

**Advice on areas of the highest conservation value in
the proposed extensions to Mount Manning
Nature Reserve**

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

**Environmental Protection Authority
Perth, Western Australia
Bulletin 1256
May 2007**

Strategic Advice Timelines

Date	Progress stages
13 December 2004	Request for advice from Minister for the Environment
April 2005	Technical Working Group established
22 February 2007	EPA briefing
26 Feb to 1 March 2007	Mount Manning Region site visit and consultation with Portman Iron and botanical consultants
16 April 2007	Conservation Commission briefing
19 April 2007	Briefing of EPA Draft Section 16 (e) advice
14 May 2007	EPA section 16(e) advice released

Advice issued by the EPA under Section 16 of the *Environmental Protection Act 1986* does not constitute a formal assessment or approval by the EPA. There is no right of appeal against Section 16 advice.

Summary and recommendations

Terms of reference

The present document presents Ministerial Advice requested from the EPA under Section 16(e) of the Environmental Protection Act, as stated below.

Requested information (Minister for the Environment, December 2004)

- The location of the highest conservation values in the proposed extensions to the Mt Manning Nature Reserve.
- Surrounding areas which require protection from extractive industries as well as those areas in the proposed extensions to the Mt Manning Nature Reserve for which there is a potential for environmental offsets.
- This advice should also give consideration to details of Ministerial Statement 627 with respect to Portman Iron Ore Ltd Koolyanobbing Expansion.

This document presents Ministerial Advice requested from the EPA under Section 16(e) of the Environmental Protection Act, following approval of the expansion in iron ore mining by Portman Iron Ore Ltd at the Windarling and Jackson Ranges. For the purpose of this advice, the request to identify “areas which require protection from extractive industries” is interpreted to include mining specifically.

The advice primarily concerns Mt Manning Range Nature Reserve and its extensions, also known as the Yilgarn Conservation Reserves. This Section 16(e) advice identifies areas that should be protected from mining and the use of environmental offsets.

Outline of the environmental issue and its significance

This request for EPA advice follows the approval of the expansion of iron ore mining by Portman Iron Ore Ltd from Koolyanobbing to the Windarling and Jackson Ranges. Environmental Commitments in Ministerial Statement 627, which concerns the Koolyanobbing Expansion, includes conditions which are both of narrow scope and specific to Portman Mining and of broader scope concerning the entire Mt Manning Range Nature Reserve and its extensions. The conditions include specific measures intended to secure and manage remaining unmined populations of the Declared Rare Flora species *Tetratheca paynterae* – Windarling Range and advance conservation reservation in the Mount Manning region.

The Mount Manning Region has been recommended as a conservation reserve since 1962. The basis for the long-standing proposals to establish a nature reserve in the Mount Manning Region (MMR), are considerably strengthened by new knowledge of the biodiversity conservation values of the region, in particular the number of rare species and plant communities endemic to the region.

The Banded Ironstone ranges, which are a focus for much of the rare and endemic flora and plant communities in the region, are also the focus of mining and mineral prospectivity in the region, particularly for iron ore. In the absence of secure

protection, exploration and mining impacts represent a significant threatening process for endemic taxa and endemic plant communities.

Methodology

- Compile information about the distribution of rare, priority and other significant taxa from existing flora, vegetation and fauna data and consultation with biological survey scientists.
- Map spatial information (vegetation types, rare/priority/other significant flora, fauna etc.),
- Assess significance of rare or possibly endemic fauna and identify key fauna habitats as best possible with existing data.
- Identify plant communities (associations) landforms and animal habitats that are not well represented in other conservation reserves. This will necessarily occur at the fairly coarse scale of the update of Beard's Vegetation mapping.
- Use State, National and International criteria for recognising areas of natural and aboriginal heritage significance, geodiversity and scientific importance.
- Identify areas of highest environmental significance using CAR objectives.
- Review effectiveness of proposed reserve boundaries for protection from extractive industries and propose additional areas for inclusion if appropriate.
- Assess appropriate conservation mechanisms for areas of high conservation value, while recognising the existence of mines and mineral leases.
- Propose a strategy to deal with biological values (especially rare, priority and endemic flora and fauna) in areas of high mineralogical value, as requested by Minister.

Biodiversity consists of three major components (A) species diversity, (B) ecosystem diversity and (C) genetic diversity (Commonwealth of Australia 1996). The assessment of significance of MMR natural areas includes all three of these components.

The framework for recognising essential biodiversity and other heritage assets is summarised in Section 3 Table 4 in the body of the report. The area searched for flora, TEC's and fauna in the MMR was: 29° 15' to 31° 15' N and 118° 45' to 120° 15' E. A supplementary geographic names search in Florabase used locality names. Flora and vegetation data was also obtained from Florabase, published and unpublished survey reports and consultation with botanists.

General EPA findings

This region is worthy of recognition as a biodiversity hotspot due to high flora and fauna diversity and endemism, Declared Rare and Priority flora, Declared, Threatened and Priority Listed Fauna, undescribed or newly described taxa and unique vegetation communities restricted to Banded Ironstone Formation (BIF) ranges.

It is significant that this region straddles the South-West Interzone, a transitional rainfall and vegetation zone between the Southwest and Eremaean Botanical

Provinces and so corresponds to the limits of distribution for many plants and plant communities of the goldfields and wheatbelt.

The concentration of conservation values associated with the Helena and Aurora Range, established that, for its size, this range is one of the more significant biodiversity assets in WA. However, other ranges in the Mount Manning Region, including the Die Hardy Range & Yorkradine Hills, the Windarling Range, the Jackson Range and the Koolyanobbing Range, also have very high environmental significance, especially as refugia for endemic rare species. Within each range, the size and complexity of massive BIF rock outcrops with cliffs was correlated with the presence of rare flora. Intact BIF ranges are important to maintain the genetic diversity within populations of endemic rare flora and to allow survival during periods of adverse climate.

The entire MMR has exceptionally high landscape diversity, including interconnected intact sandplain, woodland and salt lake habitats of critical importance for fauna and flora that are not represented in other reserves or have declining populations in the wheatbelt. These areas are also worthy of conservation for Aboriginal heritage, geodiversity and tourism. Transitional areas in the interzone, such as the MMR, may also provide species with refugia or alternate habitats in intact complex landscapes during periods of climate change.

Since the Koolyanobbing mine expansion was approved, it has become apparent that further mining of BIF ranges of highest conservation significance in the MMR region is likely to result in major impacts to BIF endemic threatened species and communities. Thus, it is unlikely that further mining in the areas of highest conservation value, proposed as an A Class Nature Reserve could be justified.

Recommendations

The EPA recommends that:

- 1) The Mount Manning Region (MMR) be recognised as a Biodiversity Hotspot for its combination of high levels of species richness, concentration of rare and endemic flora, restricted ecological communities and the threatening processes associated with the mineral potential of the BIF Range environments, which coincide with the highest concentration of threatened and endemic species and communities in the region.
- 2) Areas of the highest conservation value and surrounding areas in the MMR be protected from mining by:
 - Establishing an A Class Nature Reserve to include the highest priority conservation areas, as outlined in Table I and Map I below;
 - Defining temporary exclusions for mining and mining infrastructure in the proposed A Class Nature Reserve in areas where mining is currently approved. These areas should become part of the Reserve after successful rehabilitation (consistent with the approach of Ministerial Statement 627).
 - Proponents be advised that proposals for further mining in areas of the highest conservation value are unlikely to be found environmentally acceptable.

- 3) Renewal of mineral tenements and granting of new tenements should not be supported in the proposed A Class Nature Reserve.
- 4) The precautionary principle be applied in relation to proposals to offset loss of highly habitat specific BIF endemic species through translocation to other sites, as each BIF range generally has its own endemic species occupying equivalent habitats.
- 5) The 32 flora taxa considered on existing information to be endemic to small areas in this region be assessed for DRF listing, in recognition of the increased threats to species endemic to BIF ranges (these taxa are designated as PR in Table 6). This review should take into account the degree of protection offered by the A Class Nature Reserve, once it is established.
- 6) Further flora and vegetation surveys be undertaken to better define the status of:
 - a) Apparently rare and endemic flora.
 - b) Large areas of sandplains and woodlands not adequately surveyed within the MMR, and
 - c) Rare flora and communities in Jaurdi and Mt Elvire Conservation Parks.
- 7) The MMR be surveyed for Short Range Endemic fauna (especially invertebrates).

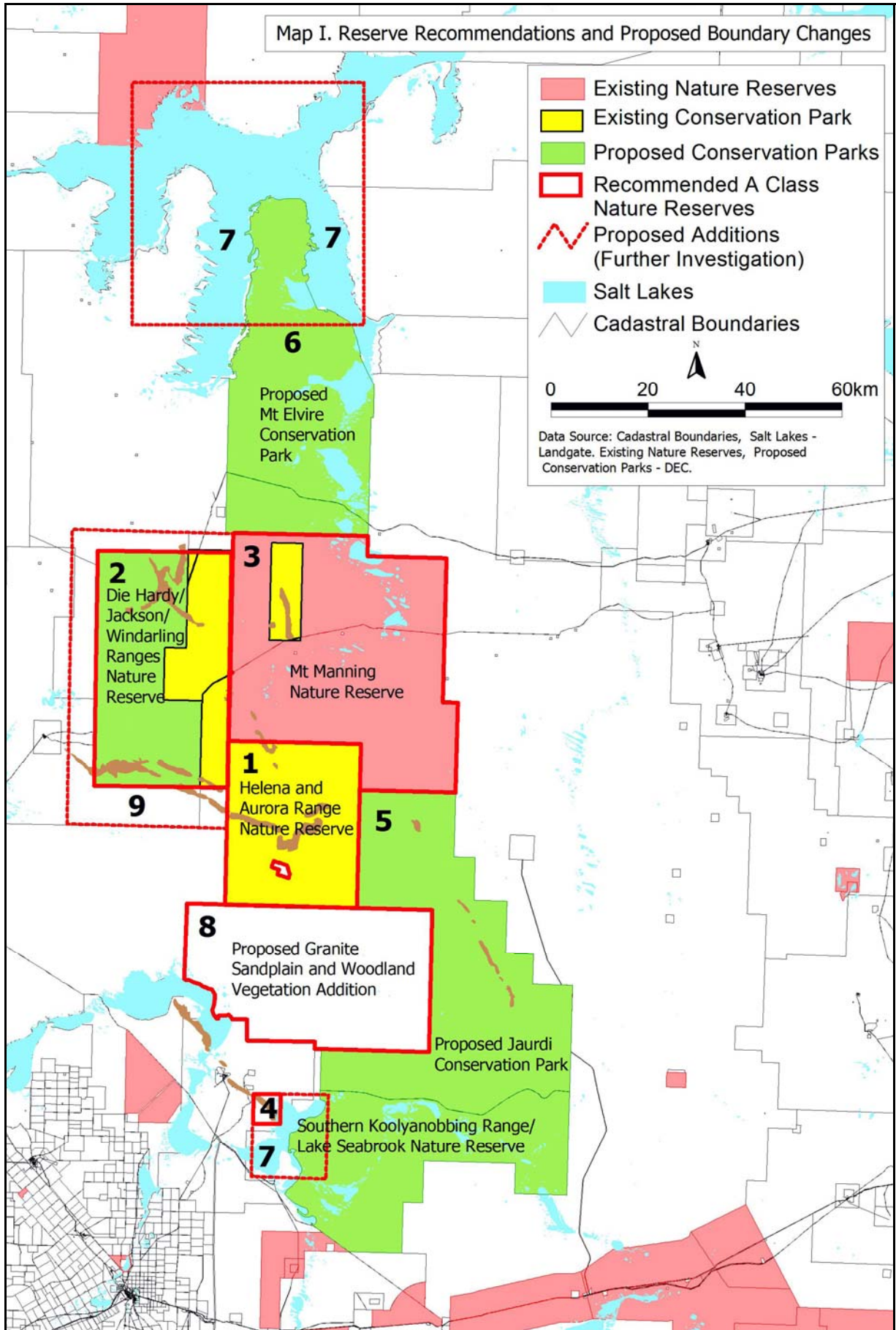
Table I. Reserve Recommendations listed in order of importance (see Map I).

No. on Map I	Conservation Reserve or location	Action	Key Factors
1	That part of the Helena & Aurora Range Conservation Park, as shown on Map I	Reserve area as an A Class Nature Reserve for protection of high concentrations of endemic rare flora and Priority Ecological Communities, exceptional landforms, threatened fauna habitats, mature eucalyptus woodlands that are declining in the Wheatbelt and Aboriginal heritage.	1, 2, 3, 4, 5, 6, 7, 8
2	Part of the Helena and Aurora Range Conservation Park, the proposed Die Hardy Range / Mt Jackson Conservation Park, as shown on Map I	Reserve as an A Class Nature Reserve for protection of endemic rare flora, extensive ecotone between Eucalypt woodland and Mulga shrubland vegetation demonstrating the interzone between the South-West and the Eremaean Botanic Provinces, as well as exceptional landforms, fauna habitats and Aboriginal heritage. See also separate recommendations for Jackson, Die Hardy and Windarling Ranges below.	1, 2, 3, 4, 5, 6, 7, 8
2a	Part of Jackson Range	Reserve the area of Jackson Range and surrounds identified on Map I as an A Class Nature Reserve to protect core areas of DRF and endemic flora and maintain ecological connectivity within ranges for rare flora.	1, 2, 3, 4, 5, 6, 8
2b	Non-mined areas of Windarling Range	Include remaining unmined parts of the Windarling Range within the A Class Nature Reserve, consistent with the requirements of Ministerial Statement 627, to protect remaining populations and habitat for endemic DRF and significant landforms.	1, 2, 3, 4, 5, 6, 8
2c	Die Hardy Range	Reserve the Die Hardy Range and Yorkradine Hills	1, 2, 3,

No. on Map I	Conservation Reserve or location	Action	Key Factors
	and Yorkradine Hills	within the proposed A Class Nature Reserve, especially to protect endemic rare flora and significant landscape values.	4, 5, 6, 7, 8
3	Mount Manning Nature Reserve	Reclassify the Mount Manning Nature Reserve as A Class and amalgamate with Reserves established over areas 1 and 2a,2b and 2c as a single A Class Reserve. Investigate the inclusion of the Mount Manning Range in this consolidated Reserve.	1, 2, 3, 4, 6, 7
4	Southern end of Koolyanobbing Range	Reserve at least 5 km of the southeast end of the Koolyanobbing Range in A Class Nature Reserve, with a linkage to Jaurdi Conservation Park via Lake Seabrook, to protect the habitat and populations of endemic Declared Rare flora and outstanding landscape values.	1, 2, 3, 4, 5, 6, 7, 8
5	Yendilberin and Watt Hills / Proposed Jaurdi Conservation Park	Further investigation of the current Conservation Park recommendations to ensure adequate conservation of rare and endemic flora and other significant factors.	1, 2, 3, 4, 5, 6, 7, 8
6	Proposed Mt Elvire Conservation Park		
7	Parts of Lake Barlee and Lake Seabrook	Extend Jaurdi and Mt Elvire Conservation Parks to include the full catena of landforms and environments, to protect habitats of rare species and particularly Lake Barlee as a wetland of national importance.	2, 3, 4, 5, 6
8	Area of UCL south of Helena & Aurora Range and east of Jaurdi Conservation Park	Consolidate the MMR reserves as identified on Map 4, by including extensive areas of exceptional sandplain vegetation, granite and Eucalyptus woodlands on UCL in areas (outside BIF and greenstone belt) north of the Koolyanobbing Range.	2, 3, 4
9	Remainder of Jackson and Die Hardy Ranges	Further investigate the need to extend the A Class Nature Reserve (recommended in 2 above) to the west and south to include the remainder of the Jackson Range and north to include all of the Die Hardy Range to provide further protection and adequate buffers for rare flora and plant communities.	1,2,4,6

Note: Key reservation factors used above:

1. Rare flora endemic to BIF range.
2. Endemic rare flora in sandplains, woodlands or other habitats.
3. Important habitat for specially protected fauna.
4. Excellent representation of woodland, sandplain and other inadequately reserved vegetation and animal habitats.
5. Aboriginal Heritage sites.
6. Substantial landforms with significant visual amenity.
7. Historical significance.
8. Geoheritage significance.



Map I: Reserve recommendations and proposed boundary changes.

Further advice

The EPA notes that a strategic review by DEC of conservation values of BIF ranges in the Yilgarn is currently in preparation. This initiative is supported as an important step in the process of identifying and resolving conflicting conservation and mining interests currently focussed on Yilgarn BIF Ranges.

Recent BIF proposals have highlighted inherent problems in securing environmentally satisfactory outcomes on the one hand, and reasonable clarity and equity for mining industry tenement holders/investors on the other hand, where two or more companies are each seeking to develop their portion of a BIF Range with unique environmental values. The situation is particularly problematic where mining threats to species or communities endemic to a single BIF range arising from one proposal require offset measures to conserve the remaining occurrence of the species or community on land that may be held by a second company in order to be environmentally acceptable. This can be a significant detriment to the community's interest in achieving outcomes that promote both reasonable environmental protection and orderly resource development.

The EPA is concerned that, on their own, the longstanding provisions of the Mining Act, based on the allocation of tenements based on a 'first to peg' principle do not facilitate strategic solutions to situations where companies share a resource that coincides with unique environmental values.

The EPA encourages consideration of possible measures that might facilitate more strategic solutions and early collaborative arrangements that consider cumulative impact issues and collaborative actions to protect areas of particular environmental significance.

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- Appendix 1: References
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Abbreviations/Acronyms (see Appendix 2 for definitions)

BIF = Banded Ironstone Formation

CALM = Department of Conservation and Land Management

CAR = Comprehensive, Adequate and Reprehensive nature reserve

DEC = Department of Conservation (includes former CALM and DoE).

DoE = Department of Environment

DRF = Declared Rare Flora listed in WA

Eremaean = inland arid vegetation zone of 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

MMR = Mount Manning Region = The Northern Yilgarn Conservation Reserves consisting of Mt Manning Range Nature Reserve, proposed extensions and several ex pastoral leases now managed for conservation (Table 2, Map 1).

P1, P2, P3, P4 = categories of Priority Flora listed in WA

PEC = Priority Ecological Community

SRE = Short Range Endemic fauna (or flora)

SWAFR = Southwestern Australian Floristic Region (formerly Southwest Botanical Province of WA).

Taxa = taxonomic entity - species, subspecies, etc.

TEC = Threatened Ecological Community

WAherb, herbarium = The Western Australian Herbarium

1. Background

The present document presents Ministerial Advice requested from the EPA under Section 16(e) of the Environmental Protection Act, as stated below.

Requested information (Minister for the Environment, December 2004)

- The location of the highest conservation values in the proposed extensions to the Mt Manning Nature Reserve.
- Surrounding areas which require protection from extractive industries as well as those areas in the proposed extensions to the Mt Manning Nature Reserve for which there is a potential for environmental offsets.
- This advice should also give consideration to details of Ministerial Statement 627 with respect to Portman Iron Ore Ltd Koolyanobbing Expansion.

This request follows the approval of the expansion in iron ore mining by Portman Iron Ore Ltd at the Windarling and Jackson Ranges. For the purpose of this advice, the request to identify “areas which require protection from extractive industries” is interpreted to include mining specifically. Environmental Commitments in Ministerial Statement 627, which concerns the Koolyanobbing Expansion, includes conditions which are both of narrow scope and specific to Portman Mining and of broader scope concerning the entire Mt Manning Range Nature Reserve and its extensions. Environmental commitments listed below are the responsibility of Portman Iron Ore Ltd, in consultation with DEC.

Relevant excerpts from Environmental Management Commitments in Ministerial Statement 627 Portman Iron Ore Ltd Koolyanobbing Expansion

5. Restricted Areas and Management of *Tetratheca paynterae* – Windarling Range

- include provision of secure conservation tenure for remaining population of *Tetratheca paynterae*.

6. Biodiversity Research and Management Plan

- 6.1 (3) management actions linked to performance criteria and aimed at ensuring the long-term conservation and recovery of restricted vegetation communities, and flora and fauna of conservation significance.

7. Landscape and Geological Features Protection Plan

9. Malleefowl Conservation Plan

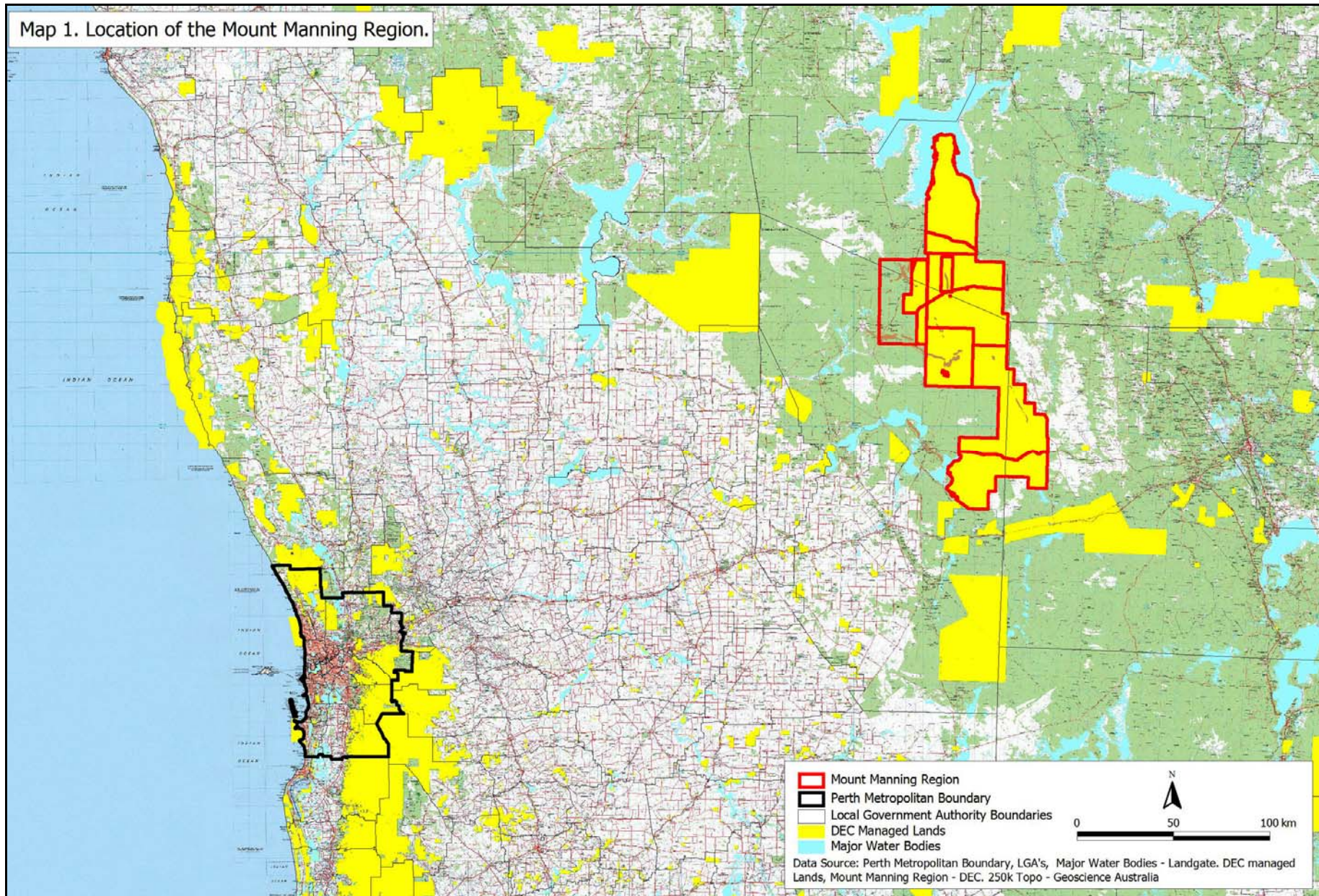
13. Agreement with Department of Conservation and Land Management

- Collaborative management of the Windarling and Mt Jackson areas.
- Acquisition of lands in the region for incorporation into the conservation estate.
- Provision of resources for the management of conservation reserves in the area, fauna, declared Rare Flora and Threatened Ecological Communities.

Procedures

- 3 The Minister for the Environment and Heritage and Minister for State Development will collaborate to facilitate the timely implementation of key aspects of the Department of Conservation and Land Management’s Goldfields Regional Management Plan (1994-2000).

In particular, the progression of the proposed Mt Manning Nature Reserve will incorporate the Helena and Aurora ranges, Marda Dam, Pigeon Rock, Deception Hill, Bungalbin Hill, Boondine Hill, Muddaring Hill, Yenyanning Hills, the Yorkradine Hills system and the Die Hardy Range. Areas disturbed by mining as part of this proposal may be added to the reserve system following rehabilitation.



Map 1: Location of the Mount Manning Region.

2. Introduction

There is a long history of nature reserve proposals for the greater Mount Manning Region (MMR) as outlined in Table 1. The Northern Yilgarn Conservation Reserves consist of Mount Manning Range Nature Reserve, Mt Manning Range Conservation Park, Helena and Aurora Range Conservation Park and three proposed Conservation Parks:

1. Die Hardy / Jackson / Windarling Ranges,
2. Mt Elvire (station), and
3. Jaurdi (station).

In this document the consolidated area of these 5 reserves are referred to as the Mount Manning Region (MMR). This area is located in the western part of the Goldfields north of Southern Cross (Map1). The entire area is similar size to the Perth Metropolitan Region (Map. 1). It includes parts of the Coolgardie 2 (Southern Cross) and the Murchison 1 IBRA subregions. For the purposes of discussion, a core area consisting of Mount Manning, Helena and Aurora and Die Hardy / Jackson / Windarling ranges and their surroundings is also defined. The boundaries of existing and currently proposed reserves in the region are shown in Map 1 and their geographic areas shown in Table 3. The history of reserve proposals and biodiversity studies for the MMR are briefly summarised in Table 1.

The MMR has very complex geology with extensive metamorphosed mafic volcanic and intrusive rock intrusions within a broader landscape of granite and gneiss (Chin & Smith 1983, DoIR 2005). These intrusions, known as greenstone belts, run predominantly in a north-south direction. These belts contain regions of banded iron formations (BIF) that have resisted erosion to protrude as hills and prominent ranges composed of bands of iron rich rocks interspersed with basalt jaspilite, chert and other minerals (Chin & Smith 1983).

Despite a relatively dry climate with variable rainfall the MMR has highly complex vegetation patterns as shown in Map 2 (Newbey & Hnatiuk 1985, Beard 1990). These patterns are regulated by geology and a long history of erosion in an ancient landscape. There is an overlying pattern of soils and landforms associated with greenstone belts within a matrix of those associated with granite. Landforms supporting distinctive vegetation types and soils include: prominent BIF ridges, granite rocks, broad valleys, undulating greenstone plains, sandplains, salt lakes, lateritic hardpans and breakaways. Vegetation of the region includes a sequence (catena) of alternating sandplains, breakaways, tall woodlands, mallee woodlands and valley floors similar to the wheatbelt. These include some of the easternmost occurrences of sandplain shrublands (Beard 1990).

The MMR area was subject to intense prospecting from the late 19th century when gold was discovered at Evanston and Jackson (Chin & Smith 1983). A period of small-scale mining and exploration followed, gradually declining until the mid 20th century. Current mineral leases are concentrated in greenstone belts where deposits of iron, gold, nickel and base metals may occur. In recent years there has been a tendency to mine smaller deposits of Banded Ironstone in WA. Portman Iron Ore Limited has recently expanded their Koolyanobbing project to include the Windarling and Jackson Ranges. This report summarises the environmental significance of areas where mineral assets occur within the MMR, where there is potential conflict between mineral production and conservation of biodiversity.

Table 1. History of reserve proposals in the Mount Manning Region (EPA 1975, Henry-Hall 1989 and cited references).

Year	Proposal/Action
1962	Mount Manning Range area recommended as a reserve by the Western Australian Subcommittee of the Australian Academy of Science Committee on National Parks.
1969	Reserves Advisory Council recommended Mt Manning Range be made a flora and fauna reserve but no action taken.
1974 1975	Original proposal for Mount Manning Nature Reserve in EPA Green Book (Conservation Through Reserves Committee 1974) and Red Book (EPA 1975) reports which excluded Mount Manning Range itself (proposal 11.4). It was recommended that the Die Hardy, Mount Manning and Mount Jackson Ranges be subject to further investigations (proposal 11.3).
1976	EPA red book recommendations endorsed by Cabinet.
1979	Mount Manning Range gazetted as a C Class Nature Reserve (No. 36208) with the exclusion of the central range itself (see Fig. 1).
1980	Keighery (1980) also proposed that BIF ranges be included to conserve unique flora and vegetation.
1985	Surveys WA Museum and CALM Staff 1978-81 of flora, vegetation and fauna which encountered many new plant species and provided ample justification for inclusion of additional areas (Dell <i>et al.</i> 1985).
1989	Biological data reviewed and found to strongly support inclusion of the Die Hardy, Mt Jackson and Helena and Aurora Range areas in an expanded Mount Manning Range Nature Reserve (Henry-Hall 1989).
1990	EPA Red Book Task Force CTRC System 11 Report repeats recommendation for expanded reserve
1994	Goldfields Region Regional Management Plan re-states System 11 objective and recommends pastoral lease extensions to Mt Manning Range Nature Reserve (CALM 1994).
2001	Major biological surveys (Table 2) required for Portman Limited application for expansion to mine iron ore deposits in Windarling and Mt Jackson areas.
2003	Approval granted for expansion of mining by Portman Iron Ore Limited at Windarling and Mt Jackson. Ministerial Conditions Statement 627 requiring nature reserve status for areas excluded from mining by Portman Limited to conserve unique flora and significant landform features.
Oct. 2004	Minister for Environment announces an expanded Mount Manning Range A Class Nature Reserve to conserve flora, vegetation and fauna, but these were later recommended to become Conservation Parks which allow access for mining.
2006	Northern Yilgarn Conservation Reserves planning area consolidates management of the existing Mount Manning Range Nature Reserve with the areas of proposed Helena and Aurora Range Conservation Park, proposed Die Hardy/Jackson/Windarling Conservation Park, proposed Mt Elvire Conservation park and Proposed Jaurdi Conservation Park (Map 1). Public comments sought for the management plan which is under development.
2006	Helena and Aurora Range Conservation Park established.
2006-	Increased taxonomic and genetic studies of rare taxa supported by DEC Biodiversity Conservation Initiative.



Figure 1: *Helena & Aurora Range viewed through woodlands from the south.*

Table 2. Geographic features in or near the Mount Manning Range Nature Reserve. Shaded ranges have existing iron ore mines. Sources of flora, fauna and vegetation information for this region are also listed.

Range/ Localities	Reserve/Station	Surveys
Mount Manning Range	Mount Manning Nature Reserve	Gibson 2004a
Hunt Range, Pittosporum Rocks	Mount Manning Nature Reserve	Gibson & Lyons 2001b, Dell et al. 1985
Jackson Range, Mt Jackson	Proposed Die Hardy Range / Mt Jackson Conservation Park	Dell <i>et al.</i> 1985, Mattiske 2001ab, Western Botanical 2003-
Helena and Aurora Range, Bungalbin Hill	Proposed Helena and Aurora Range Conservation Park	Dell <i>et al.</i> 1985, Gibson <i>et al.</i> 1997, Mattiske 2001ab
Die Hardy Range and Yorkradine Hills	Proposed Die Hardy Range / Mt Jackson Conservation Park	Mattiske 2001
Windarling Peak	Proposed Die Hardy Range / Mt Jackson Conservation Park	Mattiske 2001ab, Western Botanical 2003-
Marda Dam, Pigeon Rock, Deception Hill, Chatarie Well, Olby Rock, Olby Rockhole, Boondine Hill, Muddarning Hill, Yenyanning Hill	Proposed Die Hardy Range / Mt Jackson Conservation Park	Dell <i>et al.</i> 1985 (Marda Dam)
Koolyanobbing Range		Mattiske 2001ab, Western Botanical 2003-
Mount Dimer, Yendelberin Hills, Watt Hills	Proposed Jaurdi Conservation Park (Former Jaurdi & Timberfield Pastoral Leases)	Gibson & Lyons 2001b
Mt Elvire	Proposed Mt Elvire Conservation Park (Former Mt Elvire Pastoral Lease)	

Table 3. Areas of existing and proposed Northern Yilgarn Conservation Reserves (CALM 2006).

Reserve	Area (ha)
Mount Manning Range Nature Reserve	203,065
Proposed Die Hardy Range / Mt Jackson Conservation Park	87,901
Helena and Aurora Range Conservation Park	91,943
<i>Subtotal for core area</i>	<i>382,909</i>
Proposed Jaurdi Conservation Park	284,207
Proposed Mt Elvire Conservation Park	154,267
Total	821,383



Figure 3: Helena & Aurora Range.

3. Methodology developed to meet objectives for Section 16(e) advice

1. Compile information about the distribution of rare, priority and other significant taxa from existing flora, vegetation and fauna data and consultation with biological survey scientists.
2. Map spatial information (vegetation types, rare/priority/other significant flora, fauna etc.),
3. Assess significance of rare or possibly endemic fauna and identify key fauna habitats as best possible with existing data.
4. Identify plant communities (associations) landforms and animal habitats that are not well represented in other conservation reserves. This will necessarily occur at the fairly coarse scale of the update of Beard's Vegetation mapping.
5. Use State, National and International criteria for recognising areas of natural and aboriginal heritage significance, geodiversity and scientific importance.
6. Identify areas of highest environmental significance using CAR objectives.
7. Review effectiveness of proposed reserve boundaries for protection from extractive industries and propose additional areas for inclusion if appropriate.
8. Assess appropriate conservation mechanisms for areas of high conservation value, while recognising the existence of mines and mineral leases.
9. Propose a strategy to deal with biological values (especially rare, priority and endemic flora and fauna) in areas of high mineralogical value, as requested by Minister.

Biodiversity consists of three major components (A) species diversity, (B) ecosystem diversity and (C) genetic diversity (Commonwealth of Australia 1996). 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 2004bc). 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 & 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.

The framework for recognising essential biodiversity and other heritage assets is summarised in Table 4. The area searched for flora, TEC's and fauna in the MMR was: 29° 15' to 31° 15' N and 118° 45' to 120° 15' E. A supplementary geographic names search in Florabase used locality names in Table 2. Flora and vegetation data were also obtained from Florabase, published and unpublished survey reports and consultation with botanists (Table 4).

Table 4. Sources of information concerning flora, vegetation, fauna and landscape significance, as well as criteria for designation of nature reserves.

-
- Lists of species protected under WA legislation in the Wildlife Conservation Act (DRF, P1-P4) available from Florabase (florabase.calm.wa.gov.au) and WAherb database searches.
 - DEC Database of rare and priority flora locations (DEFL).
 - Protected flora and fauna listed under the Commonwealth EPBC act (www.environment.gov.au/epbc).
 - Flora and vegetation surveys:
 - CALM surveys of BIF ranges (see Table 2),
 - Portman Iron Ore Ltd surveys by Matiske (2001ab), Ecologia (2003a), and Western Botanical (2003-).
 - Fauna survey data (Table 2).
 - Preliminary estimate of total plant biodiversity and species endemism compiled from Florabase and other sources listed in Table 2.
 - Recognition of flora and fauna which are endemic to a restricted range or known from very few records.
 - Recently recognised flora likely to be endemic to a confined area (Florabase and pers. comm. botanists).
 - Knowledge of genetic structure and isolation of populations of rare species (Bussell & James 1997, Coates 2000, Butcher *et al.* 2007).
 - Update of Beard's vegetation maps showing the distribution of broad-scale vegetation types (Shepherd *et al.* 2002, Department of Agriculture 2005) and other more detailed maps for smaller areas (Newbey & Hnatiuk 1985, Matiske 2001).
 - List of poorly reserved vegetation types within bioregions (CALM 2002).

- DEC search of database of Threatened and Priority Ecological Communities (PEC, TEC) and other records of habitats of rare species.
- Descriptions of vegetation associations and their relationships with landforms and soils (Newbey & Hnatiuk 1985, Beard 1990).
- Structural diversity of landscapes and habitats (topographic maps and satellite imagery).
- Geology, geomorphology and mineral exploitation (Chin & Smith 1983, DoIR 2006).
- Geology and origin of BIF ranges and greenstone belts (Chin & Smith 1983, Freeman & Kojan 2005, Klein 2005).
- EPA principles, especially avoiding environmental harm and the precautionary principle, are relevant when potential rare species are not well studied (EPA 2004a).
- Criteria for Comprehensive, Adequate and Representative (CAR) reserves (www.environment.gov.au/parks/nrs/sciguide).
- Recognition of biodiversity hotspots with the highest levels of endemism, species richness and rare species in WA (Hopper & Gioia 2004).
- State, national and International criteria for management of rare species.
- Cumulative impacts to similar habitats, when regional assessment is possible.
- Aboriginal heritage sites (www.dia.wa.gov.au/Heritage).
- Significant geological, landscape and heritage features (Sharpley 2002).
- Earlier proposals for conservation reserves.

4. Significant flora, vegetation, fauna and heritage in the MMR

4.1. Plant species richness

A consolidated flora list for the area was prepared based on Florabase records for approximately 900 taxa and over 100 additional taxa from the consolidated species lists in Mattiske Consulting (2001), the transport corridor survey by Ecologia (2003a) and the CALM surveys of BIF ranges (Gibson *et al.* 1997, Gibson & Lyons 2001ab, Gibson 2004a). Most flora surveys have focussed primarily on ironstone ranges in a core area of < 400,000 ha and have not fully sampled flora in sandplains and woodlands. Thus, it is likely that the floristic diversity of the MMR core area would exceed the ~ 1000 species in the current list, once areas outside of BIF ranges and in the northern and southern MMR Conservation Park extensions are better known.

Flora surveys in the MMR often include plant taxa that appear to be new species or which remained unidentified so have no formal status. For example, over 100 unidentifiable plants were encountered by Mattiske Consulting (2001a) and there were 21 unidentifiable species in an Ecologia survey (2003a). These results highlight problems with identifying taxa from the region, especially when non-flowering material is encountered. Subsequent surveys commissioned by Portman Iron Ore Ltd that have revealed additional rare taxa in BIF areas and extended surveys to a wider range of habitats (Western Botanical 2003-). The BIF ranges in the area are now comparatively well surveyed for rare flora and there is sufficient collections to make recommendations for changes to lists of rare and priority taxa that would not have been possible in the past (Table 6). However, further surveys are required for newly recognised species, especially in areas where impacts from mining may occur.

Table 5. Native plant taxonomic diversity in selected regional biodiversity hotspots in WA.

Biodiversity Hotspot	Area (ha)	Total	Endemic	DRF	Priority	Reference
Stirling Range National Park	116,000	1615	88	26	134	Keighery 1993
Fitzgerald River National Park	330,000	1230+	75	12	96	
Lesueur National Park	27,000	900+	9	7	54	
Northern MMR (core area)	Yilgarn (383,000)	821,000 (1000+)	32	9	72	
Southern Coastal Plain	Swan 1,334,000	2082	18+	42	164	Keighery <i>et al.</i> 2006
Ironcaps, Lake Cronin Region	180,000	343+	15	6	83	Gibson 2004b
Ravensthorpe (Bandalup Hill only)	Ranges	870+	?	5	41	

Data are from Barrett, Brundrett & Keighery (in preparation), DEC management plans and cited references. The total for MMR plant taxa is primarily based on collections in the core area.

Biodiversity Hotspots, were originally defined as areas of very high species richness and endemism that also face significant pressures and potential threats to that biodiversity (Myers *et al.* 2000). The Commonwealth Department of Environment and Water Resources has followed this approach in identifying biodiversity hotspots at the national level (www.environment.gov.au/biodiversity/hotspots), but Hotspots have also been recognised on the basis of their species richness and endemism alone (Hopper & Gioia 2004). Hotspots are recognised at several different scales. In WA, the entire Southwest Australia Floristic Region of WA (SWAFR) is the only internationally recognised Biodiversity Hotspot in Australia (Myers *et al.* 2000), but it also contains smaller nationally recognised hotspots within it, such as Mt Lesueur – Eneabba, Fitzgerald River Ravensthorpe, and Busselton Augusta (www.environment.gov.au/biodiversity/hotspots).

The application of a rigorous approach using plant occurrence data in Florabase (<http://florabase.calm.wa.gov.au/>) has identified 7 subregional centres of biodiversity and endemism within the SWAFR (Hopper & Gioia 2004). This analysis only included data from the southwest of WA, but there is now sufficient evidence to suggest that the Mount Manning Region is a significant hotspot of biodiversity and endemism that occurs immediately to the east of the SWAFR within the goldfields (Table 5). Despite the comparative aridity and unpredictability of rainfall in the MMR (Newbey & Hnatiuk 1985) this region has floristic diversity that greatly exceeds what would be expected for a similar sized area elsewhere in the goldfields or in most parts of the wheatbelt.

The term Biodiversity Hotspot is generally applied here in accordance with the definition used by Hopper and Gioia. However, in the absence of reserves offering secure protection against the impacts of mineral exploration and mining, these threats to the concentration of endemic species confined to BIF ranges in the region suggest the region would also fit the original definition, combining a concentration of species richness and endemism with threats to those values.

Possible explanations for high plant diversity and endemism in this region are summarised in the box below. A comparison of plant rarity and endemism with other major conservation

reserves listed in Table 5 shows that core areas of MMR, especially the BIF ranges, are of similar importance to other biodiversity hotspot areas in WA such as the Stirling Range, the Mt. Lesueur area and the Fitzgerald River area.

Probable explanations for why the Mount Manning Region is a biodiversity hotspot

1. The region has highly diverse landforms, geology, soils, topography and hydrology with granite, woodlands and sandplain areas similar to those in the wheatbelt, as well as typical goldfields habitats such as acacia woodlands, in addition to ranges and salt lakes. This landform / soil / geological diversity equates to biodiversity because each habitat type has characteristic species.
2. The MMR is located close to centres of diversity for large families such as the Asteraceae, Chenopodiaceae, Cyperaceae, Mimosaceae, Myrtaceae and Myoporaceae. These families include genera with many species in the region (e.g. *Acacia*, *Eucalyptus* and *Eremophila*), as well as genera with many unnamed taxa (*Baeckea*, *Astartea*, and *Lepidosperma*).
3. The area contains refugia (BIF ranges and hills) where relictual taxa occur, following isolation by a drying climate and/or specialisation to specific restricted habitats (eg BIF). These refugia are “islands” unlinked by effective corridors or long-range seed or pollen dispersal. Examples of relictual taxa include *Tetratheca* and *Lepidosperma* species restricted to a single range.
4. The transitional rainfall zone between the Southwest and Eremaean Botanical Provinces corresponds to the limits of distribution patterns for many plants and plant communities of the goldfields or wheatbelt (Fig. 3).
5. This region also has specialised rare species with narrow distributions in a band running from Geraldton to east of Esperance corresponding to the edge of the SWAFR (Fig. 3).
6. As in other WA hotspots, high diversity is also linked to highly infertile soils and a long geological history without major tectonic or glacial disturbance (Hopper & Gioia 2004).



Figure 4: *Lepidosperma* sp. at Pigeon Rock. There are 6 locally endemic MMR sedges.

Table 6. Rare, priority, apparently endemic and other flora of conservation concern by location, endemism and substrate, associated with Banded Ironstone Formation (BIF) ranges (shaded columns) and other locations in the Mount Manning Region (Northern Yilgarn Conservation Reserves).

Taxon	CODE	PR?	Endemic	MM	DH	J	W	HA	K	HWY	HcH	PR	MES	JS	YYD	Other	BIF	Laterite	Granite	Woodland	Sandplain	Saline	Damp/wet	Distribution
Acacia acanthoclada subsp. glaucescens	P3					N	N	N		N						X								fairly widespread but narrow range interzone / wheatbelt boundary over calcrete
Acacia adinophylla	P1	PR	1					X									X							very restricted in interzone
Acacia cockertoniana ms	P3				X	X	X						X			X	X							widespread interzone and goldfields
Acacia cylindrica	P3					N		N													X			fairly widespread interzone and wheatbelt
Acacia formidabilis	P3							N													X			fairly narrow zone in interzone
Acacia sp. Bungalbin Hill (J. J. Alford 1119)	-	PR						X									X							apparently very restricted (newly recognised)
Astartea sp. Bungalbin Hill (K.R. Newbey 8989)	P3							N								X					X			fairly widespread interzone
Astartea sp. Mt Dimer (C. McChesney TRL4/72)	P1	PR	SRE			N				N											X			apparently very restricted
Austrostipa blackii	P3							X		X						X	X	X	X	X	X			widespread wheatbelt and interzone on BIF and greenstone
Baeckea sp. Bungalbin Hill (B.J. Lepschi, L.A. Craven)	P1		SRE			N		N	N							X				X	X			apparently very restricted
Baeckea sp. Die Hardy Range (E. Mattiske J91)	P1	PR	1		X												X							apparently very restricted
Baeckea sp. Helena and Aurora Range (G.J. Keighery 442)	P1	PR	1					N													X			apparently very restricted
Baeckea sp. Pigeon Rocks (D. Grace DJP 281)	P1	PR	1 ?									X						X						apparently very restricted
Baeckea sp. Yacke Yackine Dam (K.R. Newbey 9195)	P1	PR	1 ?												X			X						apparently very restricted
Banksia lullfitzii	P3							X									X				X			narrow zone in interzone and wheatbelt
Beyeria sp. Jackson Range (R. Cranfield & P. Spencer)	P1	PR	2			X				X							X							very restricted
Brachyscome halophila	P3												X									X		poorly known in interzone
Brachysola halganiacea	P2	PR	2												X	X					X			apparently very restricted
Caesia sp. Ennuin (N. Gibson & MN Lyons 2737)	-	PR	1								N										X			apparently very restricted in interzone
Calytrix creswellii	P1			N				N									X				X			narrow zone in north interzone
Chamelaucium paynterae	P1	PR	1					N													X			very restricted
Daviesia purpurascens	P4			X		X		X									X	X						fairly widespread in wheatbelt and interzone

Taxon	CODE	PR?	Endemic	MM	DH	J	W	HA	K	HWY	HcH	PR	MES	JS	YYD	Other	BIF	Laterite	Granite	Woodland	Sandplain	Saline	Damp/wet	Distribution	
Echinopogon ovatus var. pubiglumis	P1	PR	1					X									X							apparently very restricted	
Elachanthus pusillus	P2									X				X		X									southern interzone only - very poorly known
Eremophila caerulea subsp. merrallii	P4									X							X				X				fairly widespread
Eremophila sp. Mt Jackson (G.J. Keighery 4372)	P1		SRE	X		X										X				X					very narrow zone in interzone
Eremophila viscida	R										?								X	X					very unlikely to be present (wheatbelt sp.)
Eucalyptus formanii	P4		SRE	N	X	X	N	X				X				X	X				X				locally common
Euromyrtus recurva	P3												X							X	X				fairly widespread goldfields, wheatbelt
Frankenia brachyphylla	P2	PR	SRE													X						X	X		apparently very restricted, requires surveys
Frankenia georgei	P3															X						X	X		fairly widespread in goldfields
Gnephosis intonsa	P1							N														X	X		fairly widespread interzone and wheatbelt
Gnephosis sp. Norseman (KRN 8096)	P1										N			X											poorly known interzone and wheatbelt
Gompholobium cinereum (= G. asperulum)	P3					X										X		X			X				narrow band on wheatbelt / interzone boundary
Grevillea erectiloba	P4		SRE	N		N						X						X							restricted distribution in interzone
Grevillea eriobotrya	P3											X								X					fairly widespread - interzone, wheatbelt
Grevillea georgeana	P3		SRE	X	X			X		X		X		X			X	X							confined area in interzone
Grevillea tetrapleura	P4		SRE			N		N											X						very confined area in interzone
Gunniopsis rubra	P3															X									fairly widespread wheatbelt and interzone
Haegiela tatei	P2													X											fairly widespread - southern wheatbelt and interzone
Hibbertia lepidocalyx subsp. tuberculata	P1	PR	2					X		X							X								apparently very restricted, requires surveys
Homalocalyx grandiflorus	P1	PR	SRE					N													X				apparently very restricted, requires surveys
Jacksonia jackson	P1	PR	1			X											X								very restricted
Lepidium genistoides	P2		SRE												X	X						X	X		confined area, interzone and wheatbelt
Lepidium merrallii	P2									N													X		apparently fairly widespread in interzone but very poorly known
Lepidosperma sp. "Jackson Range"	-	PR	1			X											?								probably very restricted - currently under investigation
Lepidosperma sp. "Mt Manning "	-	PR	1	X													X								probably very restricted - currently under investigation
Lepidosperma sp. Aurora Range (N. Gibson & M. Lyons 3761)	-	PR	1					X									X								probably very restricted - currently under investigation

Taxon	CODE	PR?	Endemic	MM	DH	J	W	HA	K	HWY	HcH	PR	MES	JS	YYD	Other	BIF	Laterite	Granite	Woodland	Sandplain	Saline	Damp/wet	Distribution
Lepidosperma sp. Aurora Sandplain (R. L. Barrett 2809B)	-	PR	1					N													X			probably very restricted - currently under investigation
Lepidosperma sp. Jaurdi (N. Gibson & M. Lyons 2506)	-	PR	2											X			X				X			probably very restricted - currently under investigation
Lepidosperma sp. Mount Finnerty (S. McNee)	-	PR	1														X							probably very restricted - currently under investigation
Lepidosperma sp. Mt Jackson (L. Matiske 193-2/572)	P3	PR	2?			X		X	?								X							probably very restricted - currently under investigation
Lepidosperma sp. Pigeon Rocks (H Pringle 30237)	-	PR	2									X											X	probably very restricted - currently under investigation
Leptospermum macgillivrayi	P1	PR	SRE		N	N					N	N						X	X					very restricted habitat/distribution
Leucopogon sp. Helena & Aurora Range (B.J. Lepschi 2077)	R		1					X									X							extremely rare
Lissanthe scabra	P2	PR	SRE											X				X						very narrow range in interzone
Malleostemon sp. Adelong (G.J. Keighery 11825)	P2	PR	SRE	X								X						?	X	X				very narrow range in north interzone Needs confirmation - narrow range southern wheatbelt
Mirbelia densiflora	P1																	X	X					narrow range in interzone, extends to forrestania
Mirbelia sp. Helena & Aurora (B.J. Lepschi 2003)	P3	PR	SRE	X	X			X									X	X						
Myriophyllum lapidicola	R		2								N			X		X			X				X	rare wheatbelt and interzone
Neurachne sp. Helena & Aurora (K.R. Newbey 8972)	P3	PR	1					X									X			X				very restricted, but locally common very narrow range interzone / wheatbelt boundary (range extension)
Paracaleana lyonsii	-	?					X														X			very narrow range interzone, very poorly known
Persoonia leucopogon	P1	PR	SRE						N												X			fairly widespread interzone and goldfields
Philothea coateana	P3						X										X	X			X			very narrow range interzone and goldfields, very poorly known
Philothea deserti subsp. brevifolia	P1	?	SRE			N															X			fairly widespread interzone and southern goldfields
Phlegmatospermum eremaum	P2							X									X				X			fairly widespread in interzone
Pseudactinia sp. Bungalbin Hill (F.H. & M.P. Mollemans 3069)	P1			N		N		N						X				X			X			fairly widespread in interzone
Ricinocarpos brevis	R		1				X										X							well studied range endemic
Sowerbaea multicaulis	P4								N												X			fairly widespread interzone and southern goldfields

Taxon	CODE	PR?	Endemic	MM	DH	J	W	HA	K	HWY	HcH	PR	MES	JS	YYD	Other	BIF	Laterite	Granite	Woodland	Sandplain	Saline	Damp/wet	Distribution
Spartothamnella sp. Helena & Aurora Range (P.G. Armstrong 155-	P3	PR	SRE			N		X								X	X			X				very narrow range in interzone
Stenanthemum newbeyi	P3	PR	SRE		X			X	X		X						X	X		X				very restricted range in interzone
Stylidium choreanthum	P2							N								X					X			fairly widespread in interzone
Tetrateca aphylla subsp. aphylla	R		1					X									X							well studied range endemic
Tetrateca erubescens	R		1						X								X							well studied range endemic
Tetrateca harperi	R		1			X											X							well studied range endemic
Tetrateca paynterae subsp. cremnobata	R		1		X												X							well studied range endemic
Tetrateca paynterae subsp. paynterae	R		1				X										X							well studied range endemic
Tricoryne sp. Morawa (GJ Keighery & N Gibson 6759)	P1		SRE								N								X					very narrow range interzone / wheatbelt boundary
Verticordia mitoides	P3							N													X			
Verticordia stenopetala	P3															X					X			

Abbreviations: Code = conservation code, **R** = Declared Rare Flora, **P1-P4** = Priority Flora, **PR** = potential DRF requiring reassessment (recently recognised locally endemic taxa or endemic taxa with increased threatening processes), **Endemic** - category **1** = known from a single range or location, category **2** = known from 1- 2 ranges or locations, **SRE** = Short Range Endemic taxa confined to a range less than 10,000 km² (Harvey 2002). **BIF** = Growing on Banded Ironstone Formation, **N** = reported from locality of range (most occurrences not on BIF).

BIF Ranges: **MM** = Mt Manning, **DH** = Die Hardy Range & Yorkradine Hills, **J** = Jackson Range, **W** = Windarling, **HA** = Helena & Aurora Range (includes Bungalbin Hill), **K** = Koolyanobbing Range, **HWY** = Hunt + Watt + Yendilberin Range / Hills, **HcH** = Highclere Hills (for comparison).

Other Locations: **PR** = Pigeon Rocks (granite), **MES** = Mt Elvire Conservation Park, **JS** = Jaurdi Conservation Park, **YYD** = Yacke Yackine Dam.

Table 7. Summary of declared rare (DRF), priority (P1-4), potentially rare (PR) and apparently endemic flora of conservation concern by location, endemism and substrate within the Mount Manning Region. Ranges are ordered by numbers of rare and PR species.

Location	Rare, Priority and potentially rare flora							Location		Endemic to location(s)		Endemic to BIF range(s)	
	DRF	P1	P2-4	DRF + P	PR	DRF + PR	DRF + P + PR	On BIF	Near range	2	1	2	1
Helena & Aurora Range	2	11	18	31	14	16	34	18	16	11	9	8	6
Jackson Range	1	8	10	19	6	7	20	10	10	5	3	4	3
Hunt, Watt & Yendilberin Range / Hills	0	5	6	11	4	4	13	6	7	3	1	2	1
Mt Manning Range	0	3	6	9	2	2	10	6	4	1	1	1	1
Die Hardy Range & Yorkradine Hills	1	2	5	8	4	5	8	7	1	2	2	5	2
Koolyanobbing Range	1	3	3	7	3	4	7	3	4	2	1	2	1
Windarling Range	2	0	4	6	0	2	7	5	2	2	2	2	2
Highclere Hills (for comparison)	0	1	1	2	0	0	3	1	2	1	1	0	0
Pigeon Rocks (granite)	0	1	5	6	3	3	7	NA	NA	1	0	NA	NA
Jaurdi Conservation Park	0	2	4	6	2	2	8	NA	NA	2	0	NA	NA
Mt Elvire Conservation Park	0	0	3	3	0	0	3	NA	NA	0	0	NA	NA
Yacke Yackine Dam	0	1	2	3	2	2	3	NA	NA	1	1	NA	NA
Total for study area	9	22	41	72	32	41	79	33	46	29	22	18	16

Notes: **PR** = potential DRF requiring reassessment (recently recognised locally endemic taxa or endemic priority taxa with increased threatening processes); **Endemic Categories, 2** = only known from 1 or 2 ranges or locations, **1** = known from a single range or location; **On BIF** = Growing on Banded Ironstone Range; **Near range** = reported from locality (generally not on BIF); **BIF** = Banded Ironstone Formation.

4.2. Rare, endemic and poorly known flora

Some habitats in the MMR are now relatively well surveyed (with over 3000 collections in the WA Herbarium for the region) with many additional collections yet to be processed or vouchered. However, there are also many poorly known taxa. These include 42 taxa known from < 15 specimens, 38 from < 10 and 23 from < 5 collections in WAherb. While many of these species are likely to be rare, others may only be under-collected.

Plant taxa of conservation significance are listed in Table 6 and summarised by location in Table 7. Surveys funded by Portman Iron Ore Ltd have also been of great value in resolving the distributions of many of these species in the past few years. Taxonomic investigations of some species are still underway, and the unnamed taxa listed in Table 6 are currently the focus of a DEC Biodiversity Conservation Initiative funded project. A precautionary approach (EPA 2004a) has been used when designating species of greatest conservation concern, by recognising priority and unlisted species likely to be threatened (designated as PR in Tables 6 and 7). The available evidence suggest that up to 32 additional taxa could potentially become DRF after reassessment of their status. These species urgently require further study or reassessment of their conservation status, especially in cases where all known populations occur in BIF areas where mining could occur. Mining is the most severe threat to rare flora in the MMR region. Other threats to rare flora typically would include drought and feral animal grazing (Brown *et al.* 1998).

Information from Florabase, survey reports and conversations with botanical experts have identified plant taxa in need of further study that are listed below. These species may be rare, but require further investigation to determine their ranges and/or taxonomic identity. Some of the unnamed species are currently not well enough known for inclusion in Table 6.

- Six *Lepidosperma* species have very restricted distribution patterns (Russell Barrett pers. comm.).
- *Spartothamnella* sp. Helena & Aurora may be rare (4 locations only), but requires further surveys (Malcolm Trudgen pers. comm.).
- *Calytrix* sp. Paynes Find (F. & J. Hort 1188) - formerly *Calytrix strigosa* in part (Geoff Cockerton pers. com.).
- *Beyeria* sp. Helena & Aurora Range not yet confirmed or vouchered (Geoff Cockerton pers. comm.).
- *Trymalium urecolare* population in the Hunt Range (Gibson & Lyons 2001b) is 500 km distant from other known collections north of Perth.
- *Paraclaeana lyonsii* population at Windarling (believed to be extirpated by mining) was a substantial range extension for this species, which is confined to the wheatbelt/interzone boundary (Hopper & Brown 2006).
- *Conostylis* sp. aff. *argentea* (Helena and Aurora Range) formerly reported as *Conostylis argentea*, differs sufficiently to be reviewed (Geoff Cockerton pers. comm.).

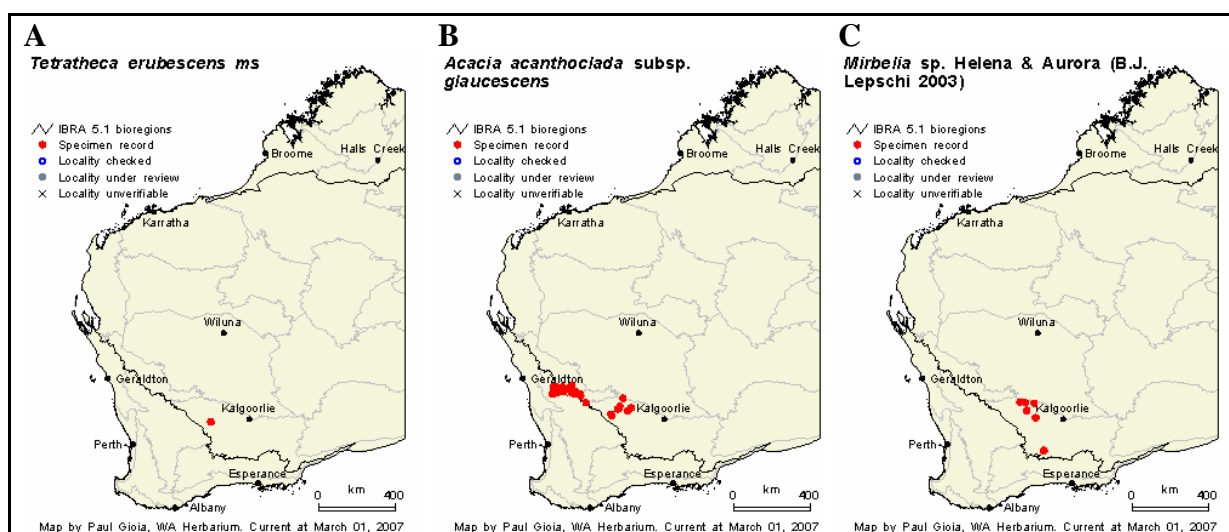
It is now considered doubtful that some of the rare species reported in surveys actually occur in the MMR. These include *Eremophila viscida* (DRF) and *E. racemosa* (P4), which are well outside known ranges and no specimens have been

vouchered in WAherb (Andrew Brown pers. comm.). There are also several currently listed priority taxa which are now known to have fairly widespread distributions and appear to be candidates for removal from P listing (e.g. *Acacia cockertoniana* ms and *Daviesia purpurescens* – Geoff Cockerton pers. comm.).

Most rare flora in the MMR have one of the distinctive distribution patterns shown in Map 2:

- the majority are locally endemic species restricted to highly specialised and isolated habitats, but
- some have restricted ranges on the wheatbelt and interzone boundary,
- or are confined to the interzone.

There also are wetland or dampland species that occur near the edges of salt lakes, in pools on granite rocks or along drainage lines. A few rare species are disturbance opportunists that seem to have widespread distributions, but are usually only found after disturbances such as fire.



Map 2: *Rare species in the MMR have distinct distribution patterns. Maps are from Florabase (florabase.calm.wa.gov.au).*

Regionally endemic taxa have are designated in Table 6 if their currently known distribution patterns are confined within a 10,000 km² area. This corresponds to the definition of Short Range Endemic (SRE) taxa defined for fauna (Harvey 2002). In some cases these species have distribution patterns which are longer than 100 km, but are very narrow, with a total area of occupancy under 10,000 km². A substantial MMR conservation reserve will provide secure habitat for these species, as most are not present in other reserves. *Dryandra arborea* is an example of a SRE species which is a characteristic feature of BIF ranges in the MMR.

The MMR has an exceptionally high number of flora endemic to one range or a small geographic area (Table 7). BIF range endemics such as *Tetratheca* species apparently are refugial species that have adapted to a specialised habitat to survive Australia’s drying climate in the past. These may have similar origins to relict species of Gondwanan origin that occur in higher rainfall areas (Hopper & Gioia 2004). Similar processes are thought to be responsible for the presence of SRE animal species such as terrestrial invertebrates or stygofauna in highly localised habitats (Harvey 2002).

Isolated rock habitats result in plants with unusual genetic structures and processes that are linked to genetic isolation and may help prevent inbreeding (Bussell & James 1997, Coates *et al.* 2003). Taxonomic and genetic studies support the conservation significance of isolated species such as *Tetralochea paynteri* on BIF ranges (Butcher *et al.* 2007). Such research and the increased mortality observed in areas next to the Windarling mine (Portman Limited Annual Report 2005), suggest that the impact of mining a substantial part of the habitat of this DRF species has been greater than was anticipated. These findings have major implications for future proposals/plans to mine BIF ranges with endemic rare flora in this area. Translocation of endangered species to potential new habitats is unlikely to be successful if:

1. Other similar species occur there. For example, translocation of *Tetralochea paynteri* to other similar habitats is prevented where other *Tetralochea* species already occur.
2. There is limited scope to collect seed or propagate species.
3. The remaining suitable habitat is considerably reduced and or altered.
4. They require highly specific habitats defined by unique soils, rock, hydrology and topography.

It was not possible to identify other categories of significant species that would normally be considered in environmental assessments (EPA 2004b). These include taxa with substantial range extensions or which have range limits in the MMR. It is reasonable to expect that a number of such species occur in this transitional area between floristic regions.

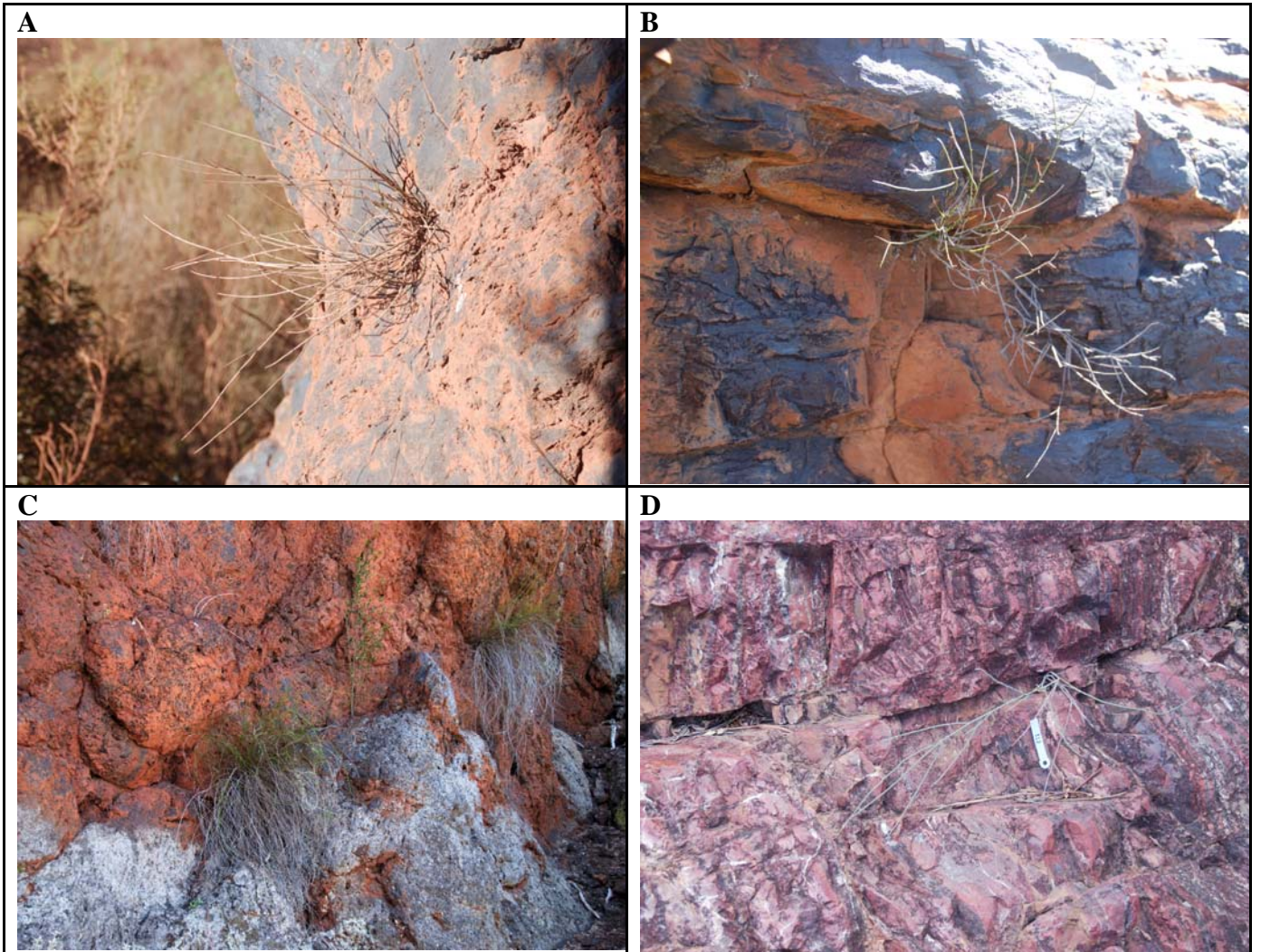
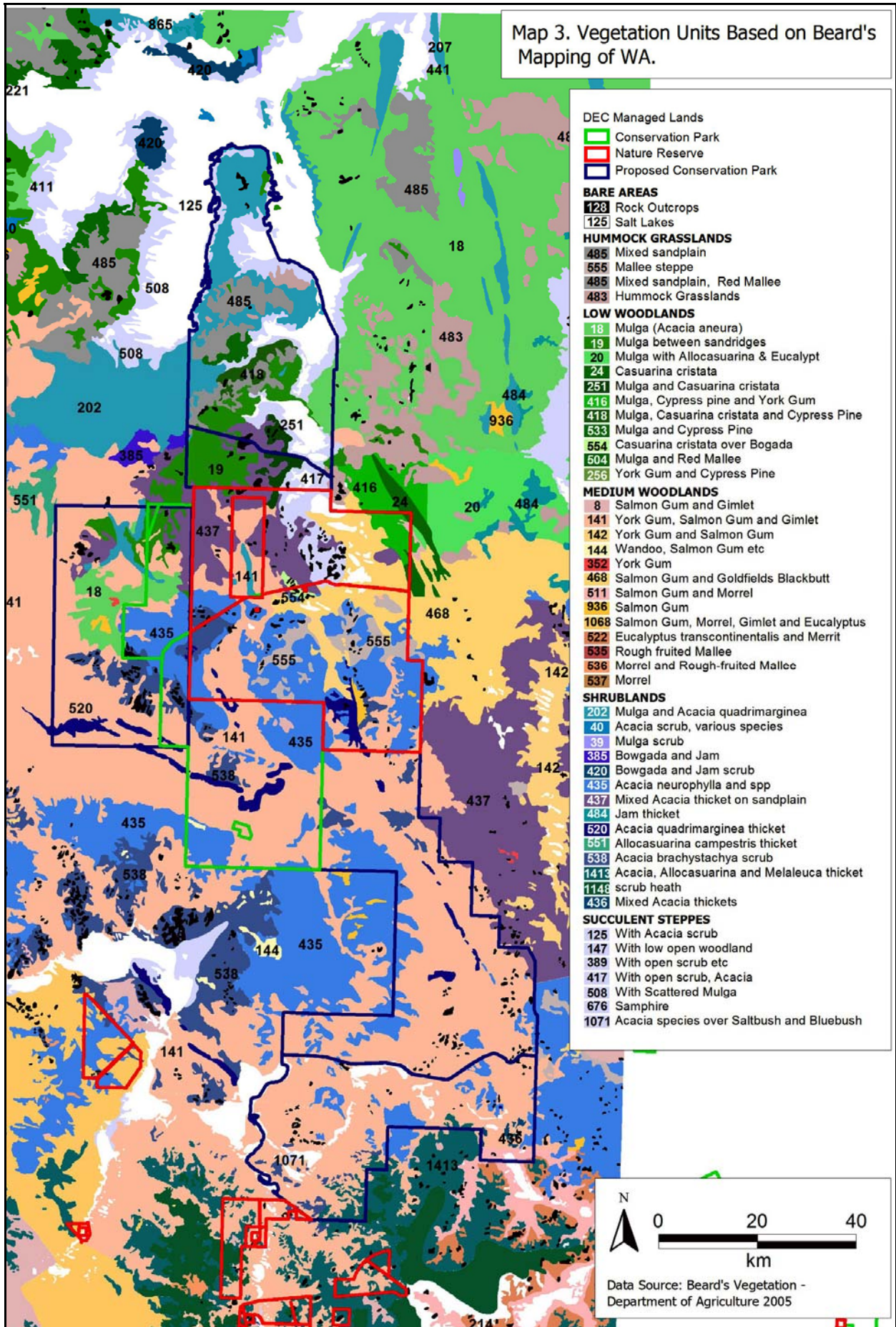


Figure 4: *Examples of Declared Rare flora endemic to massive BIF habitats.*

- A.** *Tetratheca paynterae* subsp. *paynterae* at Windarling Range (upper left).
- B.** *Tetratheca paynterae* subsp. *cremnobata* at Die Hardy Range (upper right).
- C.** *Tetratheca aphylla* subsp. *aphylla* at Helena & Aurora Range (lower left).
- D.** *Tetratheca harperi* at Jackson Range (lower right).



Map 3: Vegetation units based on Beard's mapping of WA (Department of Agriculture 2005).

4.3. Floristic communities

While there are some similarities in vegetation types between individual ranges in the MMR, there are also major differences (Newbey & Hnatiuk 1985, Gibson & Lyons 2001b Gibson 2004a). Thus, “Each banded ironstone 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). Publications and reports listed in Table 2 identify many plant communities with highly restricted distributions that include endemic species. Detailed vegetation maps were produced for Windarling and Mt Jackson for Portman Limited (Mattiske Consulting 2001b). This report identifies significant vegetation communities in both ranges, as well as the Die Hardy Range (Table 8). Currently nominated Priority Ecological Communities (PEC) are listed in Table 9, but many other floristic communities of potential conservation concern have been recognised (Table 8). Most of the additional potentially threatened plant communities listed in Table 8 include locally endemic taxa. A comprehensive analysis of floristic data from the MMR is recommended and it will almost certainly identify unique floristic community types additional to those listed in Table 9. A regional assessment of flora and vegetation of BIF ranges by DEC is currently underway and is likely to further confirm the significance of plant communities on BIF ranges in a regional context.

All the BIF ranges contain nominated plant communities potentially at risk (Table 8), but only certain endemic plant communities in the Helena and Aurora, Koolyanobbing, Windarling, Mount Jackson and Die Hardy Ranges have been given PEC status so far (Table 9). Of these, the Helena & Aurora Range, Jackson Range and Die Hardy range would seem to be the highest priorities for establishment of secure conservation reserves based on vegetation communities. However, substantial mining impacts to any of the MMR BIF ranges has the potential to result in the endangerment or permanent loss of unique vegetation. In conclusion, many of the floristic community types that occur on or near BIF ranges should be considered to be potential Threatened Ecological Communities (TEC’s), since their entire occurrence exists over BIF iron deposits in mineral lease areas.

The IBRA regional assessment at a subregional scale shows that the Coolgardie 2 subregion is a high priority for nature reserve creation (CALM 2002, Commonwealth of Australia 2002). The area provides only substantial conservation reserve for many of the Jackson, Barlee and Jaurdi vegetation types designated in Beard maps (see Map 3). It is anticipated that existing and proposed reserves in the MMR will conserve biodiversity in sandplain and woodland areas between the BIF ranges according to CAR criteria, but the inclusion of additional areas is recommended to provide a more comprehensive reserve (Section 7). In particular, there is a need to include habitats associated with salt lakes, in particular the mosaics of habitats associated with Lake Barlee that contribute to it being a wetland of national significance.



Figure 5: The MMR has large areas of woodland (top) and sandplain vegetation (bottom) which are in excellent condition.

Table 8. Referenced statements on the significant plant communities.

Attribute	Reference
The Mount Manning Area contains representative ungrazed southern mulga communities not well protected elsewhere.	EPA 1975
Floristic importance of BIF ridges recognised as many plants do not occur elsewhere.	EPA 1975, Henry-Hall 1989, Gibson <i>et al.</i> 2001b
<i>Dryandra arborea</i> communities in BIF ranges are unique.	Keighery 1980
Each BIF hill or range has its own set of vegetation types associated that differ between foothills, slopes and crests	Newbey & Hnatiuk (1985)
Pigeon Rock is a unique living laboratory worth of World Heritage listing for its scientific value.	Bussell & James 1997
Significant variation in vegetation composition occurs between ranges. Most of these vegetation communities are defined by endemic taxa.	Gibson <i>et al.</i> 1997, Gibson & Lyons 1997ab, 2001, Gibson 2004
Vegetation types are confined to ridges in Die Hardy, Windarling and Mt Jackson ranges and contain endemic species.	Mattiske Consulting 2001b
Detailed surveys have established the uniqueness of vegetation in the Helena and Aurora, Windarling and Jackson Ranges.	Mattiske 2001, Western Botanical 2003-
The Helena & Aurora Range (including the eastern Jackson Range), is a unique association of vegetation and wide range of significant flora that should be reserved as a high priority.	DEC site visit observation March 2007.
Recognition of 15 Priority Ecological Communities listed in Table 9.	DEC (await endorsement by Minister)

Table 9. Nominated communities at risk (CALM 2002) and currently recognised Priority Ecological Communities (PEC).

Location	PEC
<i>A. Wetland habitats</i>	
Flora and Fauna in granite rock pools	
All fringing vegetation in riparian zones	
<i>B. Terrestrial ecosystems</i>	
Helena and Aurora Range vegetation complexes	HA1, HA3, HA4, HA5a, HA5b,
Koolyanobbing vegetation complexes	K1
Windarling Range vegetation complex	Windarling1
Mount Jackson Range vegetation complex	MJ1
Die Hardy Range vegetation complexes	DH1, DH2, DH3, DH4, DH5, DH6, DH7
Banded Ironstone Hills with <i>Dryandra arborea</i>	
Highclere Hills vegetation complex	
Hunt Range vegetation complex	
Mount Dimmer vegetation complex	
Mount Manning Range vegetation complex	
Yilgarn Hills complexes (a general category?)	
Banded Ironstone <i>Tetratheca paynteri</i> communities	

4.4. Fauna and fauna habitats

Habitats in the MMR support a rich and diverse vertebrate and invertebrate fauna. In particular, habitats on the BIF ridges and associated slopes support a distinct fauna assemblage which is known to be different from that of surrounding areas of woodland or sandplain shrublands. Some fauna species are confined to ironstone ridges and slopes, others are confined to the adjacent woodlands and sandplains. Of regional importance too, are species which previously had extensive distributions in the now largely cleared wheatbelt, in this region have populations primarily occupying habitats in the denser vegetation of the ridges and slopes. Some vertebrate and invertebrate species inhabiting the ironstone ridges and associated slopes are listed under the Commonwealth *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. The ironstone ridges and associated slopes also support Short Range Endemic (SRE) fauna (primarily invertebrate fauna with a highly restricted distribution).

Although some fauna studies have been undertaken in the MMW area (e.g. Dell & How 1985, Lyons & Chapman 1997, Ecologia 2001, 2003b) information regarding fauna values is incomplete. Species 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 MMW area are listed in Table 10.

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

Taxon	Common Name	EPBC Act	State Listing	Record
<i>Dasyurus geoffroii</i>	Chuditch	Vulnerable	Schedule 1	1985, 1996
<i>Macrotis lagotis</i>	Bilby	Vulnerable	Schedule 1	extinct in region
<i>Dasycerus cristicauda</i>	Mulgara	Vulnerable	Schedule 1	
<i>Leporillus conditor</i>	Greater Stick-nest Rat	Vulnerable	Schedule 1	extinct in region
<i>Calyptorhynchus latirostris</i>	Carnaby's Black Cockatoo	Endangered	Schedule 1	
<i>Cacatua leadbeateri</i>	Major Mitchell's Cockatoo		Schedule 4	2001
<i>Acanthiza iredalei iredalei</i>	Slender-billed Thornbill	Vulnerable		
<i>Leipoa ocellata</i>	Malleefowl	Vulnerable	Schedule 1	1985, 1996, 2001, 2007
<i>Platycercus icterotis</i>	Western Rosella		Schedule 1	1985
<i>xanthogenys</i>				
<i>Falco peregrinus</i>	Peregrine Falcon		Schedule 4	1985, 1996, 2001, 2007
<i>Cyclodomorphus branchialis</i>	Gilled Slender Blue-tongue		Schedule 1	1997
<i>Morelia spilota imbricata</i>	Carpet Python		Schedule 4	
<i>Aspidites ramsayi</i>	Ramsay's Python		Schedule 4	
<i>Sminthopsis longicaudata</i>	Long-tailed Dunnart		Priority 4	1997, 2001

Taxon	Common Name	EPBC Act	State Listing	Record
<i>Ardeotis australis</i>	Australian Bustard		Priority 4	
<i>Calamanthus campestris montanellus</i>	Rufous Fieldwren		Priority 4	1985
<i>Hylacola cauta whitlocki</i>	Shy Heathwren		Priority 4	1985, 1997
<i>Oreoica gutturalis gutturalis</i>	Crested Bellbird		Priority 4	1985, 2007
<i>Pomatostomus superciliosus ashbyi</i>	White-browed Babbler		Priority 4	1985, 2007

Record: 1985 = Dell & How 1985, 1996 = Chapman & Pronk 1996, 1997 = Lyons and Chapman 1997, 2001 = Ecologia 2001, 2003 = Ecologia 2003c, 2007 = DEC site visit Feb 2007.

Evidence of the significance of fauna and faunal assemblages that occur in the area is listed below:

1. The MMR has exceptionally good woodland habitats for animals due to long intervals without fire resulting in exceptionally large trees and mallees.
2. The parts of the Helena & Aurora Range centred around Bungalbin Hill and nearby woodlands and sandplains are known to be very important habitat for animals, with 5 dasyurid marsupials, 51 reptiles - including 13 geckos (Dell & How 1985, Henry-Hall 1990). A fauna trapping program conducted over a 20 year period in the sandplains north of the Helena and Aurora Range has revealed a high diversity of reptiles and mammals (Prof. P C Withers pers. com.). This study also revealed changes in the presence of species over time, suggesting the MMR is important as a transition zone between animal habitat types. This very intensive trapping study detected over 40 taxa of small reptiles (Thompson *et al.* 2003).
3. There are outlying populations of Chuditch here and elsewhere in the goldfields.
4. Woolley's Pseudantechinus (*Pseudantechinus woolleyae*) seems to be dependent on BIF ranges for habitat in the region, as it occupies deep rock crevices (Ecologia 2001). It is a disjunct distribution at the southern end of its range.
5. The skink species *Ctenotus xenopleura* is known only from 4 localities, including sandplains north of Bungalbin Hill (Dell & How 1985). This species has a restricted distribution.
6. Sightings confirm the area contains very important habitats for Malleefowl that include acacia woodlands near the Jackson Range (Table 8).
7. As shown in Figure 5, Peregrine Falcon roosts / potential nesting sites are prominent feature of cliffs of substantial BIF ranges in the MMR. These areas provide protection (vertical cliffs, often with a protective overhang) and wide vistas (high in landscape) to perching birds. The most substantial cliffs were noted to provide multiple roosting sites.
8. In the north of the region, Lake Barlee is an important breeding site for Banded Stilts (*Cladorhynchus leucocephalus*) with over 200,000 nests reported (Burbidge & Fuller 1982).
9. Short Range Endemics (SRE) are species that have a naturally small range of less than 10,000km² and generally possess similar ecological traits including poor powers of dispersal, confinement to specialized often discontinuous habitats, slow growth and low fecundity (Harvey 2002). Western Australia is known to contain SRE from the Diplopoda (Millipedes), Pulmonata (Land Snails), Mygalomorphae (Trapdoor and Funnel Web Spiders) and other groups although the taxonomy of other groups of invertebrates is poorly known and some are likely to also include SRE's (M. Harvey pers. comm.). Ironstone ridges and associated slopes in the MMW area are likely to contain many of these groups particularly in relictual and

fragmented habitats. We should expect endemic species to be found on the ironstone ranges, once additional surveys that target key groups of organisms are conducted (M. Harvey pers. comm.).

- a. Undescribed subterranean fauna may occur in BIF ranges in the area (see below).
 - b. Several unidentified land snails were submitted to Western Australian Museum (Ecologia 2001).
 - c. Very little is known about insect diversity in the area, but SRE species are likely to be present.
 - d. It is likely that these BIF ranges function as refuges for endemic invertebrate rock specialists (e.g. millipedes *Antichiropus* sp.).
10. The large intact animal habitats in the region may become even more important in the future as a result of fox baiting or possible translocation of rare fauna in this area.
 11. Buffers, linkages and sufficient populations of common species that rare fauna/flora rely on for food, shelter, pollination, etc.
 12. Many restricted animal species have highly specialised habitats, so it is important to include substantial areas of common (keystone) species required to provide food or shelter within reserves designed to protect rare species.
 13. We are slowly developing a greater understanding of the importance of symbiotic relationships, such as pollinators and mycorrhizal fungi, for the survival of rare species. Thus rare species cannot be conserved in isolation from ecosystems.

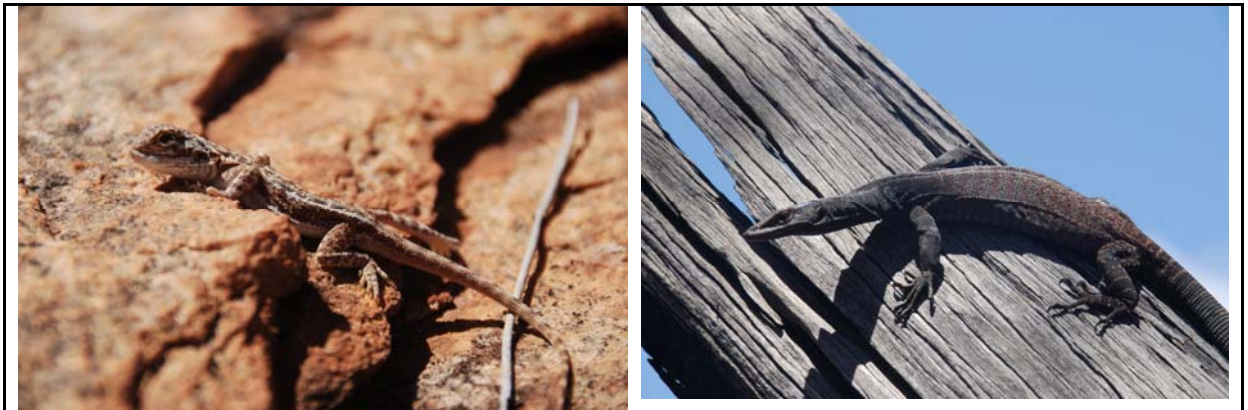


Figure 6: The MMR has a high diversity of fauna, including reptiles. The dragon *Ctenotus reticulatus* (left) and the monitor *Varnus tristus* (right) are shown.



Figure 7: *Peregrine Falcon roosting sites on BIF cliffs in the Helena & Aurora Range. This also is a probable nesting site.*

4.5. Wetlands

The MMR is bounded by major salt lake systems to the north and south. All fringing vegetation in riparian areas is considered to be significant since it is threatened by grazing (CALM 2002). It is recommended that the reserve be extended to include significant portions of salt lakes (Section 7). In particular, Lake Barlee is a wetland of national significance and major site for breeding bird populations in the years when there is sufficient rainfall (Burbidge & Fuller 1982). Several very poorly known rare species occur near salt lakes such as Lake Seabrook (Table 6). Lake Deborah East is a wetland of subregional significance (CALM 2002). Rockpools on granite near the Hunt Range contain the DRF plant *Myriophyllum lapidicola* which is only known from 2 locations (Table 6).



Figure 8: *Lake Seabrook viewed from the Koolyanobbing Range.*

4.6. Aboriginal significance

There are many Registered Aboriginal Sites scattered throughout the MMR study area, with the highest concentrations at locations in Table 11. Those at the Helena and Aurora Ranges, especially Bungalbin Hill seem to have the greatest significance. Many geographic features in the MMR also have mythological significance (Henry-Hall 1989). There are two native title claims, the Wutha People (WC99_010) and the Central West People (WC99_029). The Gubrun and Kalamaia Kabu are included within the Central West People.

Table 11. Summary of Aboriginal Heritage Listed Sites in the MMR (information provided by the Aboriginal Heritage Inquiry System, Department of Indigenous Affairs - www.dia.wa.gov.au/Heritage). Closed sites are shown in bold.

Location	Site Types
Helena and Aurora Ranges, Bungalbin Hill	womens place, engraving, ceremonial , artefacts, mythological, historical, camp, hunting place, water source, grinding patches
Windarling	ceremonial , artefacts, meeting place, rock shelter, mythological, historical
Jackson Ranges	artefacts, rock shelter
Die Hardy Ranges	mythological
Mt Manning	water source
Koolyanobbing Range	artefacts, water source
Pigeon Rock	ceremonial, meeting place, mythological
Lake Deborah	mythological, man-made structures
Lake Barlee	man-made structures

4.7. Landforms, heritage, tourism and scientific knowledge

Landscape diversity in the MMR is exceptionally high as shown in the figures included in this report. The region includes excellent examples of landforms, geological features, soils and habitats that are typical of the wheatbelt and Goldfields. While each BIF range is a significant landform, the largest ranges provide the best opportunities for conservation and promotion of major landform features for heritage and tourism. The heritage significance of landforms is not widely recognised in WA, but it is common for significant landforms to provide a focus for nature reserves such as the Stirling Range, Mount Lesueur and the Barren Ranges. In the MMR and elsewhere in WA the geographic complexity of landscapes is linked to the presence of highly diverse and endemic flora in biodiversity hotspots (Barrett, Brundrett & Keighery in prep.).

Geodiversity and geoconservation provide a framework for conserving significant geological, geomorphological and soil features, assemblages and processes (Sharples 2002). Geology and soils in the MMR region are exceptionally diverse and provide a wide diversity of geological heritage values. These ranges are comprised of some of the oldest sediments in the world, as the BIF was deposited 2.5 to 3 billion years ago (Clout & Simonson 2005, Klein 2005). Current theories suggest this iron originated from deep-sea vents, possibly with microbial involvement in the sedimentation process, in an anoxic environment (Klein 2005). Thus, the deposition of BIF probably predates the occurrence of photosynthetic life in oceans.

Evidence for high geodiversity significance of MMR BIF ranges is summarised below:

- “The Helena and Aurora Range, including Bungalbin Hill, represents the highest and largest example of hill (banded ironstone formation) in the Eastern Goldfields” (Newbey & Hnatiuk 1985). This is a substantial range in the context of south west WA extending 20 km long, with a 600-700 m high central peaks extending from Bungalbin hill 10 km east.
- The Jackson, Die Hardy, Koolyanobbing and Windarling Ranges are also excellent examples of BIF ranges (up to 20 km long and >500- >600 m high).
- The MMR area is relatively accessible to visitors (>500 km from Perth) and has historical significance (Table 12).
- Intact BIF ranges in the Yilgarn region may become less accessible elsewhere due to mining.

Key aspects of the scientific significance of the MMR is summarised below:

- BIF formations demonstrate the earliest sedimentary processes in the period before life dominated geochemical processes on the earth approximately 2.5 billion years ago (see review by Klein 2005).
- The region provides the capacity to study landscape processes in uncleared habitats similar to the wheatbelt. These include the entire catena of soils and landforms from BIF ranges and granite peaks higher in the landscape to lateritic breakaways, woodlands, sandplains, drainage lines and salt lakes lower in the landscape.
- The area contains excellent examples of intact woodland and scrubland habitats which have not been substantially altered by grazing or fire that are of key scientific importance as comparative study sites for SWAFR habitats, to study the role of linkages during a period of climate change and as potential reintroduction sites for threatened fauna.
- Rock habitats have been used as laboratories to study the impact of isolation on plant populations and studies in the MMR have contributed substantially to our knowledge of evolutionary processes (e.g. Bussell & James 1997).
- Scientific studies over the past 2 decades in sandplains near the Helena and Aurora Range have resulted in substantial gains in our understanding of the ecology and physiology of Australian animals (Prof P C Withers pers. comm.).

Recommended criteria for geoheritage (which also incorporate scientific, social and spiritual values) are listed in Table 12. Of key significance is the potential economic value of the area for tourism due to its relative close proximity to Perth, visually impressive 2.5 billion year old BIF ranges and the presence of extensive intact woodland vistas, especially extensive areas with mature healthy Salmon Gum and Gimlet trees, that have been lost in most of the WA wheatbelt. The area also has high, spiritual, cultural, scientific and geological significance, as summarised in Table 12.

Table 12. Preliminary geoheritage assessment using standardised categories (Sharples 2002).

Value	Significance	Comments
Aesthetic	Very high	Scenery and wilderness - substantial ranges with beautiful rock formations, cliffs and caves and exceptional vistas, due to the absence of major signs of human impacts in many areas. Unique and diverse flora and fauna. Scenic ranges with cliffs and caves.
Science / education	High	Geology - exemplars of ancient landscapes with excellent teaching potential, especially for geology and ecology. These include excellent examples of Precambrian geological processes. Scientific – the MMR includes important research sites for research into the genetics, evolution and ecology of rare endemic plants in isolated habitats and important sites for long-term zoological research.
Recreation	High potential	Tourism / ecotourism – MMR ranges provide excellent resources for tourism and camping, due to relatively close proximity to Perth, despite limited road accessibility, water supplies and accommodation. Some areas are unsuitable for public access due to rare flora / fauna and unstable rocks.
Social / historical	Very high	Aboriginal heritage sites and artefacts common in the region (Table 11). These include important mythological, ceremonial, artistic and historical sites as well as rock shelters, meeting places and water sources.
“Sense of Place”	High	Goldfields history and culture – the nearby town of Evanston (abandoned) was an important town during the gold rush - a key defining event early in WA history. Jackson and Evanston were the site of key gold finds from 1887 onwards. There are many small mines and diggings throughout the Marda Diemels Greenstone Belt, but most were abandoned prior to 1950 (Walker & Blight 1983). Aboriginal heritage and religion are also relevant (see above and below) and the pastoral industry also has a long history in the area.
Spiritual / religious	High	The area has spiritual significance, especially for Aboriginal people (Table 11).

5. Discussion

The earlier proposals identifying the significance of the MMR and recommending the establishment of a substantial nature reserve (Table 1) have been fully validated and considerably strengthened by knowledge of flora in the area that was not available when these proposals were first developed. In particular, many additional endemic rare species and potentially threatened plant communities have been recognised (e.g. earlier surveys found many apparently new plants, but it has taken several decades for botanists to confirm taxa are new species and establish which are endemic to the area). The long-standing knowledge of the extremely high environmental significance of the interzone region has been confirmed by major recent advances in knowledge of its biodiversity. This has resulted in the recognition that the MMR is a biodiversity hotspot as evidenced by the presence of:

- Endemic species including Declared Rare and Priority Flora.
- Endemic species likely to meet criteria to become DRF.
- A number of undescribed or newly described taxa.
- Unique vegetation communities restricted to single BIF ranges.
- A transitional zone between goldfields and wheatbelt vegetation, with many species and communities at range ends.
- Habitats for fauna species, especially those occupying restricted habitats or declining in the wheatbelt.

CAR reservation principles also support the importance of a substantial nature reserve in the MMR area to include excellent examples of woodlands not impacted by fire, as well as sandplains and salt lakes. The area also is significant for aboriginal heritage, tourism potential and scientific research. The overall size and geographic complexity of ranges seems to be well correlated with the number of endemic rare flora (e.g. the Helena and Aurora Range has the most rare species). Within each range, the size and complexity of massive BIF rock outcrops with cliffs also tends to be correlated with the presence of rare flora. Thus, there is a high degree of congruence between areas requiring conservation due to the presence of rare flora with areas worthy as conservations for other reasons (Aboriginal heritage, geodiversity, tourism).

Conservation mechanisms need both sufficient flexibility and sufficient effectiveness. The Section 16(e) request for the Mount Manning area specifically asked for areas of highest conservation significance that should be protected from mining to be identified. Flora conservation values for these areas are ranked in Table 6. However, it is important to note that while the Helena and Aurora Range, for its size, clearly rank as one of the more significant biodiversity assets in WA, the other ranges are also of very high importance, especially as refugia for endemic rare species. 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. It also needs to be noted that the MMR has exceptionally high landscape diversity and includes extensive intact examples of 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. The MMR ranges and surrounding landscapes are also important for geoconservation, Aboriginal heritage and European history.

A key issue is the need to determine how much of each range needs to be conserved to adequately protect unique vegetation types and SRE flora and fauna. For example, a limit for habitat loss for *Tetratheca paynterii* was set at Koolyanobbing for Portman Iron Ore Ltd's expansion. However, the focus on *T. paynteri* has led to a lack of appreciation of other rare species present, especially *Ricinocarpos brevis* a second species endemic to the Windarling Range. Since this mine expansion was approved, much more information highlighting the conservation significance of MMR BIF ranges has become available. It is now apparent that further mining of BIF ranges of highest conservation significance in the MMR region is likely to result in major impacts to threatened species and communities. Comprehensive scientific studies would be required to assess the impacts of substantial permanent habitat loss for each rare species before the environmental impacts of any mining proposal could be fully assessed. It is generally impossible to restore complex habitats that have been

destroyed (EPA 2006b). Thus, it is unlikely that further mining in the areas proposed as an A Class Nature Reserve in Section 7 below could be justified.

Within the MMR, substantial intact ranges are important because:

- The clustered distribution of individual plants and genetic diversity within populations of endemic rare flora indicate they are apparently unable to disperse across gaps between ranges (Krauss *et al.* 2002, Butcher *et al.* 2002, 2007).
- Endemic SRE fauna unable to disperse between ranges are expected to be present.
- Rare species may contract to core areas of prime habitat on ranges during both past and future periods where adverse climatic conditions prevail. Thus the current distributions of BIF endemics may include both core areas and linkage within ranges necessary for the long-term survival of species.
- Intact ranges without major scars resulting from mining provide the greatest ecotourism potential.

Transitional areas such as the interzone may become more important in the future due to climate change. In particular, a substantial reserve in the MMR will provide species with the capacity to seek different habitats or refugia due to its intactness and the complexity of landscapes.



Figure 9: Die Hardy Range.

6 Conclusions

6.1. Highest conservation values in the Mount Manning Region

- While a strategic review of biodiversity in BIF ranges of the midwest that is currently underway will provide further contextual information on the significance of MMR ranges, there is already abundant scientific evidence that they are highly significant, especially as habitats for endemic rare flora.
- Key areas in the MMR that are essential for conservation of threatened species and Priority Ecological Communities have been identified from current

information, the areas with the highest concentration of values are associated with BIF ranges. However, the surrounding areas of woodlands and sandplains also are of very high value for conservation.

- Ranking of areas that support the most important environmental assets has established the outstanding significance of the Helena and Aurora Range including Bungalbin Hill, but each of the BIF ranges has highly significant habitats for rare and endemic flora that require protection.
- The BIF ranges are also significant as fauna habitats, landforms, Aboriginal heritage sites, and as sites of scientific research.
- It is normally not possible to fully reinstate such ecosystem types after mining when landforms are substantially altered (EPA 2006b).
- Individually the BIF ranges are small, mostly less than 20 km long, and isolated from each other. Maintaining consolidated habitat and connectivity within each BIF range is required to maintain genetic diversity and minimise threats to the long-term survival of endemic declared rare flora.

6.2. Environmental offsets with particular respect to Portman Iron Ore Ltd Koolyanobbing Expansion

- Good progress has been made by Portman Iron Ore Ltd in implementing commitments to expand the conservation estate by acquiring adjacent pastoral areas as a general offset, and supporting management.
- Considerable work has been undertaken in relation to the requirements of the *Tetratheca paynterae* Research and Management Plan, including research into the ecology and pollination vectors of *T.paynterae*. Significant problems are anticipated in achieving environmental offsets to redress the conservation threat from clearing part of the Windarling Range endemic DRF, *Tetratheca paynterae* subsp *paynterae* population for mining. This is because: 1) this (and other DRF/endemic species confined to BIF) appear to be highly habitat specific, and each BIF range has its own endemics occupying equivalent habitats. 2) Translocation and BIF offset options are restricted by other tenements over alternative options. 3) There is insufficient evidence that alternative habitats that may be chosen would be viable in the long term. Thus, there is significant uncertainty that the translocation of populations to new areas will provide an effective means of offsetting losses to populations of highly habitat specific BIF endemics lost to mining. Until demonstrated otherwise, a precautionary approach should be adopted in relation to the future use of translocations as an offset for loss of highly habitat specific endemic flora.
- A consolidated A Class Nature Reserve is needed to provide secure protection from mining for areas of the highest conservation significance, specially in the remaining habitat for rare species in the Windarling and Jackson Ranges. Reservation of the Windarling Range will provide secure conservation tenure for *Tetratheca paynterae* consistent with the Environmental Management Commitments in Ministerial Statement 627.

6.3. Wider Conservation Values of the Mount Manning Region

- The MMR should be recognised as a Biodiversity Hotspot in the South–West Interzone, based on the high diversity of flora species represented, the concentration of endemic and threatened and priority listed species and threatening processes associated with the mineral prospectivity of the BIF Range

environments, which coincide with the highest concentration of threatened species and communities in the region.

- A consolidated reserve in the MMR would be very important due to its strategic location and inclusion of a diverse range of environments and associated plant communities across the climatic gradient that demarcates the winter rainfall dominated South-West Botanical Province from the low and variable rainfall of the Eremaean Botanical Province.
- The MMR supports extensive sandplain, granite and woodland environments, including excellent representation of a range of vegetation types that are now extensively cleared in the wheatbelt. These provide very important habitats for fauna species that are now largely absent from, or suffering declining populations, in the wheatbelt.
- The northern part of the MMR includes significant examples of largely ungrazed mulga woodlands near the south-western limit of their range.
- Creation of a large consolidated and secure nature reserve in the MMR provides an important opportunity to conserve extensive and contiguous environments representing the full catena of landscape elements in this biologically diverse region. This will be important to maintain species richness and genetic diversity in the long-term, especially in the face of anticipated climate change.
- A conservation reserve in the core areas of the MMR that is secure from mining would allow a substantial number of currently endangered species to be adequately conserved.
- Further mining in this biodiversity hotspot has the potential to result in the requirement to elevate additional endemic species and ecological communities to Critically Endangered status.

7 Recommendations

The EPA recommends that:

- 1) The Mount Manning Region (MMR) be recognised as a Biodiversity Hotspot for its combination of high levels of species richness, concentration of rare and endemic flora, restricted ecological communities and the threatening processes associated with the mineral potential of the BIF Range environments, which coincide with the highest concentration of threatened and endemic species and communities in the region.
- 2) Areas of the highest conservation value and surrounding areas in the MMR be protected from mining by:
 - Establishing an A Class Nature Reserve to include the highest priority conservation areas, as outlined in Table 13 and Map 4 below.
 - Defining temporary exclusions for mining and mining infrastructure in the proposed A Class Nature Reserve in areas where mining is currently approved. These areas should become part of the Reserve after successful rehabilitation (consistent with the approach of Ministerial Statement 627).
 - Proponents be advised that proposals for further mining in areas of the highest conservation value are unlikely to be found environmentally acceptable.

- 5) Renewal of mineral tenements and granting of new tenements should not be supported in the proposed A Class Nature Reserve.
- 6) The precautionary principle be applied in relation to proposals to offset loss of highly habitat specific BIF endemic species through translocation to other sites, as each BIF range generally has its own endemic species occupying equivalent habitats.
- 5) The 32 flora taxa considered on existing information to be endemic to small areas in this region be assessed for DRF listing, in recognition of the increased threats to species endemic to BIF ranges (these taxa are designated as PR in Table 6). This review should take into account the degree of protection offered by the A Class Nature Reserve, once it is established.
- 6) Further flora and vegetation surveys be undertaken to better define the status of:
 - a) Apparently rare and endemic flora.
 - b) Large areas of sandplains and woodlands not adequately surveyed within the MMR, and
 - c) Rare flora and communities in Jaurdi and Mt Elvire Conservation Parks.
- 7). The MMR be surveyed for Short Range Endemic fauna (especially invertebrates).

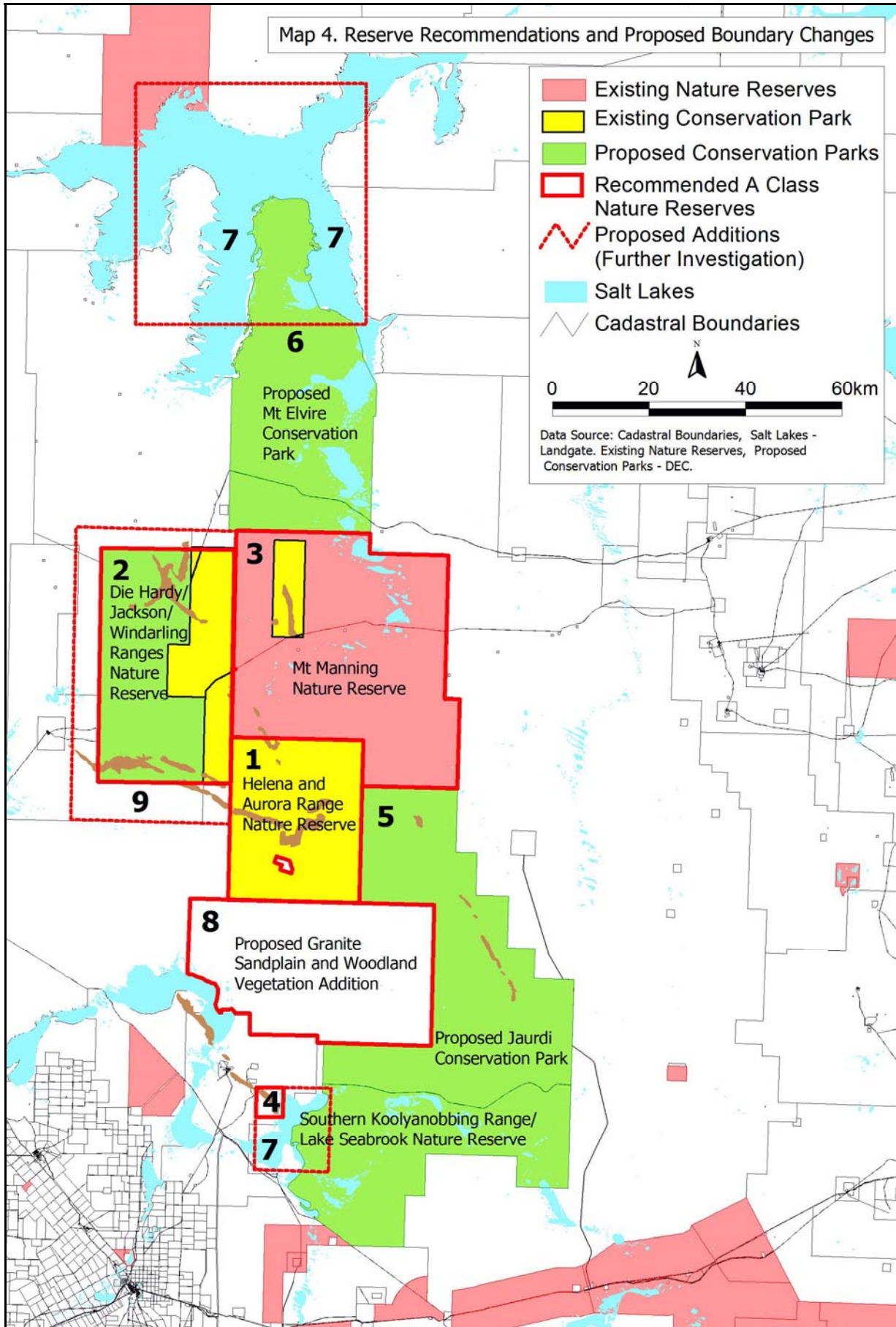
Table 13. Reserve Recommendations listed in order of importance (see Map 4).

No. on Map 4	Conservation Reserve or location	Action	Key Factors
1	That part of the Helena & Aurora Range Conservation Park, as shown on Map 4	Reserve area as an A Class Nature Reserve for protection of high concentrations of endemic rare flora and Priority Ecological Communities, exceptional landforms, threatened fauna habitats, mature eucalyptus woodlands that are declining in the Wheatbelt and Aboriginal heritage.	1, 2, 3, 4, 5, 6, 7, 8
2	Part of the Helena and Aurora Range Conservation Park, the proposed Die Hardy Range / Mt Jackson Conservation Park, as shown on Map 4	Reserve as an A Class Nature Reserve for protection of endemic rare flora, extensive ecotone between Eucalypt woodland and Mulga shrubland vegetation demonstrating the interzone between the South-West and the Eremaean Botanic Provinces, as well as exceptional landforms, fauna habitats and Aboriginal heritage. See also separate recommendations for Jackson, Die Hardy and Windarling Ranges below.	1, 2, 3, 4, 5, 6, 7, 8
2a	Part of Jackson Range	Reserve the area of Jackson Range and surrounds identified on Map 4 as an A Class Nature Reserve to protect core areas of DRF and endemic flora and maintain ecological connectivity within ranges for rare flora.	1, 2, 3, 4, 5, 6, 8
2b	Non-mined areas of Windarling Range	Include remaining unmined parts of the Windarling Range within the A Class Nature Reserve, consistent with the requirements of Ministerial Statement 627, to protect remaining populations and habitat for endemic DRF and significant landforms.	1, 2, 3, 4, 5, 6, 8
2c	Die Hardy Range	Reserve the Die Hardy Range and Yorkradine Hills	1, 2, 3,

No. on Map 4	Conservation Reserve or location	Action	Key Factors
	and Yorkradine Hills	within the proposed A Class Nature Reserve, especially to protect endemic rare flora and significant landscape values.	4, 5, 6, 7, 8
3	Mount Manning Nature Reserve	Reclassify the Mount Manning Nature Reserve as A Class and amalgamate with Reserves established over areas 1 and 2a,2b and 2c as a single A Class Reserve. Investigate the inclusion of the Mount Manning Range in this consolidated Reserve.	1, 2, 3, 4, 6, 7
4	Southern end of Koolyanobbing Range	Reserve at least 5 km of the southeast end of the Koolyanobbing Range in A Class Nature Reserve, with a linkage to Jaurdi Conservation Park via Lake Seabrook, to protect the habitat and populations of endemic Declared Rare flora and outstanding landscape values.	1, 2, 3, 4, 5, 6, 7, 8
5	Yendilberin and Watt Hills / Proposed Jaurdi Conservation Park	Further investigation of the current Conservation Park recommendations to ensure adequate conservation of rare and endemic flora and other significant factors.	1, 2, 3, 4, 5, 6, 7, 8
6	Proposed Mt Elvire Conservation Park		
7	Parts of Lake Barlee and Lake Seabrook	Extend Jaurdi and Mt Elvire Conservation Parks to include the full catena of landforms and environments, to protect habitats of rare species and particularly Lake Barlee as a wetland of national importance.	2, 3, 4, 5, 6
8	Area of UCL south of Helena & Aurora Range and east of Jaurdi Conservation Park	Consolidate the MMR reserves as identified on Map 4, by including extensive areas of exceptional sandplain vegetation, granite and Eucalyptus woodlands on UCL in areas (outside BIF and greenstone belt) north of the Koolyanobbing Range.	2, 3, 4
9	Remainder of Jackson and Die Hardy Ranges	Further investigate the need to extend the A Class Nature Reserve (recommended in 2 above) to the west and south to include the remainder of the Jackson Range and north to include all of the Die Hardy Range to provide further protection and adequate buffers for rare flora and plant communities.	1,2,4,6

Note: Key reservation factors used above:

9. Rare flora endemic to BIF range.
10. Endemic rare flora in sandplains, woodlands or other habitats.
11. Important habitat for specially protected fauna.
12. Excellent representation of woodland, sandplain and other inadequately reserved vegetation and animal habitats.
13. Aboriginal Heritage sites.
14. Substantial landforms with significant visual amenity.
15. Historical significance.
16. Geoheritage significance.



Map 4: Reserve recommendations and proposed boundary changes

8 Further Advice

The EPA notes that a strategic review by DEC of conservation values of BIF ranges in the Yilgarn is currently in preparation. This initiative is supported as an important step in the process of identifying and resolving conflicting conservation and mining interests currently focussed on Yilgarn BIF Ranges.

Recent BIF proposals have highlighted inherent problems in securing environmentally satisfactory outcomes on the one hand, and reasonable clarity and equity for mining industry tenement holders/investors on the other hand, where two or more companies are each seeking to develop their portion of a BIF Range with unique environmental values. The situation is particularly problematic where mining threats to species or communities endemic to a single BIF range arising from one proposal, require offset measures to conserve the remaining occurrence of the species or community on land that may be held by a second company in order to be environmentally acceptable. This can be a significant detriment to the community's interest in achieving outcomes that promote both reasonable environmental protection and orderly resource development.

The EPA is concerned that, on their own, the longstanding provisions of the Mining Act, based on the allocation of tenements based on a 'first to peg' principle do not facilitate strategic solutions to situations where companies share a resource that coincides with unique environmental values.

The EPA encourages consideration of possible measures that might facilitate more strategic solutions and early collaborative arrangements that consider cumulative impact issues and collaborative actions to protect areas of particular environmental significance.



Figure 10: *Mining at Windarling Range has resulted in substantial permanent alteration of landforms and loss of habitat for rare species*



Figure 11: *Dryandra arborea* on the Yokradine Hills.



Figure 12: *Excellent example of woodland (trees include york gum, salmon gum and gimlet), seen from the Jackson Range.*

Appendix 1

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Appendix 2

Definitions

Biological diversity/biodiversity - The variety of all life forms - the different plants, animals and microorganisms, the genes they contain, and the ecosystems of which they form a part (see Guidance Statement 51 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 Hotspot - A region of exceptionally high species endemism and diversity that is also subject to significant threatening processes (Myers *et al.* 2000). Also refers to areas where biodiversity are concentrated within floristic regions (Hopper & Gioia 2004, 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.).

Comprehensive, Adequate and Representative (C.A.R.) Reserve System - The development of a C.A.R. 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.

Ecosystem - The biota (plants, animals, fungi and microorganisms) 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 is 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 - for designation process see Flora Conservation Codes.

Schedule 1 – Fauna that are rare or likely to become extinct.

Schedule 2 – Fauna presumed to be extinct.

Schedule 3 - Birds protected under an international agreement.

Schedule 4 – Other specially protected fauna.

Priority Fauna:

Priority One - Taxa with few, poorly known populations on threatened lands.

Priority Two - Taxa with few, poorly known populations on conservation lands.

Priority Three - Taxa with several, poorly known populations, some on conservation lands.

Priority Four - Taxa in need of monitoring.

Priority Five - Taxa in need of monitoring.

Flora Conservation Codes – for taxa listed under the Western Australian Wildlife Conservation Act. The Minister for the Environment declares species of protected flora to be Rare Flora after recommendation by the State's Endangered Flora Consultative Committee if they are considered to be in danger of extinction, rare or otherwise in need of special protection. There are also three categories of Priority Flora for poorly known species and a fourth category for species that have been adequately surveyed and rare but not currently threatened (see florabase.calm.wa.gov.au/help/conscodes).

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.

P1 - Priority One - Poorly Known Taxa - Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

P2 - Priority Two - Poorly Known Taxa - Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

P3 - Priority Three - Poorly Known Taxa - Taxa which are known from several populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in need of further survey.

P4 - Priority Four - Rare Taxa - Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5–10 years.

Floristic Community Type – a vegetation classification based on the presence and absence of plant 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 (land forms and processes) and soil features, assemblages, systems and processes (Sharples 2002, Gray 2005). The significance of geoheritage 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.

Interim Biogeographic Regionalisation for Australia (IBRA) – 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)

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.

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, 2003).

Priority Ecological Communities - Possible threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to CALM'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 (www.naturebase.net).

Priority Flora (P1, P2, P3, P4) - see flora conservation codes.

Priority Fauna – see fauna conservation codes.

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

- 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.
- Extremely restricted distributions.

Short Range Endemic (SRE) - fauna species confined to less than 10,000 km² (Harvey 2002). Some plants are also confined to small areas.

Southwestern Australian Floristic Region (SWAFR) – The vegetation zone occupying the Mediterranean climate region of southwestern WA (Hopper & Gioia 2004). Formerly the Southwest Botanical Province of WA (Beard 1990).

Threatened Ecological Community – As defined by English and Blyth (1999) are those ecological communities that have been assessed through a procedure (co-ordinated by CALM) 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.

Appendix 3

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