforms and scenery as well as natural areas of high public use are also commonly included in parks and reserves.



Table 6 analyses Department of Agriculture (2005) Pre-European Vegetation database, adapted from Beard's (1972) mapping and description of vegetation in the area to determine if the proposed Lake Cronin Reserve will result in the increase of protection of significant vegetation associations. The analysis area is based on the Henry-Hall (1990) recommendation area (Map 3).

**Table 6.** Representation of Vegetation Associations and Protection Areas

Vegetation Association Number	Vegetation Description	IBRA Subregion	% Remaining in Subregion	% Current Extent in All DEC Managed Lands	Area (ha) within proposed Lake Cronin Reserve	% Current Extent in All DEC Managed Lands with proposed Lake Cronin Reserve included
<b>Current Lake Cronin Nature Reserve</b>						
125	Bare areas; salt lakes	Southern Cross	98.64	10.32	6.91	10.32
511	Medium woodland; salmon gum and morrel	Southern Cross	93.84	19.33	997.74	19.33
1413	Medium open woodland; Eucalypts over teatree	Southern Cross	97.95	19.79	11.61	19.79
<b>Proposed Lake Cronin Reserve</b>						
125	Bare areas; salt lakes	Southern Cross West Mallee	98.64 11.40	10.32 38.72	1252.76 36.71	10.86 39.08
128	Bare areas; rock outcrops	West Mallee	45.85	36.83	313.58	39.07
511	Medium woodland; salmon gum and morrel	Southern Cross West Mallee	93.84 33.54	19.33 19.33	64847.79 6368.62	34.21 32.93
519	Shrublands; mallee scrub, <i>Eucalyptus eremophila</i>	Southern Cross West Mallee	100.00 47.63	11.71 26.03	1249.04 22336.87	12.65 29.03
936	Medium woodland; salmon gum	West Mallee	56.32	27.57	276.35	28.67
941	Mosaic: Medium woodland; salmon gum and morrel / Shrublands; mallee scrub, redwood	Southern Cross	100.00	0.00	387.68	3.58
1413	Medium open woodland; Eucalypts over teatree	Southern Cross West Mallee	97.95 96.23	19.79 6.02	2312.61 318.52	20.03 8.02
2048	Shrublands; scrub-heath in the Mallee Region	West Mallee	47.80	15.78	27631.82	34.21

Many of the vegetation associations represented in the Southern Cross IBRA Subregion have large areas remaining but very little protected in secure reserves. Currently, Vegetation Association 941 has no representation in secure conservation estate and is a high priority for reservation (CALM 2002). The implementation of the Henry-Hall (1990) recommendation area (Map 3) results in 3.58% of the current extent of Vegetation Association 941 being secured within DEC conservation estate.



The West Mallee IBRA Subregion generally has less vegetation remaining than Southern Cross IBRA Subregion while having similar, or large secure reserved figures. Vegetation Association 1413 has less than 5.8% in secure reserves. Many vegetation associations within the West Mallee Subregion increase to ~30% protection within conservation estate.

CALM (2002) stated that the Ironcaps Hills complex, which is represented within the LCR is a high priority for reservation. Reserves in the LCR have additional regional significance due to its strategic location adjacent to the Wheatbelt and inclusion of a diverse range of environments and ecological communities. The importance of conserving ecological assemblages within transitional zones is further emphasised within the context of mitigating the anticipated impacts of climate change.

It is anticipated that existing and proposed reserves in the LCR will conserve more of the region's biodiversity in sandplain and woodland areas according to CAR criteria, but the inclusion of additional areas is recommended to provide a more comprehensive CAR reserve particularly for species with restricted distributions or Wheatbelt species near the edge of their distribution.

## 5 Lake Cronin Region Values

The Lake Cronin Reserve is located mainly on the Skeleton Rock and Forrestania Systems within the Roe Botanical District (Beard, 1980). The Forrestania System is a greenstone belt stretching from Mt Holland in the north to Hatter Hill in the south (Map 3 and 5). The system encompasses a variety of communities occurring in mosaic form associated with the geology of the area (Beard 1972).

Knowledge of environmental values in the LCR and much of the surrounding area is limited outside of areas where surveys have occurred, i.e. the Southern Ironcaps area (Gibson 2004) and some areas near Forrestania Mines (Frost *et al.* 2004, Western Areas NL 2004). Table 7 outlines some of the sources of local information utilised for this report.

**Table 7.** Geographic features and sources of flora, fauna and vegetation information in or near the Lake Cronin Nature Reserve.

<b>Range/ Localities</b>	<b>Flora and Vegetation Surveys</b>	<b>Fauna Surveys</b>
Forrestania	Newbey and Hnatiuk 1988, Durell and Silvester 1988, Frost <i>et al.</i> 2004	How <i>et al.</i> 1988a, 1988b
North Ironcap	Newbey and Hnatiuk 1988, Armstrong 2006	How <i>et al.</i> 1988a, 1988b
Lake Cronin	Newbey and Hnatiuk 1988, Halse <i>et al.</i> 1993, Lyons <i>et al.</i> 2004	How <i>et al.</i> 1988a, 1988b, Lyons <i>et al.</i> 2004, Pinder <i>et al.</i> 2004, refs for Jewel beetles, opportunistic snake surveys by H. Ehmann (1983) and B. Maryan (pers. comm)
Hatters Hill	Newbey and Hnatiuk 1988, Gibson 2004	
Middle and South Ironcaps and surrounding Greenstone Belt	Gibson 2004	
General Regional Surveys	Newbey and Hnatiuk 1988	How <i>et al.</i> 1988

**Table 8.** Rare, Priority, apparently endemic and other flora of conservation concern by location, endemism and substrate located in the Lake Cronin Region.

**Abbreviations:** R = Declared Rare Flora, P1-P4 = Priority Flora, X = presumed extinct, PR = potentially rare flora.

Wb =Wheatbelt, Gf = Goldfields, E =Esperance, F =Forrestania, BIF = Banded Ironstone Formations

Taxa	WC Act Code	EPBC Act Code	Distribution	Habitat	WAherb Records
<i>Acacia asepala</i>	2		Restricted - F region	Plains, drainage lines	14
<i>Acacia heterochroa</i> subsp. <i>robertii</i>	2		Restricted - F region	Laterite and ironstone	21
<i>Acacia kerryana</i>	2		Restricted - Gf, F	Various habitats	11
<i>Acacia lanuginophylla</i>	R	Endangered	Fairly restricted –Wb, F, Eremaean	Various habitats	27
<i>Acacia repanda</i>	3		Restricted - F	Near granite	18
<i>Acacia singula</i>	3		Restricted – Wb, F, Hatters Hill	Hills, sand	31
<i>Acacia tetraeneura</i>	1		Restricted - Bruce Rock, Hyden, F	Ridges, laterite	24
<i>Baeckea</i> sp. Hyden (J.M. Brown 141)	3		Widespread - Wb, F	Various soils	19
<i>Baeckea</i> sp. Lake Cronin (K. R. Newbey 9191)	1		Very restricted – F, Lake Cronin	Plains, sandy soils	1
<i>Baeckea</i> sp. Forrestania (K. R. Newbey 1105)	1		Very restricted - F	Sand, plains	9
<i>Baeckea</i> sp. Hatter Hill (K.R. Newbey 3284)	3		Restricted - F, Frank Hann NP	Sandy loam with laterite	16
<i>Baeckea</i> sp. Flying Fox Mine (A. O'Connor and V. Longman FF 532)	PR		Very restricted - F	Sand and ironstone	2
<i>Baeckea</i> sp. North Ironcap (R. J. Cranfield 10580)	2		Very restricted - F	Sand / clay	2
<i>Banksia sphaerocarpa</i> var. <i>dolichostyla</i>	R	Vulnerable	Restricted - Eastern Wb, F	Ironstone or laterite	29
<i>Bentleya diminuta</i>	2		Fairly restricted – F, E, Wb	Calcareous sandy clay	9
<i>Boronia revoluta</i>	R	Endangered	Very restricted – F, Ironcaps	Ironstone	17
<i>Boronia westringioides</i>	2		Very restricted - F	Damplands in association with <i>Melaleuca uncinata</i> , sands	15
<i>Brachyloma nguba</i>	1		Localised – Wb, F, E	Sand, plains	8
<i>Brachyloma</i> sp. Forrestania White (M. Hislop and F Hort MN 2591)			Highly restricted - F	Sandy shrubland	2
<i>Calamphoreus inflatus</i>	4		Restricted - near F	Plains, clay, gravel	23
<i>Comesperma calcicola</i>	3		Fairly widespread - near F and E	Calcareous / saline habitats	4
<i>Conospermum sigmoideum</i>	2		Fairly widespread - mostly Wb	Sand	8

Taxa	WC Act Code	EPBC Act Code	Distribution	Habitat	WAherb Records
<i>Cryptandra intonsa</i>	PR		Restricted – F, Wb	Ironstone	17
<i>Cryptandra polyclada</i> subsp. <i>polyclada</i>	3		Fairly widespread – Wb, F, E	Sandplains	19
<i>Cryptandra exserta</i>	1		Restricted – F, Hatters Hill	Sandy soils with laterite	2
<i>Dampiera scaevolina</i>	1		Fairly widespread - most Wb	sand and gravel	15
<i>Daviesia elongata</i> subsp. <i>implexa</i>	3		Fairly restricted - south Wb	Sand and gravel	32
<i>Dicrastylis capitellata</i>	1		Restricted - F, E	Sandy loam woodland or shrubland	6
<i>Dillwynia acerosa</i>	1		Widespread - Wb	Gravelly clay with laterite	27
<i>Drosera browniana</i>	PR		Restricted - F	Ironcaps and granite peaks	9
<i>Banksia rufa</i> subsp. <i>flavescens</i>	3		Localised – Wb, F, E	Sandy Banksia heath	26
<i>Banksia shanklandiorum</i>	4		Localised – Wb	Sandy laterite	33
<i>Banksia viscida</i>	3		Restricted - Digger Rocks, Ironcaps, Hatters Hill	Ironstones	19
<i>Elatine macrocalyx</i>	3		Widespread - Eremaean, Gf, F	Near saltlakes	3
<i>Eremophila biserrata</i>	4		Limited - south Wb, F Lake Cronin	Sand or clay	18
<i>Eremophila lucida</i>	1		Very limited – Gf, F	Near sapphires or granite	13
<i>Eremophila racemosa</i>	4		Fairly restricted - F, Wb	Sand	32
<i>Eremophila serpens</i>	4		Fairly widespread – Wb, E	Drainage lanes	30
<i>Eucalyptus cerasiformis</i>	4	Vulnerable	Restricted - F	Loam	27
<i>Eucalyptus deflexa</i>	4		Localised – Wb, F	Sandy woodlands	50
<i>Eucalyptus exigua</i>	3		Fairly widespread - Wb, Gf	Sandplains	27
<i>Eucalyptus georgei</i> subsp. <i>fulgida</i>	4		Highly restricted - F	Clay sand	16
<i>Eucalyptus histophylla</i>	3		Fairly widespread - Gf	Granite	21
<i>Eucalyptus myriadena</i> subsp. <i>parviflora</i>	1		Restricted - mostly Wb, F	Swamps, plains	11
<i>Eucalyptus rugulata</i>	4		Highly restricted - F	Laterite and ironstone	13
<i>Eucalyptus</i> sp. Southern Cross (D. Nicolle and M. French DN 3480)	PR		Localised – Gf, F	Unknown	
<i>Eucalyptus</i> sp. Southern Goldfields (D. Nicole and M. French DN 3652)	PR		Widespread - Gf	Unknown	9
<i>Eucalyptus steedmanii</i>	R	Vulnerable	Restricted - mostly F	Ironstone and sandplains	35
<i>Euryomyrtus leptospermoides</i>	3		Fairly widespread - Gf, Wb	Sand	48

Taxa	WC Act Code	EPBC Act Code	Distribution	Habitat	WAherb Records
<i>Eutaxia acanthoclada</i>	3		Restricted - Wb, F	Clay, gravel	9
<i>Frankenia drummondii</i>	3		Widespread - most Wb	Sand near lakes	13
<i>Gastrolobium tenue</i>	1		Restricted - F, Bruce Rock	Sand /gravel dunes, outcrops	16
<i>Gnephosis intonsa</i>	1		Fairly widespread - Gf, Wb	Saline habitats near lakes, outcrops	14
<i>Goodenia trichophylla</i>	3		Widespread - mostly Wb	Sand and gravel	15
<i>Grevillea aneura</i>	4		Fairly restricted - South Wb, E	Sand and gravel	42
<i>Grevillea baxteri</i>	4		Fairly restricted - mostly near E	Sandplains	37
<i>Grevillea dissecta</i>	4		Very restricted - F	Sand over ironstone	3
<i>Grevillea insignis</i> subsp. <i>elliottii</i>	3		Restricted – mostly F	Ironstone	18
<i>Grevillea lullfitzii</i>	1		Very restricted - F	Granite	18
<i>Grevillea marriottii</i>	1		Very restricted - Mt Holland	Laterite ridges	6
<i>Grevillea pilosa</i> subsp. <i>redacta</i>	3		Restricted - F, Mt Holland	Sand laterite	15
<i>Grevillea prostrata</i>	4		Localised - southern Wb	Sandplains	33
<i>Gyrostemon ditrigynus</i>	4		Localised - southern Wb, E	Plains, ironstone	29
<i>Haegiela tatei</i>	2		Fairly widespread – Wb, Gf, E	Saline habitats	19
<i>Hibbertia axillibarba</i>	1		Very restricted – F, South Ironcap	Laterite / ironstone	4
<i>Hibbertia carinata</i>	1		Fairly restricted – F, E	Sand with gravel, shrubland	7
<i>Hibbertia pachyphylla</i>	3		Fairly restricted – mostly F	Sand and gravel plains	8
<i>Isoetes brevicula</i>	3		Restricted - F	Pools on granite	7
<i>Isolepis australiensis</i>	2		Fairly restricted - southern Wb	Non-saline wetlands	5
<i>Keraudrenia adenogyna</i>	2		Fairly restricted - southern Wb, and F	Laterite	14
<i>Keraudrenia cacaobrunnea</i> subsp. <i>undulata</i>	1		Very restricted (Maggie Hays)	Sand over BIF	5
<i>Lasiopetalum ferraricollinum</i>	PR		Restricted – F, slopes of BIF ranges	Sand laterite	14
<i>Lepidosperma andamantiferrum</i>	1		Slopes of BIF ranges - F	Shallow soil	
<i>Leucopogon</i> sp. Ironcaps (N. Gibson and K. Brown 3070)	3		Fairly restricted - southern Wb	Sand, ironstone or laterite	17
<i>Logania exilis</i>	2		Restricted - F	Sandplains with laterite \ ironstone	6
<i>Melaleuca agathosmoides</i>	1		Very restricted – F	Gravel hills	13
<i>Melaleuca macronychia</i> subsp. <i>trygonoides</i>	3		Fairly restricted - mostly Gf	Granite rocks	11

Taxa	WC Act Code	EPBC Act Code	Distribution	Habitat	WAherb Records
<i>Microcorys lenticularis</i>	2		Fairly restricted - at NE of range	Sand	16
<i>Microcorys</i> sp. Forrestania (V. English 2004)	1		Restricted – F	Woodlands	28
<i>Microcybe pauciflora</i> subsp. <i>grandis</i>	1		Fairly restricted – F	Loam near hills or breakaways	14
<i>Mirbelia densiflora</i>	1		Localised - Wb	Loam, gravel, sand ridges	17
<i>Mirbelia</i> sp. Helena and Aurora (B. J. Lepschi 2003)	3		Southern range extension – mostly Gf	Stony hills, steep slopes	10
<i>Muelleranthus crenulatus</i>	R		Very restricted - F	Laterite, clay or loam	5
<i>Myriophyllum petraeum</i>	4		Restricted to rock pools - Wb, Gf, E	On granite	29
<i>Olearia laciniifolia</i>	2		Fairly restricted - southern Wb	White sand (after fire)	12
<i>Persoonia cymbifolia</i>	3		NW limit of range – Wb, E	Flats or rock crevices	23
<i>Phebalium brachycalyx</i>	3		Widespread - Wb	Lateritic gravel	12
<i>Pityrodia</i> sp. Yilgarn (A. P. Brown 2679)	3		Fairly restricted - F	Sand over laterite	16
<i>Pultenaea daena</i>	3		NW range limit – Wb, F	Near salt lakes	11
<i>Scaevola tortuosa</i>	1		Fairly widespread - Wb	Near salt lakes	8
<i>Sowerbaea multicaulis</i>	4		Fairly widespread – Gf, E	Sand	21
<i>Stenanthemum liberum</i>	1		Very restricted - F	Woodland or shrubs sand over laterite	4
<i>Stylidium sejunctum</i>	2		Fairly restricted - Wb and F	Various habitats	17
<i>Stylidium validum</i>	1		Fairly restricted - F	Greenstone gravel and sand	4
<i>Synaphea divaricata</i>	PN		Fairly widespread – Wb, E	Rocky sand	14
<i>Thomasia gardneri</i>	X	Extinct	C. Gardner collections - Mt Holland	Unknown	7
<i>Verticordia gracilis</i>	3		Fairly restricted - Wb	Sand	20
<i>Verticordia multiflora</i> subsp. <i>solox</i>	2		Restricted – Wb	Sand	26
<i>Verticordia stenopetala</i>	3		Fairly restricted - Gf and Wb	Yellow sand	20

## 5.1 Rare, Endemic and Poorly Known Flora

Plant taxa of conservation significance are listed in Table 8 and summarised in Table 9. A precautionary approach (EPA 2004) has been used when designating species of greatest conservation concern through recognising recently recognised species likely to be threatened (designated PR in Table 9). The available evidence suggest that some of these additional taxa could potentially become DRF after detailed assessment of their conservation status, particularly in cases where all known populations occur in areas where mining could occur. Mining is the most significant threat to flora in the LCR. Other threats to flora include fire, drought and feral animal grazing (Brown *et al.* 1998).

Most significant flora in the LCR has one of four distinctive distribution patterns:

1. locally endemic species restricted to highly specialised and isolated habitats;
2. species with restricted ranges on the Wheatbelt and interzone boundary;
3. species which are Wheatbelt or Eastern Goldfields species at range limits in the LCR; or
4. species which are confined to the interzone.

There also are some rare flora which occur in wetlands or damplands, or are disturbance opportunists with fairly widespread distributions that are usually only found after disturbances such as fire.

The LCR has an exceptionally high number of flora endemic to a small geographic area (Table 9). Regionally endemic taxa are designated in Table 9 if their currently known distribution patterns are confined within a 10,000 km<sup>2</sup> area. This corresponds to the definition of Short Range Endemic (SRE) taxa defined for fauna (Harvey 2002).

**Table 9.** Summary of Declared Rare Flora (DRF), extinct (X), Priority (P1-4), potentially rare (PR) and apparently endemic flora (EF) of conservation concern by endemism and substrate (BIF shaded brown, sandplains and other soil types shaded yellow) within the Lake Cronin Region.

	DRF	X	P1	P2	P3	P4	All P	DRF + P	PR	Total
EF on BIF	2		1		3	2	6	8	6	15
EF on sandplains, etc.	3		8	3	1		12	15	1	17
All EF	5	1	9	3	4	2	18	24	7	32
P Flora not EF			10	12	26	13	64	64		64
<b>Total</b>	5	1	19	15	30	15	82	87	7	96

Many of the Declared Rare and Priority Flora in LCR occur on ironstones (e.g. *Cryptandra intonsa*, *Boronia revoluta* (Ironcaps *Boronia*), *Grevillea dissecta* and *Banksia sphaerocarpa* var. *dolichostyla*). These apparently are refugial species that have adapted to a specialised habitat to survive Australia's drying climate in the past. A similar pattern is observed with species restricted to the ironstone ranges in the Mt Manning region (EPA Bulletin 1256, 2007). These species may have similar origins

to those relictual species of Gondwanan origin that occur in higher rainfall areas (Hopper and Gioia 2004).

Further to the identification of flora species extant within the LCR, the regional requirements for the persistence of these species in regard to such factors as dispersal and habitat requirements is currently poorly understood. Given the transitional nature of the LCR and probable impacts of climate change within the region, there is a need to identify and undertake an analysis of factors necessary for the persistence of both species and communities.



**Figure 3** North Ironcap (photo Mark Brundrett, March 2007).

## **5.2 Floristic Communities**

While there are some similarities in vegetation types between individual ranges in the Yilgarn, there are also major differences (Newbey and Hnatiuk 1988, Gibson 2004, EPA 2007). Each hill or range has a unique set of vegetation patterns, and much of the flora does not occur on the surrounding plains (Henry-Hall 1989).

Gibson (2004) identified a number of plant communities with highly restricted distributions that include endemic species, none of which were protected in a nature reserve. Flora surveys for the Western Areas Flying Fox Mine (Frost *et al.* 2004) also identified significant plant communities are likely to occur in the region.

- Local botanical studies by Gibson (2004) identified seven significant endemic plant communities within the LCR generally described as:
- Four vegetation communities on southern Forrestania greenstone belt between Middle Ironcap and Hatter Hill;
- Three sandplain heath communities at Forrestania and Lake Cronin; and

- One vegetation community of mosaic of low eucalypt woodlands and mallees over clays at Forrestania.

Most of the potentially threatened plant communities identified in the area include locally endemic taxa. Some of the four floristic community types described that occur on or near Banded Ironstone Formations (BIF) should be considered to be potential Threatened Ecological Communities (TECs), since their entire occurrence exists over small isolated BIF ranges in mineral lease areas. The areas with the highest concentration of values are associated with hills in greenstone belts and sandplains.

### 5.3 Fauna and Fauna Habitats

Habitats in the LCR are known to support a rich and diverse vertebrate fauna (How *et al.* 1988a and 1988b). The amphibian community is the richest known in the Eastern Goldfields which is undoubtedly related to Lake Cronin itself, which is both freshwater and semi-permanent, and its associated drainage areas. Some winter-breeding species recorded at Lake Cronin are at the inland extremes of their distribution, while summer-breeding species are close to their southern limits. The reptile fauna of the area is similarly rich and diverse with 35 species recorded during the limited surveys by How *et al.* (1988a and 1988b). The number of species actually present is likely to be far greater as the WA Museum collections (DEC 2009) includes an additional 22 species from the region around Lake Cronin.

Although not fully documented, the bird assemblage in the Lake Cronin area is both rich and diverse with 90 species recorded during the surveys by How *et al.* (1988a and 1988b). However the number of species actually present in the area is likely to be far greater as the wider regional survey outlined in How *et al.* (1988a and 1988b) included 105 species. In a species conservation sense, it is also significant that population numbers of many species in the Lake Cronin area are considerably higher than recorded in other areas in the region with the mean number of birds recorded per observation day in the Lake Cronin area being nearly double that recorded at McDermid Rock further east (How *et al.* 1988a and 1988b). Seasonal movement patterns in the area are likely to be complex with extensive bird movement in and out of the area depending on seasons and seasonal conditions both here and elsewhere. Movement is likely to be enhanced because of the availability of resources in adjacent contiguous habitats. This may be particularly important during severe perturbations such as uncontrolled wildfires.

The mammal assemblage in the Lake Cronin area is relatively rich with 15 species recorded (How *et al.* 1988). However as pointed out by How *et al.* (1988a and 1988b) many additional species could be expected on the basis of distribution, see NatureMap (DEC 2009) for species known from the region. Species recorded in the Lake Cronin area by How *et al.* (1988a and 1988b) included several small terrestrial mammals that were once wide ranging in the Wheatbelt (e.g. White-tailed Dunnart *Sminthopsis granulipes*, Gilbert's Dunnart *S. gilberti*, Ash-grey Mouse *Pseudomys albocinereus*, Mitchell's Hopping Mouse *Notomys mitchellii* and Western Pygmy Possum *Cercartetus concinnus*) but now confined to isolated reserves in the region. Some mammal species are at the extremes of their known range in the Lake Cronin area, e.g. Southern Ningau *Ningau yvonneae* and Bolam's Mouse *Pseudomys bolami* are near the most south-westerly part of their range, and *Sminthopsis gilberti* is at the most north-easterly extent of its distribution. An examination of endemism in the ground vertebrate fauna of Western Australia (How and Cowan 2006) indicated that



the Hyden 1:250000 map sheet, which includes Lake Cronin, has up to 40% of its species being endemic to WA. This is probably accounted for by the transitional climate and vegetation characteristics of this region and as represented by the overlap of taxa that are at the extremes of their range in the area, as cited above. These characteristics provide strong argument for an extensive conservation reserve in a region where habitat continuity provides opportunity for continuing evolutionary and dispersal processes to operate.

Of particular regional importance in the Lake Cronin area are populations of species which previously had extensive distributions in the now largely cleared Wheatbelt. Surveys in the Wheatbelt, to the west of the Lake Cronin area, identified at least 20 species of passerine birds (Kitchener *et al.* 1982) which were restricted to and resident in native vegetation on isolated reserves, and whose conservation status was insecure in that region. Fourteen of those bird species were recorded in the Lake Cronin area by How *et al.* (1988a and 1988b), indicating the significance of the Lake Cronin area in conserving populations of what were once wide-ranging species and whose long-term survival in the Wheatbelt is now questionable.

Although some fauna studies have been undertaken in the Lake Cronin area (e.g. How *et al.* 1988a and 1988b, Lyons *et al.* 2004) information regarding total fauna values is incomplete and a full list of conservation significant species in the area is not available. However, Table 10 identifies those species that are listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* and/or the *State Wildlife Conservation Act 1950*, or are listed as Priority fauna by DEC because of limited distribution, few populations or regional declines, that are known to occur in the Lake Cronin area. This list includes the rarely recorded Priority 3 listed Lake Cronin Snake which is only known from a few localities in the region centred in the region of Lake Cronin.

Further to the identification of fauna species extant within the LCR, the regional requirements for the persistence of these species in regard to such factors as dispersal and habitat requirements is currently poorly understood. Given the transitional nature of the LCR and probable impacts of climate change within the region, there is a need to identify a suite of indicator species and undertake an analysis of factors necessary for their persistence.

**Table 10.** Rare vertebrate fauna recorded from or expected to occur in the area.

Record sources: 1988 = Dell and How (1988a), 2007 = Unpublished records from J. Dell site visit Feb 2007, 2008 = records pers. comm. B. Maryan 2008.

Taxon	Common Name	EPBC Act	State Listing	Record
<i>Dasyurus geoffroii</i>	Chuditch	Vulnerable	Schedule 1	1988
<i>Macrotis lagotis</i>	Bilby	Vulnerable	Schedule 1	extinct in region
<i>Leporillus conditor</i>	Greater Stick-nest Rat	Vulnerable	Schedule 1	1988 extinct in region
<i>Calyptorhynchus latirostris</i>	Carnaby's Black Cockatoo	Endangered	Schedule 1	1988
<i>Leipoa ocellata</i>	Malleefowl	Vulnerable	Schedule 1	1988, 2007
<i>Platycercus icterotis xanthogenys</i>	Western Rosella		Schedule 1	1988
<i>Falco peregrinus</i>	Peregrine Falcon		Schedule 4	
<i>Morelia spilota</i>	Carpet Python		Schedule 4	1988

<b>Taxon</b>	<b>Common Name</b>	<b>EPBC Act</b>	<b>State Listing</b>	<b>Record</b>
<i>imbricata</i>				
<i>Paraplocephalus atriceps</i>	Lake Cronin Snake		Priority 3	1988, 2008
<i>Ardeotis australis</i>	Australian Bustard		Priority 4	1988
<i>Calamanthus campestris montanellus</i>	Rufous Fieldwren		Priority 4	1988, 2007
<i>Hylacola cauta whitlocki</i>	Shy Heathwren		Priority 4	1988, 2007
<i>Oreoica gutturalis gutturalis</i>	Crested Bellbird		Priority 4	1988, 2007
<i>Pomatostomus superciliosus ashbyi</i>	White-browed Babbler		Priority 4	1988, 2007

## 5.4 Wetlands

The significance of Lake Cronin is well documented (Henry-Hall 1989, Halse *et al.* 1993, Lyons *et al.* 2004, Pinder *et al.* 2004). The lake is an excellent habitat for waterbirds, containing water even at the end of the dry season (Figure 4). In a classification of Wheatbelt wetlands based on aquatic invertebrates, Lake Cronin clustered with 23 other freshwater lakes and swamps in a group called “species rich freshwater wetlands” (Pinder *et al.* 2004) and had the third highest species richness (78 species) within this group. Amongst the invertebrates were several species that were otherwise rare to absent in other wetlands of the inland south-west.

In a combined analysis of waterbirds, invertebrates and wetland vegetation, Halse *et al.* (2004) identified Lake Cronin as having the highest representation of a suite of species typical of the southern and eastern central Wheatbelt. Freshwater wetlands are uncommon and mostly threatened by salinisation throughout the Wheatbelt, therefore Lake Cronin represents a significant and increasingly rare habitat for freshwater fauna in the region. Large salt lakes to the east of Lake Cronin also are significant though different habitats for fauna and flora (How *et al.* 1988) but have been poorly documented.

The species at Lake Cronin fell into two species assemblages identified in Lyons *et al.* (2004) being:

- Assemblage 2.1 - Taxa of inland freshwater wetland basins/claypans; and
- Assemblage 3.1 – Ubiquitous non-saline wetland taxa.

In the South West Agricultural zone these Assemblages were recognised as being under immediate threat from secondary salinisation (Lyons *et al.* 2004) and are currently under consideration for listing as a Threatened Ecological Community (Rees, pers comm.).



**Figure 4.** Lake Cronin waterbirds (photo Mark Brundrett, March 2007).

Lake Cronin is listed on the Register of National Estate (Commonwealth of Australia 2009) and in the Directory of Important Wetlands in Australia (Commonwealth of Australia 2001) in recognition of the unique values of the wetland in the Region.

## **6 Key Threats to Biodiversity in the LCR**

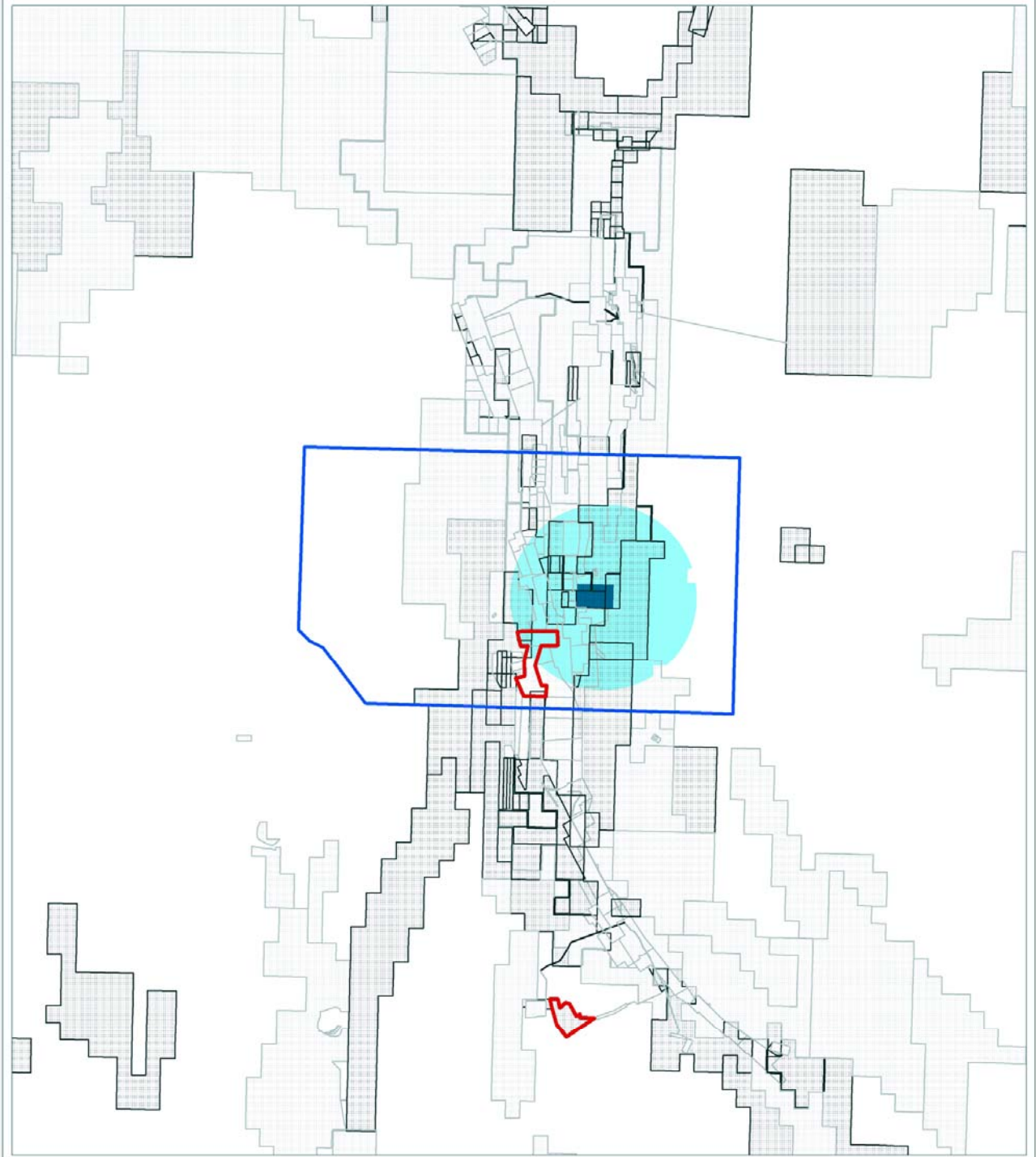
The LCR possesses significant values in terms of wetland, flora and fauna habitat, however the area also contains mineral wealth and exploration and mining leases have claim to the majority of Unallocated Crown Land (UCL) within the Coolgardie IBRA Region.

The potential for large scale clearing for mineral exploration and extraction is the most significant threat in the LCR (Map 6). Threats may include management issues such as the introduction of weeds and pathogens from vehicle movement and introduced materials, and hydrological changes that may occur from dewatering.

Additional threats may occur from other environmental aspects such as climate change, which may impact the ability for ecosystems to adapt. It is thought that viability of an area is related to size and diversity, i.e. smaller areas have less opportunity for communities to move in a landscape in response to wetter or dryer conditions.

Fire management is a major issue in this region where past fires have spread over vast distances. Woodlands in particular are slow to recover (and replenish seed reserves) in an arid environment and the lack of mature woodlands is likely to impact significantly on those fauna species which require specialised resource elements, especially tree hollows.

Environmental Protection Authority  
**Map 6: Mining Activity**



<p><b>Legend</b></p> <ul style="list-style-type: none"> <li><span style="border: 1px solid blue; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Proposed Lake Cronin Reserve (1990)</li> <li><span style="background-color: darkblue; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Current Lake Cronin Nature Reserve</li> <li><span style="background-color: cyan; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Proposed Interim Protected Area (1975)</li> </ul> <p><b>Mining Tenements</b></p> <ul style="list-style-type: none"> <li><span style="border: 1px solid black; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Live</li> <li><span style="border: 1px dashed black; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Pending</li> </ul> <p><b>EIA register - mining proposals</b></p> <ul style="list-style-type: none"> <li><span style="border: 2px solid red; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Referral currently being Assessed by the EPA</li> </ul>	<p style="text-align: center;">0 2 4 8 12 16 20 km</p> <p style="text-align: center;">1:200,000</p> <p style="text-align: center;">Projection: Map Grid of Australia Zone 50          Datum: Geocentric Datum of Australia, 1994</p> <p><b>Data Source</b></p> <p>Proposed Lake Cronin Reserve (Department of Environment and Conservation 1990)          DEC Managed Lands (Department of Environment and Conservation 2006)          Proposed Interim Protected Area (Environmental Protection Authority 1975)          Mining Tenements (Department of Industry and Resources 2008)          EIA register of mining proposals (Environmental Protection Authority 2008)</p> <p><b>Analysis</b>          none</p> <p><b>Presentation</b>          Environmental Protection Authority (2009)</p>	<p>This map is produced for the Environmental Protection Authority. Both map and report are produced by the Environmental Protection Authority, an independent advisory body on the environment.</p> <p>This map depicts the current and proposed reserve systems of Lake Cronin in relation to mining proposals referred to the EPA and live or pending mining tenements.</p> <p><small>Disclaimer: This map is intended as a generalised interpretation of environmental issues. The information contained on this map is to be considered indicative only and in no event shall the Environmental Protection Authority be liable for any incident or consequential damages resulting from use of the material.</small></p> <p><small>© Copyright Environmental Protection Authority, 2008.          All Rights Reserved. All works and information displayed are subject to Copyright. For the reproduction or publication beyond that permitted by the Commonwealth Copyright Act 1968 written permission must be sought from the Authority.</small></p>
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**Map 6: Mining Activity**

Key threats to values are:

- Mining and exploration – clearing and edge effects;
- Weeds and pathogens;
- Hydrology changes from dewatering impacts or substrate removal;
- Climate change – rainfall changes, adaptation ability over short period of time (diversity); and
- Large-scale fire.

## **7 Conclusions**

The EPA notes that earlier proposals which identified the significance of the LCR and recommended the establishment of a substantial nature reserve have been fully validated and considerably strengthened by increased knowledge of flora in the area that was not available when the proposals were developed. In particular, many additional endemic rare species and potentially threatened plant communities have been recognised. The long-standing knowledge of the extremely high environmental significance of this transitional/interzone region has been confirmed by major recent advances in knowledge of its biodiversity.

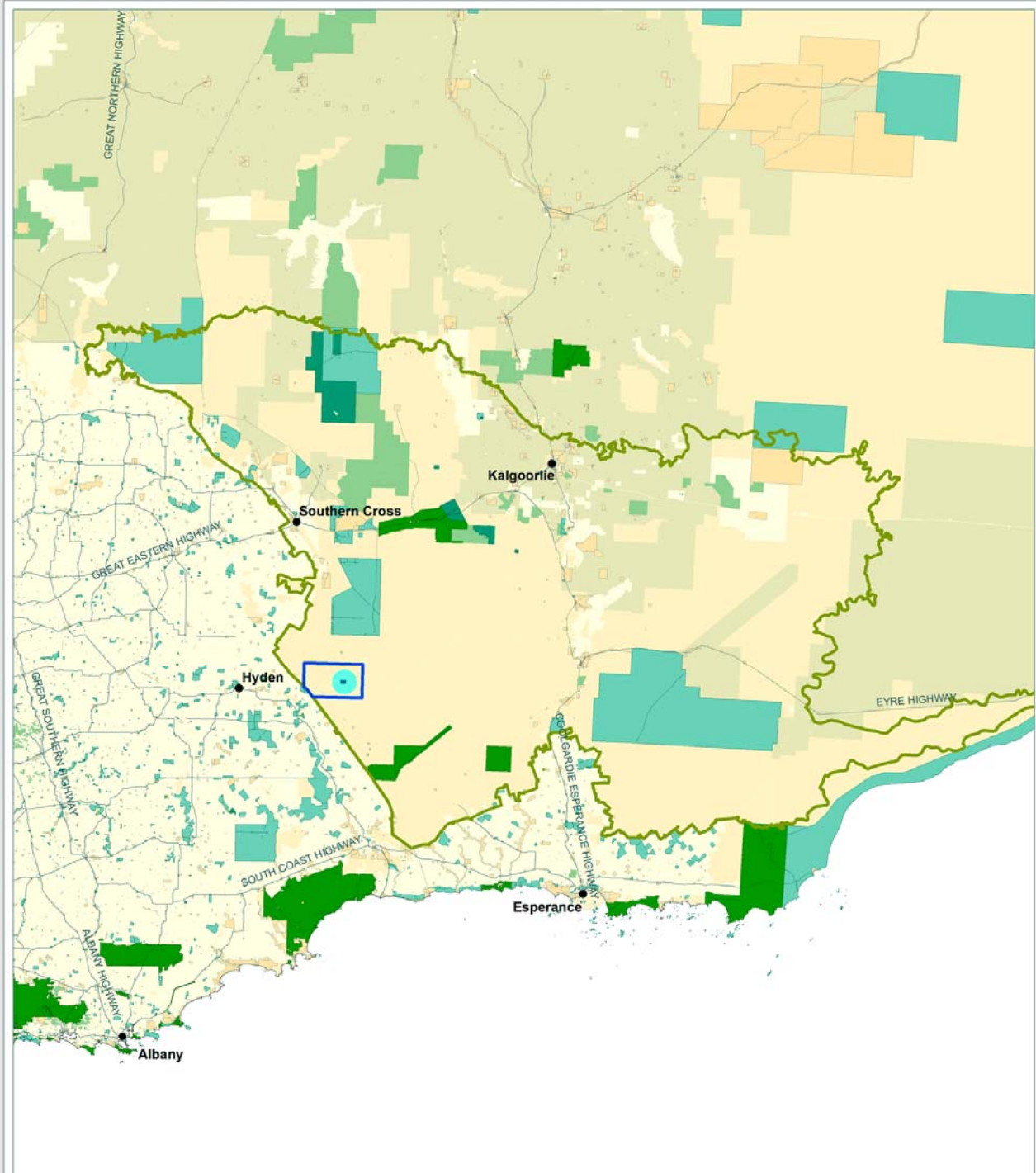
The LCR supports shrubland, sandplain and woodland environments, including excellent representation of a range of vegetation types that are now extensively cleared in the Wheatbelt. These areas provide very important habitats for fauna species that are now largely absent or suffering declining populations in the Wheatbelt. Creation of nature reserves in the LCR provides an opportunity to conserve a portion of this extensive and contiguous environment representing the full catena of landscape elements in this biologically diverse region.

Mining and mineral prospecting interests make it unlikely that a large contiguous “A” Class Nature Reserve will be established as recommended by Henry-Hall (1990). The Great Western Woodlands conservation strategy is expected to provide an effective approach to achieve regional scale conservation management to protect critical values (Map 7).

The LCR is found within a transition zone which demarcates the South West Botanical Province and the Eremaean Botanical Province. A consolidated reserve in the LCR would be very important due to its strategic location and inclusion of a diverse range of environments and ecological communities. The importance of conserving ecological assemblages within transitional zones is further emphasised within the context of mitigating the anticipated impacts of climate change.

There remain significant gaps in knowledge of the biota of this region and further investigations should be undertaken. Increasing knowledge of the biota of the LCR will determine if the area is worthy of recognition as a biodiversity hotspot for its combination of high levels of species richness, concentration of rare and endemic flora, restricted ecological communities and the potential impacts of threatening processes associated with the mineral potential of the greenstone belt environments. Key areas that are essential for conservation of threatened species and endemic plant communities have been identified in the LCR, i.e. highest concentration of values are associated with hills in greenstone belts and sandplains.

Environmental Protection Authority  
**Map 7: Proposed Lake Cronin Reserve and Great Western Woodlands**



Legend	
●	Town
■	Proposed Lake Cronin Reserve (1990)
■	Current Lake Cronin Nature Reserve
■	Proposed Interim Protected Area (1975)
■	Great Western Woodlands Boundary
■	National Park
■	Conservation Park
■	Nature Reserve
■	Other DEC Managed Tenure
■	Crown Reserves
■	Pastoral Lease
■	Unallocated Crown Land
—	Main Road

0 10 20 40 60 80 100 km	
1:1,500,000	
Projection: Map Grid of Australia Zone 50 Datum: Geocentric Datum of Australia, 1994	
<b>Data Source</b> Proposed Lake Cronin Reserve (Department of Environment and Conservation 1990) DEC Managed lands (Department of Environment and Conservation 2005) Proposed Interim Protected Area (Environmental Protection Authority 1975) Pastoral Lease (Landgate 2007) Unallocated Crown Land (Landgate 2007) Major Rivers (Water and Rivers Commission 1995) Main Roads (AUSLIG 1995)	
Analysis none	Presentation Environmental Protection Authority (2009)

This map is produced for the Environmental Protection Authority. Both map and report are produced by the Environmental Protection Authority, an independent advisory body on the environment.

This map depicts the location of the proposed Lake Cronin Reserve.

Disclaimer: This map is intended as a generalised interpretation of environmental issues. The information contained on this map is to be considered indicative only and in no event shall the Environmental Protection Authority be liable for any incident or consequential damages resulting from use of the material.

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**Map 7**

**Proposed Lake Cronin Reserve and Great Western Woodland**

Finalisation of the historical proposal for a larger, but fragmented reserve that includes Lake Cronin should be an immediate priority. The LCR reserve planning must consider regional scale ecological processes as well as site-specific values and long-term objectives. For example, genetic processes require connectivity within populations and a diversity of habitat types required to support fauna. Thus a large reserve in the LCR will also help to meet CAR conservation objectives across larger areas of the Wheatbelt and Goldfields by including significant woodlands, shrublands, sandplains and salt lakes. It also needs to be noted that this area has high landscape diversity and includes sandplain, woodland and salt lake habitats which are of critical importance as habitats for species that are not well represented in other reserves or have declining populations in the Wheatbelt.

Additionally, reserve management should be informed by targeted regional biological surveys to identify core areas of the highest conservation value that should be protected from ground disturbing mineral exploration and mining, while recognising that mining will continue to occur through the region more generally.

Future reserve planning must consider regional-scale values and ecological processes as well as site-specific values and long-term objectives. To this end, the EPA supports the development of the Great Western Woodlands conservation strategy proposed by the Western Australian Government as an important initiative that should greatly benefit conservation, cultural and tourism management at the whole-of-region and cross-region scales.

## **8 Recommendations**

Based on the values identified in this report, it is recommended that:

1. The Great Western Woodlands conservation strategy, which provides a basis for whole-of-region scale recognition of conservation and heritage values, and management priorities, is strongly supported.
2. The proposed expanded Lake Cronin conservation proposals (as outlined in Map 1) be implemented through the Great Western Woodlands conservation strategy. Highest priority in this process should be to establishing:
  - d. The proposed “C” Class Nature Reserve to protect the catchment of Lake Cronin;
  - e. The proposed “A” Class Nature Reserve to protect North Ironcap Banded Ironstone Formation; and
  - f. The proposed “C” Class Nature Reserve representing extensive sandplain and woodland vegetation located immediately east of the Wheatbelt, which represents vegetation communities and fauna habitats that have been extensively cleared and fragmented in the adjacent Wheatbelt.
3. The Great Western Woodlands conservation strategy should be used to review the potential to:
  - a. Expand the “A” Class Nature Reserve around North Ironcap; and
  - b. Upgrade the recommended “C” Class Nature Reserve protecting the Lake Cronin catchment and the “C” Class Nature Reserve representing

extensive sandplain and woodland vegetation located immediately east of the Wheatbelt to “A” Class status.

## **9 Further advice**

The EPA notes that there are significant gaps in knowledge of the biota of this region and recommends that further investigation be undertaken. This should include but not necessarily be restricted to:

1. Some flora taxa considered on existing information to be endemic to small areas in this region should be assessed for possible DRF listing, in recognition of the potential threats to these species. This review should also consider whether these species are adequately protected by the proposed Lake Cronin Reserve, once they are established.
2. Vegetation communities known to be endemic to the region should be further investigated for inclusion as possible Threatened Ecological Communities.
3. Further surveys should be undertaken to better define the status of:
  - a. Newly recognised, apparently rare and endemic flora;
  - b. The distribution of Declared Rare and Priority Flora relative to conservation reserve boundaries in the LCR study area;
  - c. Plant species within the large areas of sandplains and woodlands not adequately surveyed within the LCR study area; and
  - d. Poorly known vertebrate and short-range endemic invertebrate fauna.
4. Investigate the values of the area in representing environments that have been extensively cleared in the adjacent Wheatbelt, including critical fauna habitat value.



## **Appendix 1**

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## **Appendix 2**

### **Definitions and Acronyms**

**Biological Diversity/Biodiversity** - The variety of all life forms - the different plants, animals and micro-organisms, the genes they contain, and the ecosystems of which they form a part (see EPA 2004 for fully definitions of these components). It is not static, but constantly changing; it is increased by genetic change and evolutionary processes and reduced by processes such as habitat degradation, population decline, and extinction (Commonwealth of Australia 1996).

Biodiversity consists of three major components (Commonwealth of Australia 1996):

- a) species diversity;
- b) ecosystem diversity; and
- c) genetic diversity.

The assessment of significance of MMR natural areas includes all three of these components.

1. Species diversity is the total taxonomic diversity of plants and animals and to a lesser extent fungi and microbes. Plant and animal diversity is assessed from species lists and surveys taking survey effort, coverage and other limitations into account (EPA 2004). In most cases the primary focus is on rare, priority and locally significant species.
2. The ecosystem diversity component concerns the spatial diversity of assemblages (communities) of plants and animals. This approach allows Threatened Ecological Communities (English and Blyth 1999) and assemblages of plants or animals that are not well represented in existing reserves to be recognised (CALM 2002).
3. Genetic diversity concerns variations between individuals and populations within a taxa. This must be considered when sourcing seed for rehabilitation projects (EPA 2006) and distinguishing similar looking taxa isolated by geographic barriers (Coates 2000, Butcher *et al.* 2007), but also allows the impacts of projects on populations of rare species to be assessed.

**Biodiversity Hotspot** - A region of exceptionally high species endemism and diversity (Myers *et al.* 2000). Also refers to areas where biodiversity are concentrated within floristic regions (Hopper and Gioia 2004, [www.environment.gov.au/biodiversity/hotspots](http://www.environment.gov.au/biodiversity/hotspots)).

**Biotic Ecosystem Components** - Populations of species comprising an ecosystem (communities, assemblages, etc.). These can be classified using taxonomic hierarchies (family, genus, species, etc.), life forms (tree shrub, etc), or functional roles, (primary producers, herbivores, carnivores, etc.).

**CAR (Comprehensive, Adequate and Representative Reserve System)** - The development of a CAR reserve system is guided by nationally agreed criteria (Commonwealth of Australia 1999).

1. **Comprehensive** – includes the full range of ecological communities recognised by an agreed scientific classification at appropriate hierarchical levels.
2. **Adequacy** – the maintenance of ecological viability and integrity of populations, species and communities.
3. **Representativeness** – adequately reserve known species and genotypes to maximise their viability within a bioregion.



**Declared Rare Flora (DRF)** – See Flora Conservation Codes.

**Ecological Linkage** – A series of (either contiguous or non-contiguous) natural areas that, within a landscape context, and by virtue of their proximity to each other, share a functional ecological connection. An ecological connection is deemed functional when it enables those natural areas within an ecological linkage to act as stepping stones of habitat which facilitate a substantial movement of organisms and genetic material.

**Ecosystem** - The biota (plants, animals, fungi and micro-organisms) occurring in a given area, along with the abiotic environment that sustains it (landforms, soils, hydrology) and their interactions.

**Endemic** - The distribution of an organism confined to a particular geographic area.

**Eremaean** - Inland arid zone province of Western Australia containing vegetation adapted to dry areas (Beard 1990).

**Fauna Conservation Codes** - Taxa listed under the Western Australian Wildlife Conservation Act if they are considered to be in danger of extinction, rare or otherwise in need of special protection.

- Schedule 1 are fauna that are rare or likely to become extinct,
- Schedule 2 are fauna presumed to be extinct,
- Schedule 3 are birds protected under an international agreement,
- Schedule 4 are other specially protected fauna.

There are also five categories (P1-5) of Priority fauna for poorly known species listed by DEC (see also **Priority Fauna**).

**Flora Conservation Codes** – Taxa listed under the Western Australian Wildlife Conservation Act if they are considered to be in danger of extinction, rare or otherwise in need of special protection.

- R - Declared Rare Flora (DRF) - Extant Taxa (Threatened Flora = Endangered + Vulnerable). Taxa which have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection.
- X - Declared Rare Flora - Presumed Extinct Taxa. Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently.

There are also three categories of Priority Flora for poorly known species (P1-3) and a fourth category (P4) for species that have been adequately surveyed and rare but not currently threatened (see [florabase.dec.wa.gov.au/help/conscodes](http://florabase.dec.wa.gov.au/help/conscodes)). (See also **Priority Flora**).

**Floristic Community Type** – Vegetation classification based on the presence and absence of species. These are defined by all the vascular plant taxa present in standard areas (a plot).

**Geodiversity/Geoconservation** – Conservation of the range of geological (rocks, minerals and fossils), geomorphological (landforms and processes) and soil features, assemblages, systems and processes (Sharples 2002).

The significance of geoh heritage features can be assessed by the following criteria;

- (i) aesthetic;
- (ii) scientific / educational;
- (iii) recreational;
- (iv) social/historical value;
- (v) sense of place; and
- (vi) spiritual/religious values (Sharples 2002).

**Habitat** - The natural environment of an organism or a community, including all biotic and abiotic elements; a suitable place for it to live (Commonwealth of Australia 1996). Vegetation can become a reasonable surrogate for outlining habitat when its main components, structure and the associated landform are also described.

**IBRA (Interim Biogeographic Regionalisation for Australia)** – Divides the Australian continent into 85 bioregions and 404 sub-regions based on major geomorphic features. These are important reporting units for assessing the status of native ecosystems ([www.environment.gov.au/parks/nrs/ibra](http://www.environment.gov.au/parks/nrs/ibra)).

**Keystone Species** - Species with a major role supporting other species by providing food, shelter or habitat. These often are canopy of dominant species in ecosystems.

**LCR (Lake Cronin Region)** – Defined by the boundaries 32° 10' to 32° 35' and 119° 20' to 119° 55', centred on Lake Cronin and the intersection of Hyden-Norseman and Forrestania-Southern Cross Roads in the Southern Goldfields DEC Region, near the eastern boundary of the Wheatbelt.

**Precautionary Principle** - Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation. Decision making should be guided by (a) a careful evaluation to avoid serious or irreversible damage to the environment wherever possible and (b) an assessment of risk-weighted consequences of the options (*Environmental Protection Act 1986*, EPA 2002).

**Priority Ecological Communities** - Possible threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to DEC's Priority Ecological Community Lists under Priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that consideration can be given to their declaration as threatened ecological communities. Ecological Communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (<http://florabase.dec.wa.gov.au/>).

**Priority Flora** - Taxa listed by DEC that are either under consideration as Threatened Flora but are in need of further survey to adequately determine their status, or are adequately known but require monitoring to ensure that their security does not decline. There are four categories of Priority Flora, from Priority 1 to 4.

**Priority Fauna** – Conservation significant animal taxa listed by DEC but are not currently listed under Section 14 (2) (ba) of the *Wildlife Conservation Act 1950* as Specially Protected Fauna. There are five categories of Priority Fauna, from Priority 1 to 5.

**Significant taxa** - consist of (EPA 2004, 2006):

- Rare and priority plant species;
- Newly recognised unnamed plant species;
- Relatively widespread species at limits of distribution;
- Highly variable species expected to be redefined into narrower taxa in the future - especially when populations are highly disjunct; and
- Extremely restricted distributions.

**Short Range Endemic (SRE)** - Fauna species confined to less than 10,000 km<sup>2</sup> (Harvey 2002). Some plants are also confined to small areas.

**SWAFR (Southwestern Australian Floristic Region)** – The vegetation zone occupying the Mediterranean climate region of South Western Australia (Hopper and Gioia 2004). Formerly the Southwest Botanical Province of Western Australia (Beard 1990).

**Threatened Ecological Community (TEC)** – As defined by English and Blyth (1999) are those ecological communities that have been assessed through a procedure (co-ordinated by DEC) and assigned to one of the following categories related to the status of the threat to the community. One of the criteria used to determine the categories of threatened ecological community is an estimate of the geographic range and/or the total area occupied and/or the number of discrete occurrences reduced since European settlement. The categories are:

1. **Presumed Totally Destroyed**
2. **Critically Endangered:** < 10% of pre-European extent remains in an intact condition in the bioregion.
3. **Endangered:** 10 to 30% of pre-European extent remains.
4. **Vulnerable:** declining and/or has declined in distribution and/or condition, and whose ultimate security is not yet assured (it could move into a category of higher threat in the near future if threatening processes continue).
5. **Data Deficient**
6. **Lower Risk:** > 30% of pre-European extent remains, and does not qualify for one of the above categories of threat.

**Vegetation Type** – Vegetation types as defined by Beard (1990) are based on three principle characteristics of vegetation:

1. **Floristic Composition:** the species of plants which comprise vegetation.
2. **Vegetation Structure:** the height of plants in layers, their shape and their spacing.

3. **Growth-form:** the morphological characteristics of the component plants, such as woody or herbaceous, annual or perennial, thorny or succulent, evergreen or deciduous, and leaves of a certain texture, size and shape. Beard mapped Western Australia's vegetation types, principally at the level of plant formation and most often at the 1: 250,000 scale, doing this at the level of plant formation, with minor attention to plant associations where they could be readily distinguished.
4. **Plant Association:** the component species, with particular dominants, of a given area. If the vegetation of another area has the same dominants it is in the same association. The association is the basic unit of vegetation.
5. **Plant Formation:** a vegetation unit that considers plant associations that have a similar physiognomy (a combination of vegetation structure and growth-form), independent of specific floristic composition.

**WAherb, herbarium** - Western Australian Herbarium.

## **Appendix 3**

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