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Buntine-Marchagee Natural Diversity Recovery Catchment STEERING COMMITTEE MEETING

Thursday, 7 and Friday, 8 March 2002 Coorow

FOCUS

The aim of the meeting is to build a common understanding of the issues involved in recovering natural diversity, generate consensus on the objectives and roles of the Steering Committee, and detail the outcomes required of the project.

OBJECTIVES

By the end of the meeting, participants will have:

- gained an awareness of the range of issues affecting the recovery of natural diversity;
- interpreted the issues within the landscape context of the Buntine-Marchagee catchment area;
- developed a sense of team within the Steering Committee and confirmed the > contribution and skills of each member;
- built consensus on the initial objectives of the Recovery Catchment project;
- developed a clear understanding of the roles of the Steering Committee and the sponsoring Agency;
- set targets and operational guidelines for the first twelve months; and
- agreed on the next steps for action.

Buntine-Marchagee Natural Diversity Recovery Catchment

STEERING COMMITTEE MEETING

Thursday, 7 and Friday, 8 March 2002 Coorow

AGENDA

Thursday, 7 March 2002

9.30 am Participants arrive at Maley Park, Coorow for morning tea
 10.00 am Welcome

Concept of a Recovery Catchment

Values of the Buntine-Marchagee Recovery

Catchment

Introductions

10.40 am Setting the directions of the project

11.40 am **Member interaction**

12.00 pm *Lunch*

12.40 pm Bus trip, incorporating site visits, farmer input and

Steering Committee interaction

6.30 pm Return and free time

7.30 pm Dinner at Coorow Hotel

Friday, 8 March 2002

6.30 am

Breakfast

8.00 am

Review

Outline of the day

8.30 am

Setting the objectives for the project

10.00 am

Morning tea

10.20 am

Project resources

Situation reports

11.10 am

Developing strategies for the objectives

12.20 pm

Lunch

1.00 pm

Setting goals and targets

Planning for implementation

3.00 pm

Afternoon tea

3.20 pm

Review

Next steps

4.00 pm

Finish

Participants depart

BUS Tour Notes

(bring along your project file with maps)
(all speakers 5 - 10 minutes)

- > Jodie Watts
- > Depart Maley Park 12.30 12.35
- Introduction of what to expect on the Bus Tour
- > Included in the project file is a map, which depicts the bus route
- Various people have been asked to talk to you whilst we drive around the catchment
- > We have scheduled an:
 - o afternoon tea break and toilet stop at Wubin around 2pm
 - a brief stop at John and Robyn Stacey's to look at applying broad acre contour farming of Oil Mallee's
 - o an afternoon walk through Alison Doley's wetlands
 - finishing around 6.30 pm to 7.00 pm back at Maley Park before dinner at the Hotel at 7.30pm.

- Help yourself to the food and drinks in the eskies
- Ann-Maree O'Callaghan will be our first speaker.
- > Ann-Maree O'Callaghan
- Coorow to Marchagee turn-off
- > Marchagee Nature Reserve
- > Geology/soils
- > Main vegetation complexes in the district
- > Overview of remnants left in catchment
- > Saline channels still vegetated
- Point out trial of pine species
- > Marchagee causeway (10 years ago expression of groundwater)
- > Mining lime south of Marchagee
- > Surface Drainage pattern can be a bit confusing, which way the water flows?
- > Point out the surface water catchment (project area) to the east
- > 23 km from Coorow Marchagee turn off

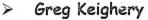
- > Noel Dodd
- > From Marchagee turn-off to the corner of Keighley Road and Gunyidi-Wubin Road
- > Systems of Landcare
- > Landcare type on-ground works to date
- > What have we learnt? What we could have done better?
- > Good intentions
- > Example of treating the symptoms and not the cause
- > Drainage line to the east
- > Valley floor planting
- Ask the group to look around for examples of where on-ground landcare work has been done in the catchment
- > Stuart Halse
- > From the corner of Keighley Road to first set of wetlands
- > Shire reserve 21788, good quality
- > Pause bus at wetlands (stay on bus)
- > Point out values of catchment
- Discuss the Biodiversity Survey
- > Ted Lefroy

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- > From first set of wetlands to Wubin
- Pause bus at second wetland chain just after Pears Road, can see where the wetland chain heads north and some linkages in vegetation

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- Discuss CSIRO 'Focal' Bird Project
- Wubin (approx. 2pm)
- > Afternoon tea stop
- > Pull off road into bay 15 minutes maximum
- > Toilets
- > Liam
- > From Wubin to Buntine
- Liebe Group
 - o why the group was formed?
 - o who is in the Liebe group?
 - o how is it run?
 - o what does it get up to?
 - o how might it contribute to the project?
 - o how can we ensure we include its farmers?
 - o crop updates



- > Buntine Reserve
- > Drive up Buntine East Road turn around at catchment divide
- > Pause bus at Chessemen drive-way
- > 7 terrestrial survey sites
- > Values

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- Biodiversity Survey
- > Michael O'Callaghan and Vern Muller
- > Buntine to Vanzetti Road
- > Marchagee Catchment Group and the Marchagee Bushcare Project
 - o when was the MCG group formed?
 - o how did the Bushcare project get started?
 - o what have both been up too? E.g. bushcare corridor
 - o future plans?
 - what advice can you offer this group about what has worked well and what could be done better, both as a group and as a project?

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- Discuss farmers environmental concerns
- > John Stacey
- > Stop on Vanzetti road near the two cement tanks on the hill top overlooking the property
- > Association with Marchagee Catchment Group
- Association with the Bushcare Project, what work has been undertaken on the property?
- What other type of landcare works has been tried or would you like to try?
- > Discuss using Oil mallee's as a wind break, contour farming
- From the landholders point of view what is important that this project takes into consideration?
- > Point out different landscape units- salmon gum on ridge lines
- > Alison (assisted by Fiona)
- > From John's place to House, down Mamboobie Road to Koobabbie
- Pause bus where Dolerite Dyke has impeded drainage, extensive tree planting in an effort to stabilize the water table
- > Discuss treating the symptom and not the cause, some benefits
- Point out Eremophila koobabbiensis, a new species that has survived as seed for 80 years to re-appear once the timber belt was fenced off

- > Eremophila sargantii
- > Waddy LCDC

- > Roadside revegetation project
- > Toilet stop at Koobabbie Cottages
- > Drive on one kilometer west of Koobabbie house
- > Walk to salt lakes
- > Session with Facilitator
- Visit Gypsum lake with its large crystals and Halosarcia koobabbiensis ms (Priority 1)
- > Back on the bus head back to Maley Park, Coorow to pick up cars and be guided to your accommodation

RECOVERY CATCHMENT STEERING COMMITTEE MEETING

WELCOME & INTRODUCTION

Good morning everyone and welcome to the first meeting of the Buntine – Marchagee Recovery Catchment Steering Committee. Firstly I would like to thank you for giving us your time today and tomorrow. We have a busy but exciting agenda that I hope you will find challenging, enjoyable and rewarding.

Basically you have been invited / selected to join us in forming a team to prepare a Recovery plan for the Buntine – Marchagee Catchment, a catchment that has been identified as a component of the State Salinity Strategy having significant biodiversity values as associated with nature vegetation, drainage systems and water bodies.

Our aim over the next few days is:

- 1. Clarify the role and responsibilities of CALM.
- 2. Clarify the role of committee members.
- 3. Clarify the operating procedures of the committee.
- 4. To establish an effective working relationship & rapport amongst committee members.
- 5. To provide a form in which an overview of the catchment, it's values and the issues and threats facing at can be discussed.
- 6. Achieve of the committee in identifying initial objectives for the catchment.
- 7. Reach agreement on a range of strategies to be pursued over the next 12 months.
- 8. Reach agreement on a set of tasks for the Recover Catchment Officer for the next 6 months.
- 9. Make a decision on the scale of hydrological research to be conducted this financial year.
- 10. Develop a process that we need to work through to enable us to prepare a recovery plan.

ROLE OF CALM

Under the terms of the State Salinity Strategy CLAM has been given responsibility for the identification of natural diversity recovery catchments and for developing plans that when implemented will work towards the protection and enhancement of biodiversity values in the catchment.

We are therefore charged with the preparation of a Recovery Catchment Plan to guide the necessary actions to achieve the objectives.

This catchment is different to other National Diversity Catchments identified so far in that there is no central waterbody that is the focus of our interest. Rather it is biodiversity values within the catchment as a whole, but particularly associated with the system of primary saline braided channels that cross the catchment.

So while CALM has a lead role to play in this project, there is only a relatively small area of land within the catchment for which CALM has statutory management responsibility. Therefore if there are actions that can be taken to protect the biodiversity in the catchment, those actions will most likely have to occur on private or other crown lands.

CALM has identified a catchment boundary based on advice from Water & Rivers Commission – however we will be flexible in the final area that is included.

CALM is responsible and accountable for the expenditure of funds allocated under the Salinity Strategy. Therefore, CLAM must follow guidelines with respect to how funds are expended and on what activities. Private benefit is an issue here.

CALM will drive the process to develop a recovery plan and to help this process has appointed a Recovery Catchment Office – Jodie Watts – whom you have all met.

CALM will prepare, call and chair Committee Meetings.

BUDGET

The 2001/2002 budget of	contains funding for work in the catchment.	
This includes \$geophysics.	_ for hydrological studies and \$	_ for

A decision on the scope of works in these 2 areas is required out of this meeting.

Also the estimates for 2002/2003 are required next week. Hence we need to identify the needs of the next financial year over the next 2 days.

In undertaking this project we have assumed that the data required will be able to be gathered over the next few years and that a range of on ground actions will be able to be identified.

The project will depend heavily on impact from the CALM Regional Office, the steering committee and other government departments.

As the project is primarily aimed at the conservation of biodiversity it's objectives may not be compatible with those of agricultural production and therefore decisions on resources use have to be consistent with the objectives determined for the project.

ON BEVAN

We are pleased to have Bevan Bessen with us over the next two days. Bevan is a skilled facilitator and will assist us with the progress of the meeting. He has a very successful background as a facilitator, particularly in rural / landcare related issues. He many landowners in this area and has an interest and knowledge of the catchment area.

We have elected to use a facilitator in the process of this meeting to allow us (CALM) to participate along with other members of the committee in the important discussions that need to happen. I'm confident that Bevan is going to make sure we get down to business and meet the objectives we have set for the meeting – and have some fun along the way.

CONCEPT OF A RECOVERY CATCHMENT

Greg Keighery

BACKGROUND TO RECOVERY CATCHMENTS

In 1996 the Western Australian Government launched the Salinity Action Plan, a thirty-year plan to combat rising saline groundwater in the Agricultural Region of Western Australia (Government of Western Australia, 1996). Delivery of the plan was based on the individual, the catchment scale and the State scale. Restoring hydrological balance was the major aim of many of the programs under the plan. Activities designed to promote this restoration were allocated between these scales, for example developing new crops was a State level activity based in the Department of Agriculture, field trials of these crops was at the catchment to individual scale.

The plan was reviewed and re-issued as the State Salinity Strategy in 2000 (Government of Western Australia, 2000).

In both of these strategies Individuals and groups were to receive salinity management support within several categories of priority catchments

• Focus Catchments (mainly to protect agricultural lands)

and three types of recovery catchments:

- Water Resource Catchments (Department of Environment, Water and Catchment Protection) (these were all allocated in 1996, being the Mundaring Weir (Helens River), Wellington Dam (Collie River), Warren, Denmark and Kent Rivers).
- Natural Diversity Catchments (Department of Conservation and Land Management) Three nominated in 1996, six more by 2005, based on biological survey results.
- Rural Infrastructure (Town Recovery) Catchments (Local Government and Departments of Transport, Planning and Infrastructure). At least 30 towns in this system by 2005.

It was recognised that the recovery catchments were primarily to protect public assets, therefore, they would be co-coordinated and actions assisted by those departments who had primary responsibility in the nominated major function of that catchment. This method is perhaps, best considered as sharing the load in a small State and maximising expertise and resources available.

This **DOES NOT** mean that Water Resource Catchments ignore Bio-diversity Protection or that Natural Diversity Catchments ignore private lands or assisting with new crops. The priority catchments are focussed towards a goal and require holistic solutions, they will, however, have long term support towards implementing those solutions.

For example CALM has major programs in the Wheatbelt devoted to Oil Mallees, Maritime Pines, Development of new Tree and Shrub Crops and new industries based on these crops. As well as "more traditional" nature conservation activities as the Better Management of Crown Reserves Program, Land for Wildlife Program, The Biological Survey Program, and Wetland Monitoring. These programs were all reviewed in 2000 (Wallace, 2000) and will be continually updated to assist in better Nature Conservation Outcomes in the Wheatbelt.

WHY HAVE NATURAL DIVERSITY CATCHMENTS?

SALINITY IMPACTS ON BIODIVERSITY

Terrestrial Communities

Plants

A diversity of tall woodlands of Wandoo (E. wandoo), Inland Wandoo (E. capillosa), Salmon Gum (E. salmonophloia), Red Morrell (E. longicornis), Black Morrell (E. melanoxylon) and Gimlet (E. salubris) once dominated the better-drained heavy soils of the valley floors and slopes throughout the Wheatbelt. These woodlands generally extend into the adjacent pastoral regions. However, we know that the woodland understory varies across their range with rainfall and soil. These woodlands are now greatly fragmented but remain evocative of the area and are of considerable significance to our local and national heritage. The Wheatbelt will lose much of its local landscape character if they are lost.

In the south-east Wheatbelt there are woodlands of different composition and dominants (for example, Eucalyptus ovularis, E. myriadena and E. flocktoniae). In this area diverse and variable Mallee communities (Eucalyptus platypus, E. celastroides, E. calycogona, E, cooperana, E. forrestiana and E. kessellii) largely replace these woodlands on clays and calcareous clays and are being impacted by rising saline groundwaters.

There are also a number of possibly naturally rare woodlands, such as Lowland Brown Mallet (E. astringens) and Black Wandoo (E. melanophitra) that are also at risk.

Areas affected by secondary salination show significant declines in vascular plant biodiversity and loss of structural diversity. Rich complex communities are replaced by a few succulents and weeds.

Naturally Saline Habitats:

The plants and the communities they occur in are at major risk from rising water tables and saline surface water flows, altering the hydrological regime of these areas. These areas contain a diversity of Mallet (Eucalyptus spathulata), Mallee (including the oil Mallees, E, suggrandis and E. vergrandis), Woodland (Casuarina obesa, Eucalyptus salicola, E. sargentii and E. kondinensis), shrubland, heath and herb communities that are at major risk from rising water tables. These areas have a diverse range of herbs that are only found in specific areas. These areas also contain much of the genetic biodiversity that will be needed to help provide economic drivers to help revegetate the wheatbelt (for example the oil mallees, Broomebush (Melaleuca uncinata), saline adapted shrubs and bunch grasses, such as Austrostipa teretifolia).

The naturally saline areas of the central/western Wheatbelt are a conservation priority because the threat of hydrological changes is more rapid and advanced in these areas.

Freshwater wetlands: (Creeks, Rivers, Lakes, Ephemeral wetlands).

Rivers in the incised western Wheatbelt are fringed by *Eucalyptus rudis* communities and these are already greatly impacted. Inland of these rivers Flat Topped Yate woodlands (*E. occidentalis*) and its related Mallee form (*E. sporadica*) are dominant around small freshwater swamps are also being impacted by salination and more frequent flooding.

The communities of lakes and ephemeral wetlands of the Wheatbelt contain an enormous diversity of plant communities depending on soil type and inundation, ranging from woodlands of *Melaleuca* species, through shrublands, heaths and sedgelands to aquatic herblands and are all under great threat.

Of the 4,000 species of plants present in the Wheatbelt over 1,500 occur low in the landscape, in riverine valleys, freshwater or primarily saline lands. Of these taxa an estimated 450 are endemic to the Wheatbelt. These species are in danger of extinction over the next 100 years as a consequence of rising saline groundwaters. Several hundred other species found only in lowland woodland, Mallee and *Melaleuca* shrubland sites will be under threat in the longer term. Another 400-500 lowland species are centered on

the Wheatbelt although not confined to it. These taxa are also under immediate threat of major genetic erosion from salination and hydrological changes.

Rising groundwaters and drought are also causing stress of several of the major trees species of the western Wheatbelt such as Flooded Gum, Yate and Wandoo leading to increased insect and fungal attack.

Outside of the Wheatbelt hydrological changes threaten the diverse floras of naturally saline landscapes and areas of species rich heathland and ephemeral wetlands of the northern sandplains and eastern Swan Coastal Plain. The karst communities, both subterranean and surface heaths, of the northern Swan Coastal Plain are threatened by flooding and perhaps increased impact of diseases from *Phytophthora* species.

Fauna

Approximately 25% (37 of 144 species) of its small ground-dwelling vertebrates (Mammals, Reptiles and Frogs) have distributions centred on the Wheatbelt or are endemic to it. At least 40% (210 of 500+ species) of the region's terrestrial invertebrates have distributions centred on the Wheatbelt or are endemic to it.

A significant decline in the biodiversity of terrestrial invertebrates is apparent at secondarily saline quadrats (even partially affected), which have an average of 30% fewer species than their non-salinised counterparts. This loss is actually higher as localised specialists are replaced by "weedy" generalist species.

Wetland Communities

Plants

The impacts are greatest low in the landscape in and around all wetland types. However as the terrestrial and wetland plant communities intergrade specific comment is made under Flora in the section above.

Fauna

Birds

Of the 61 more common waterbird species in the south-west, only 16 prefer strongly saline (more than 20,000 mg/L) or hypersaline (more than 50,000 mg/L) conditions. Data from a 1981-85 survey of the south-west showed that an average of five waterbird species used hypersaline wetlands, compared with 20 in saline wetlands and 40 in fresh wetlands containing live trees and shrubs. Death of shrubs and trees in many Wheatbelt wetlands, due to salinity, has caused a 50% decrease in the number of waterbird species using them. If the trend of increasing salinity continues, only 16 species, plus three or four species that use freshwater dams, will persist in the wheatbelt out of an original waterbird fauna of more than 60 species.

Invertebrates

Of the 700 species, 253 species (45%) are restricted to fresh water with salinity less than 3,000 mg/L. However, 35 of the species occur on granite rock outcrops where salinity is unlikely to occur, leaving 218 species (39% of the fauna) that are vulnerable to increasing salinity. If all wetlands in the wheatbelt became saline (more than 10,000 mg/L), most of these 218 species will disappear from the wheatbelt, despite the fauna being more saline tolerant than in eastern Australia.

Species richness declines with salinity and the average number of invertebrate species present in fresh wetlands is about 50, in wetlands with salinity 20,000 mg/L about 25, in wetlands with salinity 50,000 mg/L about 12 and in wetlands with salinity greater than 100,000 mg/L about four. As a rule of thumb, doubling salinity halves the number of aquatic invertebrate species.

Caveats that must be attached to the above statements at this stage of the work are that probably not all wetlands will become saline, some species will persist in dams, and many species have ranges that extend outside the Wheatbelt.

Summary

Areas affected by secondary salination show major declines in vascular plant and animal biodiversity. Rich complex communities are replaced by a few succulents and weeds. Similarly major declines in diversity occur in animal communities where specialists are lost and/or replaced by generalist species.

Salinity will impact on biodiversity of the Wheatbelt Valleys at all levels of biodiversity - community, species and population in a wide variety of the organisms studied. The impacts are greatest low in the landscape, along drainage systems such as Buntine- Marchagee, which is a very good example of a braided naturally saline drainage line. These impacts must be managed on a catchment basis.

To combat these effects CALM is selecting and assisting in managing up to 25 Natural Diversity Recovery Catchments. Three catchments were nominated in the Salinity Action Plan in 1996. They were Toolibin Lakes System, Lake Warden System and the Muir-Unicup System. Another was added in 1999, Lake Bryde and East Lake Bryde System. Buntine – Marchagee was added in 2000 and the Drummond Recovery Catchment has recently been approved. Another four will be added by 2005 under the aims of the State Salinity Strategy

SELECTING NATURAL DIVERSITY RECOVERY CATCHMENTS

Potential Natural Diversity Recovery Catchments are prioritised on their biological values, but are selected on the matrix listed below. As we will hear Buntine-Marchagee scores highly in all categories but only the local community can ensure the final and most crucial criteria is met to ensure success.

CRITERIA FOR SELECTING NATURAL DIVERSITY RECOVERY CATCHMENTS

- 1. Biodiversity Values at Risk.
- Biogeographic Representation
- 3. Opportunities for Research and Development and/or Demonstration Sites
- 4. Tenure of Land at Risk
- 5. Representation of Hazard
- 6. Potential for Success
- 7. Socio-political Considerations

References

Government of Western Australia (1996). Western Australian Salinity Action Plan. Government of Western Australia, Perth.

Government of Western Australia and the State Salinity Council (2000). *Natural Resource Management in Western Australia: Salinity*. Government of Western Australia, Perth.

Wallace, K.J. (2001) State Salinity Action Plan 1996: A review of the Department of Conservation and Land Management's programs, 1997-2000. Department of Conservation and Land Management, Perth.

Proposed Natural Diversity Recovery Catchment Buntine-Marchagee Catchment

This document outlines the case for the Buntine-Marchagee Catchment to become the fifth Natural Diversity Recovery Catchment designated under the State Salinity Strategy (Government of Western Australia, 2000).

1. Catchment overview

The Buntine-Marchagee catchment straddles the boundary of the Geraldton Sandplains and Avon-Wheatbelt Interim Biogeographic Regionalisation of Australia (IBRA) regions (Figure 1). The catchment includes vegetation typical of the northern Avon-Wheatbelt and the sandplain communities of the Geraldton Sandplains. In the southern part of the catchment, the sandplain in dissected by wide and poorly defined saline drainage lines that are often referred to as "braided channels". These consist of large areas of samphire and associated shrubs, small meandering saline streams, many open saline pans of varying sizes, and pockets of slightly elevated land supporting eucalypts. The majority of saline streams, open saline pans and samphire areas in this catchment are naturally saline (primary salinity). That is, they have not developed due to water tables rising since clearing for agriculture.

North of the Buntine-Marchagee, there is a catchment running west from Latham with more subdued topography. The two catchments join just east of Marchagee Nature Reserve (Figure 2). Koobabbie Farm, which contains some of the larger fenced remnants in the Buntine-Marchagee catchments including a number of Priority Flora, lies on the junction of the catchments. Because only two wetlands in the Buntine-Marchagee catchment were sampled as part of the Salinity Action Plan surveys, and because visual inspection showed the braided channels in the Latham catchment and Marchagee Nature Reserve were very similar to the Buntine-Marchagee channel, wetland sites from these areas were used to help document the likely faunal values of Buntine-Marchagee (see Table 1, Figure 2). We refer below to this group of wetlands being in the 'Marchagee area'.

Downstream from Marchagee Nature Reserve, west of the Midlands Road, water from Buntine-Marchagee and Latham discharge into Capamouro Swamp and Lake Eganu. These well-known wetlands are in large nature reserves but have become saline over the past 30 or more years as a result of increasing salinisation in the upstream catchment (of which Buntine-Marchagee and Latham make up a significant proportion). These lakes, and the Marchagee Nature Reserve, are not included in the proposed Recovery Catchment but may also benefit, to some extent, from recovery actions.

There are a number of National Parks and Nature Reserves located in (and surrounding) the Buntine-Marchagee Catchment. These are shown in Figure 3.

Clearing of native vegetation for agricultural purposes began in the Buntine-Marchagee catchment in the 1890's with the arrival of the Midlands Railway. Large-scale clearing continued into the 1970's with the last land clearing occurring in the early 1990's.

Rising water tables are becoming an issue in the catchment. Research has shown that water tables in valley floors are shallow in many places and are therefore very susceptible to changes in the water balance. Sandplain seeps have undergone very rapid and significant increases in volume in recent years. This increasing level of water tables has expressed itself in some areas as a degradation of low-lying vegetation.

2. Biodiversity Values of Buntine-Marchagee Catchment

Table 1. Salinity Strategy biological survey sites shown in Figure 1 or mentioned in text

Biodiversity sites: terrestrial fauna and flora	Terrestrial flora sites	Wetland sites: aquatic invertebrates, birds and floristics
WU02	WU5A	SPS157
WU03	WU5B	SPS158
WU04	WU16	
WU05	WU20	
WU13	1	
Relevant sites outside propos	ed recovery catchment	
WU06	WU12	SPS155
DN01	WU13	SPS171 - just N of Figure1
DN02	WU15	SPS172 - just N of Figure 1
DN08	WU17	SPS201
	WU21	SPS203

2.1 Flora values

Upland flora

Buntine Nature Reserve, a large remnant supporting good examples of upland plant communities, lies at the top of the Buntine-Marchagee catchment. Numerous smaller upland remnants occur on private land and species lists for many of them have been provided by Davies & Ladd (2000). Davies and Ladd will do additional surveys over the next two years. To date, they have recorded 278 taxa, including populations of seven taxa on CALM's Priority Flora list. Several areas of sandplain vegetation largely on private land also occur within the catchment.

Terrestrial biological survey sites have been established in the eastern part of the catchment, largely within Buntine Nature Reserve (Table 1, Figure 2). They include five primary survey sites (fauna and floristics) and four additional floristic sites. Data for these sites are yet to be compiled.

Wetland-associated flora

Two wetlands within the catchment (SPS157 and 158) were sampled as part of the Salinity Strategy Biological Survey. A total of 145 species of wetland-associated flora were recorded from the margins of the two sites (Appendix 1). Seven species of Declared Rare and Priority Flora were recorded (Table 2).

Table 2. Declared Rare and Priority Flora recorded from wetland sites SPS157 and SPS158 in the Buntine-Marchagee catchment

Declared Rare and Priority Flora	Status
Ptilotus fasciculatus	DRF (presumed extinct)
Fitwillia axilliflora	P2
Frankenia bracteata	P1
Gnephosis setifera	P1
Goodenia pussiliflora	P2
Hydrocotyle hexaptera	P1
Podotheca pritzellii	P2

Floristically, the plant communities recorded from SPS157 and 158 provide good examples of the flora and plant communities of naturally saline drainage lines within the northern wheatbelt and reflect, at least at a regional scale, the flora and plant communities within the remainder of the catchment. Further survey of the mosaic of communities within the drainage line, or braided channel, between Buntine and Marchagee is likely to record a large proportion of the regional flora of these systems.

The braided channels include large corridors of remnant vegetation and retain good examples of shrublands and woodlands of these systems. The remnants on Koobabbie Farm and Mailey's farm are in particularly good condition and include several taxa of note (see below).

Priority flora

The catchment includes populations of 39 taxa listed on CALM's 1999 Declared Rare and Priority Flora lists (Appendix 2). These taxa occur within the braided channels, sandplain and uplands of the catchment. Of particular note are:

- Caladenia drakeoides ms (Critically endangered) which occurs on private land east of Marchagee
 Nature Reserve (Koobabbie Farm) and within the braided channel east of Gunyidi;
- Halosarcia koobabbiensis ms (Priority 1) known only from the type locality on Koobabbie Farm in the lower part of the catchment;
- Ptilotus fasciculatus (currently listed as Presumed extinct) known from Koobabbie Farm and Mailey's farm near SPS158 in the Buntine-Marchagee catchment and from Kondinin Salt Marsh. These specimens were previously determined as P. caespitulosus. The status of the taxon will be amended to Declared Rare Flora (extant);
- Hydrocotyle hexaptera ms (Priority 1), from the margins of SPS157, which is undescribed (although a manuscript name exists) and previously recorded only from Lake King; and
- Eremophila vernicosa ms (Presumed extinct) which was recently rediscovered on private land within the catchment.

Two other undescribed species were recorded from SPS157 and 158, namely *Halosarcia* sp. Gunyidi (M.N. Lyons 2607) and *Halosarcia* sp. aff. *undulata* (M.N. Lyons 2622). Based on current collections (all made during the Salinity Strategy survey of the northern wheatbelt), the populations at SPS157 and 158 represent the southern limit of the distributions of these species.

2.2 Fauna values

Upland fauna

A recent survey in the Buntine-Marchagee catchment by Harold (2000) recorded 51 species of bird, four non-volant mammals, six frogs and 24 reptiles but noted that considerably more species may be present. Harold will do additional surveys over the next two years. Sampling by CALM in Buntine Nature Reserve (which is not yet complete) found an additional two species of non-volant mammals and four reptiles. A large number of frogs were collected but await species-level determinations. Thirty-seven per cent of non-volant mammals known from the wheatbelt and 29 per cent of reptiles have been recorded in the Buntine-Marchagee catchment in recent surveys and it is likely that further surveys will increase these percentages.

Aquatic invertebrate fauna

A total of 104 species were collected in spring 1999 at the six wetlands sampled in the Marchagee area (Appendix 3). Although only two of the wetlands are in the Buntine-Marchagee catchment itself (SPS157 and 158), the others are in connected catchments and, taken together, the six wetlands give a more accurate impression of the fauna of the braided channels in the Buntine-Marchagee catchment than do SPS157 and 158 alone.

The braided channel wetlands of the Marchagee area contained a mix of salt-lake invertebrate communities, with salinity being the major factor determining community structure. There was an inverse relationship between salinity of a wetland at time of sampling and species richness: the number of species varied from 11 in SPS157, which was almost three times saltier than seawater, to 61 in the slightly brackish SPS203. The types of species also varied according to salinity, with salt

lake specialists in the saltier wetlands and a large number of ubiquitous freshwater species in brackish wetlands.

Visual inspection suggests the braided channels of Buntine-Marchagee catchment contain all the wetland habitats represented by the six wetlands in Table 2. The braided channels support a significant proportion of the regional invertebrate fauna, especially salt-adapted species. The total number of aquatic invertebrate species in the wheatbelt is probably around 800 (Pinder et al. 2000) and, with 104 species recorded in spring 1999, the braided channel supported about 13 per cent of the whole wheatbelt's aquatic invertebrate fauna and a very much larger proportion of the fauna typical of saline systems in the northern wheatbelt. Further sampling under different climatic conditions will increase the species list from the catchment.

Significant invertebrate species

Four of the species records from the braided channel wetlands are worthy of mention:

- Daphniopsis australis (a small cladoceran) was collected in Western Australia for the first time in SPS201 (previously this species was known from a few localities in eastern Australia);
- Daphniopsis sp nov, recorded from SPS158, is either an undescribed or recently named species not previously recorded from Western Australia;
- Sarscypridopsis sp. 165 (an ostracod) has previously been recorded only from in Dunn Rock Nature Reserve and the sediments of Lake Toolibin; and
- Calamoecia salina occurs across southern Australia in naturally saline wetlands but the SPS158 record was only the second from more than 150 Salinity Strategy wetland samples. The species has been recorded in Western Australia three times in recent years (see Maly et al. 1997).

Waterbirds

The braided channel wetlands of the Marchagee area do not contain major waterbird habitats supporting large numbers of birds. More important waterbird habitats occur further downstream in the Touche lakes, Capamouro Swamp and Lake Eganu. In spring 1999, after extensive flooding, the braided channels as a whole probably had a moderately diverse waterbird fauna but there were low numbers and few species in individual pans (Table 3). For example, the most species-rich braided channel wetland (SPS171) supported nine species and only 77 birds in spring 1999, while Capamouro Swamp supported 283 birds of 13 species. Counts at Lake Eganu have been much higher: 5,396 birds of nine species in spring 1998. Previous counts of ducks alone include 8,628 ducks of four species in autumn 1989 and 3570 ducks of 10 species in autumn 1990 (Halse et al. 1990, 1992).

Table 3. Waterbirds counted in the braided channel wetlands in the Marchagee area in spring 1999.

Waterbird	SPS157 Gunyidi Lake East*	SPS158 Gunyidi Lake West*	SPS171 Latham Lake	SPS172 Just's Lake	SPS201 Marchagee NR Lake West	NR
Black Swan			3			
Australian Shelduck	2	2				3
Australasian Shoveler			2			
Grey Teal		4	11		3	
Pink-eared Duck			12			
Hardhead			3		5	
Hoary-headed Grebe		11	28		2	22
Eurasian Coot			15			6
Black-fronted Dotterel			2			
Red-kneed Dotterel			1		2	
Red-necked Avocet		22			5	
TOTAL No. OF SPECIES	1	4	9	0	4	3
TOTAL No. OF BIRDS	2	39	77	0	11	31

3. Biological Values at Risk in the Buntine-Marchagee Catchment

Of the biological values outlined, rising watertables and salinity are less likely to affect the upland vegetation and probably the majority of the upland reptile and mammal species. However the loss of integrity in the area will have effects on fauna but these cannot be predicted at this stage. The wetland flora, and particularly the five species listed as of note, are at risk from the effects of rising watertables and salinity. The surveys so far have shown that the aquatic invertebrate fauna is potentially at high risk with significant differences in composition of the fauna of primarily and secondarily saline sites. This is particularly true of the four significant invertebrate species mentioned above.

4. Biogeographic Representation

The Buntine-Marchagee catchment straddles the boundary of the Geraldton Sandplains and Avon-Wheatbelt IBRA regions. The catchment includes vegetation typical of the northern Avon-Wheatbelt and the sandplain communities of the Geraldton Sandplains.

Thirty-seven per cent of non-volant mammals known from the wheatbelt and 29 per cent of reptiles have been recorded in the Buntine-Marchagee catchment in recent surveys and it is likely that further surveys will increase these percentages.

The braided channels of the Buntine-Marchagee Catchment support a significant proportion of the regional invertebrate fauna, especially salt-adapted species. The total number of aquatic invertebrate species in the wheatbelt is probably around 800 and, with 104 species recorded in spring 1999, the braided channel supported about 13 per cent of the whole wheatbelt's aquatic invertebrate fauna and a very much larger proportion of the fauna typical of saline systems in the northern wheatbelt. Further sampling under different climatic conditions will increase the species list from the catchment.

5. Opportunities for Research and Development /Demonstration Sites

This recovery catchment is the first braided naturally saline channel to be nominated as a Natural Diversity Recovery Catchment. As such it provides opportunities for investigating and demonstrating techniques of water control applicable to large areas of the Northern Agricultural Region and Wheatbelt. The Marchagee Catchment Group established plantings of maritime pines and sandalwood in 1999 and has plans for further plantings in 2000. Significant interest has been shown in Oil Mallee plantations in the area with plantations currently being established.

6. Tenure of Land at Risk

Rising saline water tables and the resulting salinisation are affecting both Crown reserves and private land, however, not all land in the catchment is at risk from salinity. Affected or potentially affected areas are mainly located in the floor of the catchment.

The Nature Reserves (management order with the NPNCA) within the catchment are:

- Buntine Nature Reserve, 26837 (1919 ha)
- Unnamed Nature Reserve 21175 (121 ha)
- Unnamed Nature Reserve 28669 (157 ha) *
- Unnamed Nature Reserve 38401 (107 ha)*
 - *Threatened by rising water tables

The management order for Buntine Reserve, 16379 (1370 ha), is with the Minister for Water Resources. The purpose of the reserve is Water and Conservation of Flora and Fauna. The reserve is considered to be of high conservation value. It is therefore proposed to commence negotiations to vest the majority of the reserve with the NPNCA.

Many of the naturally saline Playa lakes in the catchment are Unallocated Crown Land. The potential for vesting these areas with the NPNCA will be explored.

7. Representation of hazard

The salinity hazard situation in the Buntine-Marchagee Catchment differs from existing Natural Diversity Recovery Catchments in that:

- the area is threatened by rising water tables but has not yet reached a critical stage;
- it is naturally saline and at risk mainly from secondary salinity;
- the system is based on a braided drainage channel rather than a lake system; and
- the system represents the agricultural lands to the east of the Darling Fault and in the Northern Agricultural Region.

Although braided channels are common in the Wheatbelt as a whole, no attempts at restoring or recovering this form of wetland have been undertaken. As this has not been attempted previously no assurance of success can be given, however the information gathered from attempting recovery activities in this catchment will be applicable across a very large area of the Wheatbelt.

8. Potential for success

Hydrological changes

The hydrology of the area is poorly understood due to a lack of long term data. The results of the Agriculture WA Focus Catchment project in the Marchagee Catchment, although unpublished, suggest that some 14.5 per cent of the arable areas of the catchment have become saline and this may increase to 20 per cent in the next 10 years.

Within the Marchagee Catchment dramatic increases in the volumes of some sandplain perched lake systems have been observed in the last ten years. Many of these areas are not highly saline at this stage.

A series of approximately 60 monitoring bores have been installed in the Marchagee Catchment in the last 18 months. Although no trend data are available at this early stage, results show shallow water tables exist in the valley floors. These areas are likely to be susceptible to small changes in the water table.

Catchment characteristics

The catchment covers approximately 140 000ha. Land Monitor data show that only 4 per cent of the Marchagee Catchment is vegetated. However the techniques used in determining the vegetated areas are aimed at determining woody vegetation greater then 2 metres high with more than 15-20 per cent vegetation cover. This under-represents the true vegetated area in the catchment as the naturally saline drainage channels, often dominated by samphire and low-density shrublands, are often not captured. It is estimated that the area of remnant vegetation incorporating the samphire flats and significant vegetated areas outside the Marchagee Catchment but within the Buntine–Marchagee Catchment is likely to be closer to 8-10 per cent of the total area.

Local Support

The Recovery Catchment encompasses a number of catchment groups based on a combination of physical and social groupings. The groups are the Coorow Land Conservation District Committee, Marchagee Catchment Group, the Waddy Forest Land Conservation District and the East Maya Land Conservation District.

The Marchagee Catchment Group covers the majority of the catchment. The group has been very active with the appointment of a Bushcare Support Officer to the Coorow LCDC to assist with the implementation of an NHT funded project beginning in 1998. The NHT project "Marchagee Catchment Bushcare Project" was funded in 1998/99 and has continued in 1999/2000 with a planned

continuation to 2000/2001. Bushcare support for the group has resulted in a high level of understanding of nature conservation and the role of CALM. The Marchagee Catchment was an Agriculture Western Australia "Focus Catchment" in 1998, however the report on the area is still to be published. This delay in reporting results has resulted in a degree of disillusionment within the group. As a consequence the community consultation process to be conducted prior to commencing the recovery catchment will be of great importance.

The Waddy Forest Land Conservation District group has also been very active. The Waddy Forest group covers the north-western end of the Buntine-Marchagee Catchment and is responsible for a number of NHT funded projects. In 1998/99 the group was funded to conduct a survey of remnant vegetation of the Waddy Forest area. The group has recently assumed control from the Coorow Shire of the NHT funded project "Coorow Roadside Vegetation Rehabilitation".

The West Maya Land Conservation District Committee and Buntine-West Wubin Land Conservation District Committees have not been very active recently. These two groups cover the eastern edge of the Buntine-Marchagee catchment. Both committees are currently re-establishing themselves with newly elected officer bearers. Many of the landholders in this area and members of these committees are members of the Liebe Group, a very active group promoting whole farm planning benefits with a strong production orientation.

A series of meetings with the various groups is planned for the near future. Discussions with a number of local landholders and the Coorow LCDC Bushcare Support Officer have indicated that there is likely to be support within the local community for the area to become a Natural Diversity Recovery Catchment.

A number of local advocates have been identified. In addition the presence in the community of a Land for Wildlife Officer is beneficial and will assist with communications with the community. Strong local community support is also evident for the Coorow LCDC Bushcare Support Officer.

9. Socio-political Considerations

In the past the area has had little direct interaction with CALM apart from the involvement of Bushcare Officers. This project represents an opportunity to improve relations with the local Shires of Dalwallinu and Coorow and demonstrate CALM's role in biodiversity conservation and the Salinity Strategy.

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Figure 1. IBRA Regions of South western Australia Note: AW = Avon-Wheatbelt, GS = Geraldton Sandplains.

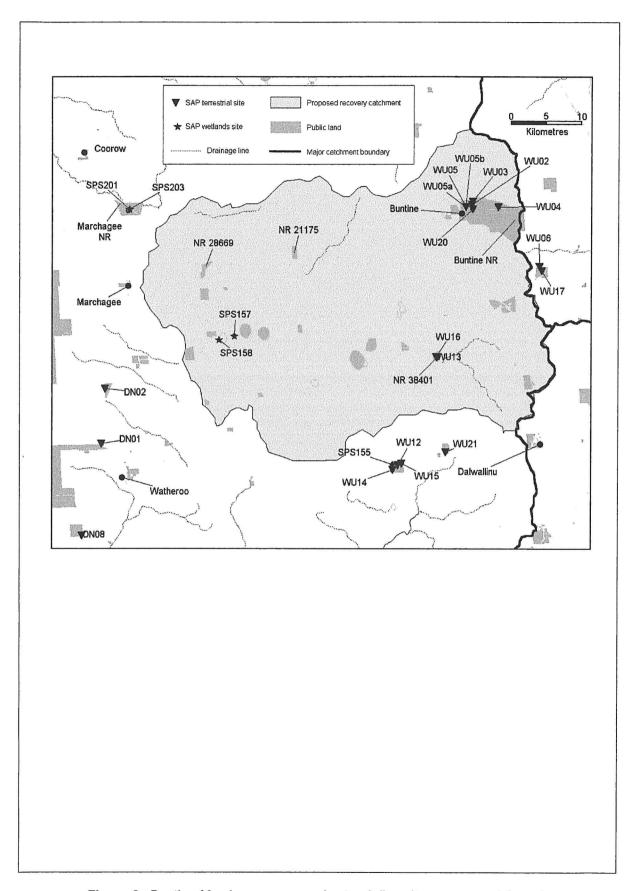


Figure 2. Buntine-Marchagee proposed natural diversity recovery catchment

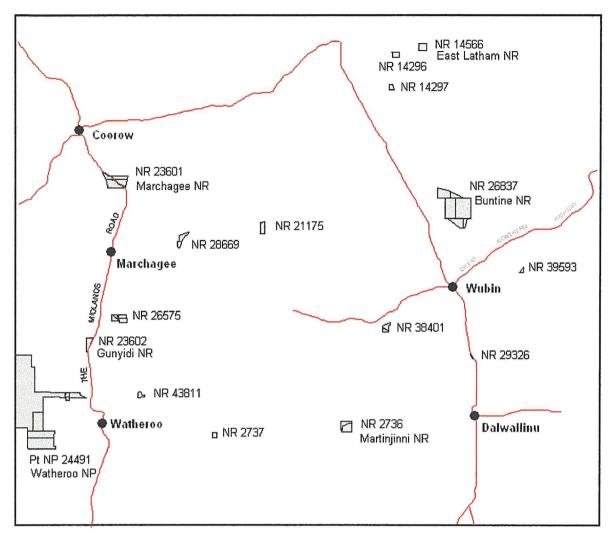


Figure 3. National parks and nature reserves located in (and surrounding) the Buntine-Marchagee proposed natural diversity recovery catchment

Appendix 1 Plant species recorded from wetland sites SPS157 and 158 in 1999

Aizoaceae

Disphyma crassifolium Gunniopsis septifraga Gunniopsis quadrifida Carpobrotus modestus

* Mesembryanthemum nodiflorum Tetragonia diptera

Amaranthaceae

Ptilotus divaricatus var. divaricatus Ptilotus gaudichaudii Ptilotus humilis subsp. humilis Ptilotus sp. Sunrise Hill (M.A.Burgman 4484)

Anthericaceae

Thysanotus manglesianus

Apiaceae

Hydrocotyle hexaptera P1 Trachymene ornata Trachymene cyanopetala Hydrocotyle pilifera var. glabrata Daucus glochidiatus Uldinia ceratocarpa Trachymene pilosa

Apocynaceae

Alyxia buxifolia

Asphodelaceae

Bulbine semibarbata

Asteraceae

Gnephosis setifera P1

- * Arctotheca calendula Erymophyllum tenellum Brachyscome lineariloba
- * Ursinia anthemoides
- * Urospermum picroides
- * Sonchus tenerrimus Gnephosis tridens Brachyscome iberidifolia Brachyscome perpusilla Lawrencella rosea Brachyscome pusilla

* Sonchus oleraceus Podotheca angustifolia Hyalochlamys globifera Fitzwillia axilliflora P2 Gnephosis angianthoides Gnephosis drummondii Cotula coronopifolia Rhodanthe polycephala

Waitzia acuminata var. acuminata * Hypochaeris glabra

* Osteospermum clandestinum

Senecio lautus subsp. maritimus

Senecio lautus Senecio glossanthus Dithyrostegia amplexicaulis Podolepis capillaris

Schoenia filifolia subsp. filifolia * Sonchus asper Rhodanthe manglesii

Podotheca pritzelii P2 Podolepis canescens Podolepis lessonii

Blennospora drummondii Podotheca gnaphalioides

Rhodanthe chlorocephala subsp. rosea

Pogonolepis stricta

Chthonocephalus pseudevax

Brassicaceae

* Brassica tournefortii Lepidium rotundum

Campanulaceae

Wahlenbergia preissii * Wahlenbergia capensis

Carvophyllaceae

* Petrorhagia velutina

Centrolepidaceae

Centrolepis polygyna Centrolepis humillima Centrolepis cephaloformis subsp. cephaloformis Centrolepis aristata

Chenopodiaceae

Didymanthus roei Enchylaena tomentosa Atriplex holocarpa Threlkeldia diffusa Sclerolaena eurotioides Sclerolaena diacantha Rhagodia drummondii Halosarcia fimbriata Atriplex hymenotheca Maireana carnosa Halosarcia syncarpa Halosarcia peltata

Halosarcia halocnemoides subsp. nov inland variant

Halosarcia indica subsp. bidens

Halosarcia pergranulata subsp. pergranulata Halosarcia sp. aff undulata (M.N.Lyons sn) Halosarcia sp. Gunyidi (M.N. Lyons 2607)

Crassulaceae

Crassula exserta

Crassula colorata var. colorata

Crassula colorata Crassula closiana

Cyperaceae

Schoenus nanus

Dasypogonaceae

Lomandra effusa

Droseraceae

Drosera zigzagia Drosera glanduligera

Frankeniaceae

Frankenia bracteata P1 Frankenia setosa

Gentianaceae

Sebaea ovata

Geraniaceae

Erodium cygnorum

Goodeniaceae

Velleia rosea Scaevola spinescens Goodenia berardiana

Goodenia pusilliflora P2

Haloragaceae

Gonocarpus nodulosus

Iridaceae

* Gynandriris setifolia

Juncaginaceae

Triglochin centrocarpum Triglochin mucronatum Triglochin sp. C Flora of Australia

Loganiaceae

Phyllangium sulcatum

Malvaceae

Lawrencia squamata

Mimosaceae

Acacia tetragonophylla Acacia acuminata Acacia eremaea

Myrtaceae

Melaleuca acuminata Eucalyptus loxophleba subsp. loxophleba

Ophioglossaceae

Ophioglossum lusitanicum Ophioglossum gramineum

Papilionaceae

Jacksonia arida

* Trifolium tomentosum

Pittosporaceae

Pittosporum phylliraeoides var. microcarpa

Plantaginaceae

* Plantago coronopus Plantago aff. hispidula ng & ml 1732

Poaceae

- * Ehrharta longiflora
- * Bromus rubens
- * Bromus japonicus
- * Parapholis incurva
- * Pentaschistis airoides
- * Bromus diandrus
- * Briza maxima
- * Lamarckia aurea
- * Vulpia myuros Eragrostis dielsii Austrostipa elegantissima
- * Schismus barbatus

Portulacaceae

Calandrinia polyandra Calandrinia granulifera

Proteaceae

Hakea preissii

Ranunculaceae

Clematis delicata

Santalaceae

Exocarpos aphyllus

Scrophulariaceae

* Parentucellia latifolia

Solanaceae

Nicotiana occidentalis

Stylidiaceae

Levenhookia leptantha Levenhookia dubia

Thymelaeaceae

Pimelea imbricata var. simulans

Urticaceae

Parietaria cardiostegia

Zygophyllaceae

Zygophyllum eremaeum

^{*}Introduced plants

Appendix 2 Threatened and priority flora known from the Buntine-Marchagee catchment

X - Declared rare flora (presumed extinct)

Amaranthaceae

Ptilotus fasciculatus

Myoporaceae

Eremophila vernicosa ms

R - Declared rare flora (extant)

Lamiaceae

Hemiandra gardneri

Mimosaceae

Acacia vassalii

Myoporaceae

Eremophila pinnatifida ms

Myrtaceae

Eucalyptus rhodantha var. rhodantha

Orchidaceae

Caladenia drakeoides ms

Papilionaceae

Daviesia dielsii

Gastrolobium appressum

Rutaceae

Boronia adamsiana

Priority 1

Apiaceae

Hydrocotyle hexaptera

Asteraceae

Gnephosis setifera

Chenopodiaceae

Halosarcia koobabbiensis ms

Chloanthaceae

Pityrodia axillaris

Frankeniaceae

Frankenia bracteata

Mimosaceae

Acacia pravifolia

Acacia trinalis

Myrtaceae

Eucalyptus subangusta subsp. virescens

Proteaceae

Grevillea pinifolia

Priority 2

Asteraceae

Fitwillia axilliflora Podotheca pritzelii

Goodeniaceae

Goodenia pusilliflora

Juncaginaceae

Triglochin stowardii

Lamiaceae

Microcorys tenuifolia

Proteaceae

Grevillea nana subsp. abbreviata

Rhamnaceae

Stenanthemum grandiflorum ms

Priority 3

Chenopodiaceae

Sarcocornia globosa

Goodeniaceae

Lechenaultia galactites ms

Lechenaultia juncea

Mimosaceae

Acacia filifolia

Acacia isoneura subsp. nimia

Acacia scalena

Myrtaceae

Calytrix plumulosa

Eucalyptus macrocarpa x pyriformis

Verticordia venusta

Proteaceae

Grevillea asparagoides

Grevillea granulosa

Persoonia chapmaniana

Priority 4

Proteaceae

Banksia benthamiana

Appendix 3
Aquatic invertebrates collected from braided channel wetlands in the Marchagee area in spring 1999

		SPS157 Gunyidi Lake East*	SPS158 Gunyidi Lake West*	SPS171 Latham Lake	SPS172 Just's Lake	SPS201 Marchagee NR Lake West	SPS20: Marchagee Lake Ea
PROTISTA							
Arcellidae	Arcella cf. catinus						1
ROTIFERA							
Hexarthridae	Hexarthra fennica			1		1	1
Brachionidae	Brachionus plicatilis		1	1	1		
	Brachionus rotundiformis			1			
	Keratella australis			1			
Colurellidae	Lepadella ovalis						1
Euchlanidae	Euchlanis dilatata						1
Lecanidae	Lecane bulla						1
	Lecane ludwigii			1			1
OLIGOCHAETA							
Tubificidae	Tubificidae						1
Enchytraeidae	Enchytraeidae					1	1
ARTHROPODA		(6)					
HYDRACARINA							
Eylaidae	Eylais sp.			1			1
Water mites'	Mesostigmata			1			
	Trombidioidea sp. 5					1	
ANOSTRACA							
Branchiopodidae	Parartemia sp.	1					
CLADOCERA							
Chydoridae	Alona rigidicaudis s.l.						1
	Alona cf. rigidicaudis s.l.			1			
	Alona cf. rectangula novaezelandiae			1			1
	Alona sp.			1			
	Pleuroxus sp.						1
Daphniidae	Daphnia carinata			1			1
	Daphniopsis australis					1	
	Daphniopsis pusilla				1		
	Daphniopsis sp.nov.		1				
Macrothricidae	Macrothrix sp. 1			1			1
	Macrothrix sp. 2			1			
OSTRACODA							
Cyprididae	Australocypris insularis	1	1		1	1	
	Bennelongia barangaroo			1			1
	Cyprinotus edwardi			1		1	1
	Diacypris dictyote				1		
	Diacypris compacta		1		1		

	Diacypris whitei	1					
	Diacypris sp. 562	•				1	
	Diacypris sp. 649 (aff. whitei)		1.			•	
	Mytilocypris mytiloides						1
	Mytilocypris tasmanica chapmani		1		1	1	•
	Platycypris baueri		1		1	•	
	Reticypris clava		1		1		
Cypridopsidae	Sarscypridopsis sp. 165 (Bennetts)			1			
COPEPODA	San soyp, naopona op. 105 (Semietts)			•			
Centropagidae	Boeckella triarticulata			1	1		1
Centropagidae	Calamoecia clitellata		1	•	**		1
	Calamoecia salina		1				
	Calamoecia sp. 342 (ampulla variant)			1			1
Cyclopoidae	Metacyclops arnaudi (sensu Kieffer)	1	1	1	1		1
Cyclopoldae	Metacyclops sp. 442 (salinarum in Morton)	1	1	1	1		1
	Australocyclops australis			1			
	Australocyclops similis			1			1
	Mesocyclops brooksi			1			1
				1		1	1
TTtiide!	Apocyclops dengizicus		1	1	4	1	
Harpacticoids'	Schizopera clandestina Harpacticoida sp. 626		1		1		,
A A MILITODIA	Harpaciicolda sp. 626						1
AMPHIPODA	Austrochiltonia subtenuis		,				40
Ceinidae ISOPODA	Austrochitionia subtenuis		1				1
Oniscidae	Haloniscus searlii					1	
COLEOPTERA	Halomscus searth					1	
Carabidae	Carabidae						
Haliplidae	Haliplidae						1
Dytiscidae	Allodessus bistrigatus			1			1
Dytiscidae	Antiporus gilberti			1			1
	Antiporus sp. (larvae)			1			1
				1			1
	Sternopriscus multimaculatus			1			1
	Sternopriscus sp. (larvae)	1	1	1	,	9	1
	Necterosoma penicillatus	1	1	1	1	1	1
	Necterosoma sp. (larvae)						1
	Megaporus howitti			1			
	Megaporus sp. (larvae)						1
	Platynectes sp. (larvae)						1
	Rhantus suturalis			1			
	Rhantus sp. (larvae)						1
	Lancetes lanceolatus			_			1
	Onychohydrus scutellaris			1			~~
	Bidessini (larvae)						1
Gyrinidae	Gyrinidae (larvae)			1			
Hydrophilidae	Berosus discolor		1				
	Berosus sp. (larvae)			1	1	1	1
	Hydrophilidae (larvae)			1			1

TOTAL NO OF S		11 92	22 37	51 5.3	19 53	24 21	62 4.2
	Triplectides australis			1			1
Leptoceridae	Oecetis sp.			1			1
TRICHOPTERA							
Hemicorduliidae	Hemicordulia tau			1			1
Aeshnidae	Hemianax papuensis			1		1	1
ANISOPTERA	atticopied and description atticopied and and an articles and an articles are also as a second and a second a			-		•	•
Lestidae	Austrolestes annulosus			1		1	1
ZYGOPTERA	1 1				•		
Pyralidae	Lepidoptera sp. 4				1	1	
LEPIDOPTERA	Anisops thienemanni			1			1
Notonectidae				1			1
Corixidae	Agrapiocorixa parvipunciaia Micronecta robusta			1			1
HEMIPTERA Corixidae	Agraptocorixa parvipunctata						
THEN AUDITED A	Cryptochironomus griseidorsum			1			1
	Polypedilum nubiferum			1			1
	Dicrotendipes lindae						1
	Dicrotendipes conjunctus			1			1
	Chironomus aff. alternans			1			1
	Chironomus tepperi			1			1
	Tanytarsus sp. A (nr. K10)			1	1		1
	Tanytarsus barbitarsis	1	1	_	1	1	
	Orthocladiinae sp. G					1	
	Ablabesmyia notabilis			1			1
	Procladius villosimanus			1			
Chironomidae	Procladius paludicola		1	1	1	1	1
	Muscidae sp. F					1	
Muscidae	Muscidae sp. A	1				• 527	
Ephydridae	Ephydridae	1	1	1.	1		1
Syrphidae	Syrphidae						1
Dolichopodidae	Dolichopodidae sp. A		1			1	1
Stratiomyidae	Stratiomyidae			1		1	
Tabanidae	Tabanidae	1	1		1		
Psychodidae	Psychodidae sp. 2					1	
	Nilobezzia sp. 2						1
	Monohelea sp. 1			1		1	1
Ceratopogonidae	Culicoides sp.	1	1		1		1
Culicidae	Aedes camptorhynchus		1			1	
DIPTERA	-						
Staphylinidae	Staphilinidae sp.	1					

Buntine-Marchagee Natural Diversity Recovery Catchment Facts

- The total area of the catchment is 181,008 hectares.
- > There are approximately 106 landholders in the recovery catchment.
- The average (median) size parcel of land managed by any one landholder is 1879 hectares.
- There are 23,704 hectares of remnant vegetation (13.1% of catchment).
- There are 56,479 hectares within the Coorow Shire (31.2% of catchment).
- There are 108,977 hectares within the Dalwallinu Shire (60.2% of catchment).
- There are 2,008 hectares within the Perenjori Shire (1.1% of catchment).
- There are 13,544 hectares within the Moora Shire (7.5% of catchment).
- There are 169,527 hectares of private property (93.7% of catchment).
- There are 2,225 hectares Department of Conservation and Land Management managed estate (1.2 % of catchment). See Table 1.

Table 1: CALM Managed Estate in Catchment Area

Name	Name Status	Tenure Category	Area (Ha)
Buntine Nature Reserve	Gazetted	Nature Reserve	1784.7290
Jocks Well Nature	Unofficial	Nature Reserve	39.9090
Reserve			
Nugadong Nature Reserve	Unofficial	Nature Reserve	10.3940
-	Un-named	Nature Reserve	389.9990

Total of CALM Estate = 2225

There are 1726 hectares of unallocated crown land (UCL) (1% of catchment).

There are 4888 hectares of 'other' type reserves (2.7% of catchment). See Table 2.

Table 2: 'Other' Reserve Types in Catchment area

Reserve Type	Area (Ha)
Road Train Assembley Area	4.1
Aerial Landing Ground	89.2
Agricultural Hall Site	0.5
Arboretum	2.3
Camping	4.6
Cemetery	4.0
Church Purposes Church Of	0.1
England	
Church Site Churches Of Christ	0.1
Church Site Roman Catholic	0.1
Conservation Of Flora	119.6
Conservation Of Flora & Fauna	129.5
Conservation Of Flora And Faun	156.6
Conservation Of Flora And Fauna	1908.9
Drainage	0.1
Effluent Disposal Site	0.4
Emergency Services	0.2
Excepted From Sale	0.3
Gravel	73.6
Hall Site	0.1
Hall Site R S L	0.1
Historic Site - School	0.4
Hotel Site	0.2
Memorial Hall Site	0.1
Public Building	0.1
Railway Purposes	7.5
Recreation	165.0
Recreation & Caravan Park	3.7
Recreation & Swimming Pool	233.9
Recreation Camping & Caravan	5.7
Park Recreation Childrens Playground	0.1
Recreation Golf Links	76.5
	2.0
Rubbish Depot	13.8
Sanitary & Rubbish Disposal Site School Site	3.5
Stock Yards	2.2
	0.7
Tank Site	7.0
Trigonometrical Station	452.3
Water & Comping	8.0
Water & Camping	0.0

Water & Conservation Of Flora &	1369.5
Fauna	
Water Supply	41.7

total 'other' reserves

4888.4

Table 3: Length of roads in Catchment area- by Road Type

Shire	Road Type	Length (km)
Coorow	MAIN ROADS	23.1
	SEALED & OTHER	50.6
	ROADS	
	UNSEALED ROADS	106.1
	TRACKS	167.7
	tota	l 347.5
Dalwallinu	HIGHWAY	17.2
	MAINROADS	51.2
	SEALED & OTHER	79.6
	ROADS	
	UNSEALED ROADS	357.6
	TRACKS	268.6
	tota	l 774.2
Moora	SEALED & OTHER	0.3
	ROADS	
	UNSEALED ROADS	25.2
	TRACKS	37.1
	tota	l 62.6
		anguaran an ann an
Pereniori	UNSEALED ROADS	13.2

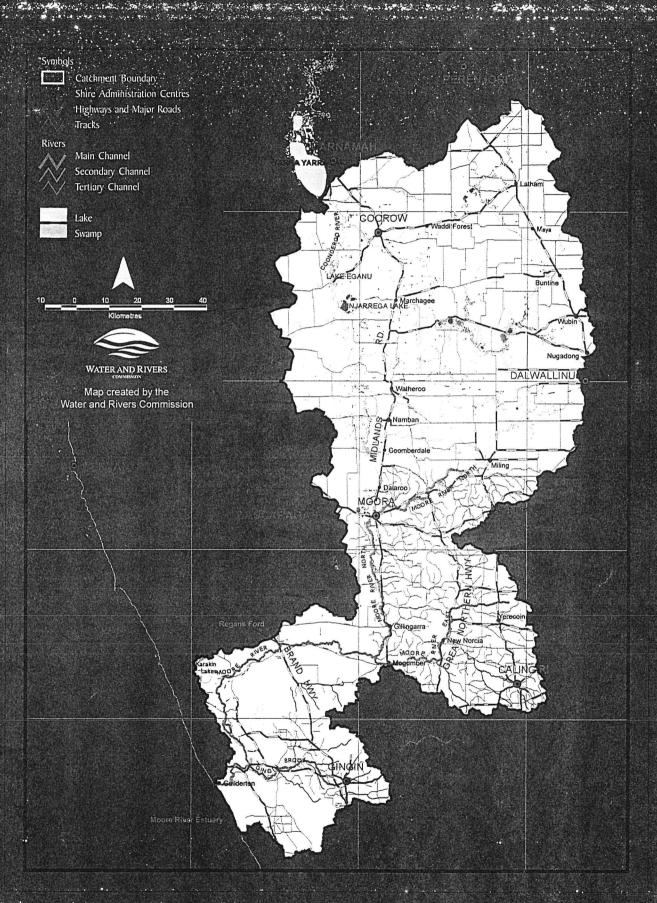
grand total

total

1197.4

	BUNTINE-MARCHAGEE NATURAL DIVERSITY RECOVERY CATCHMENT STEERING COMMITTEE						
Full Name	Representing	Comments	Phone	Fax	Mobile	Postal Address	
Alison Doley	Waddi LCDC	Landholder and president of the Waddi LCDC	9952-3211	9952-3212		Koobabbie', Coorow WA, 6515	
Ann-Maree O'Callaghan	Department of Conservation and Land Management	Bushcare Facilitator - Midwest Region	9964-0908	9921-5713	438914970	PO Box 72, Geraldton, WA 6531	
Anthony Desmond		Regional Leader Nature Conservation - Midwest Region	9964-0912	9921-5713	419919097	PO Box 72, Geraldton, WA 6532	
Cr Helen Nankivell	Shire of Dalwallinu	Landholder	9668-1010	9668-1010		Post Office, Wubin, WA 6612	
Dr. Stuart Halse	Department of Conservation and Land Management	Principal Research Scientist - Woodvale	9405-5136	9306-1641		PO Box 51, Wanneroo, WA 6946	
Fiona Falconer	Department of Conservation and Land Management	Landholder, Land for Wildlife Officer, MCG, and member of the Moore Catchment Council	9952-1074	9952-1074		Wynmara', Box 84, Coorow, WA 6515	
Greg Keighery	Department of Conservation and Land Management	Principal research scientist - Woodvale	9405-5142	9306-1641		PO Box 51, Wanneroo, WA 6946	
Jodie Watts	Department of Conservation and Land Management	Recovery Catchment Officer - Midwest Region	9964-0914	9921-5713	428919995	PO Box 72, Geraldton, WA 6532	
John Borger	Department of Agriculture	District Manager at Three Springs	9954-1004	9954-1115		Station Street, Three Springs, WA 6519	
Cr John Stacey	Shire of Coorow	Landholder, member of the MCG	99518246	99518268		PO Box 24, Coorow, WA 6515	
Kelly Gillen	Department of Conservation and Land Management	Regional Manager - Midwest Region	9964-0918	9921-5713	419941629	PO Box 72, Geraldton, WA 6532	
Liam Carter	Liebe Group	Landholder, member of the MCG and member of Liebe Group	9651-7053	9651-8204		PO Box 55, Watheroo, WA 6513	
Michael O'Callaghan	Marchagee Catchment Group (MCG)	Landowner, president of the MCG, member of Moore Catchment Council, member of the Liebe Group	9951-8282	9951-8282	429966900	Treeview Farm', Box 54, Coorow, WA 6515	
Noel Dodd	Systems of Landcare	Landholder, Private Consultant - Landcare Technician	9675-1050	9675-1059		Valour Downs', C/O Post Office, Kalannie, WA 6468	
Prof. Richard J Hobbs	Murdoch Uninversity	Professor of Environmental Science	9360-2191	9360-7412		School of Environmental Science, Murdoch Uninversity, Murdoch, WA 6150	
Roger Forte	Latham LCDC	Landholder, president of the Latham LCDC, and member of the Moore Catchment Council	9386-4004	NA		PO Box 105, Nedlands, WA 6909	
Ted Lefroy	CSIRO Sustainable Ecosystems	Principal Research Scientist	9333-6442	9333-6444	429990390	Private Bag 5, Wembley, WA 6913	
Vern Muller	Marchagee Catchment Group	Landholder, member of the MCG	9951-8212	9951-8212		Mamboobie Road, Coorow, WA 6515	

Do you live in the Moore Catchment?



'I think ... knowing the community and being involved in the community makes you belong.'

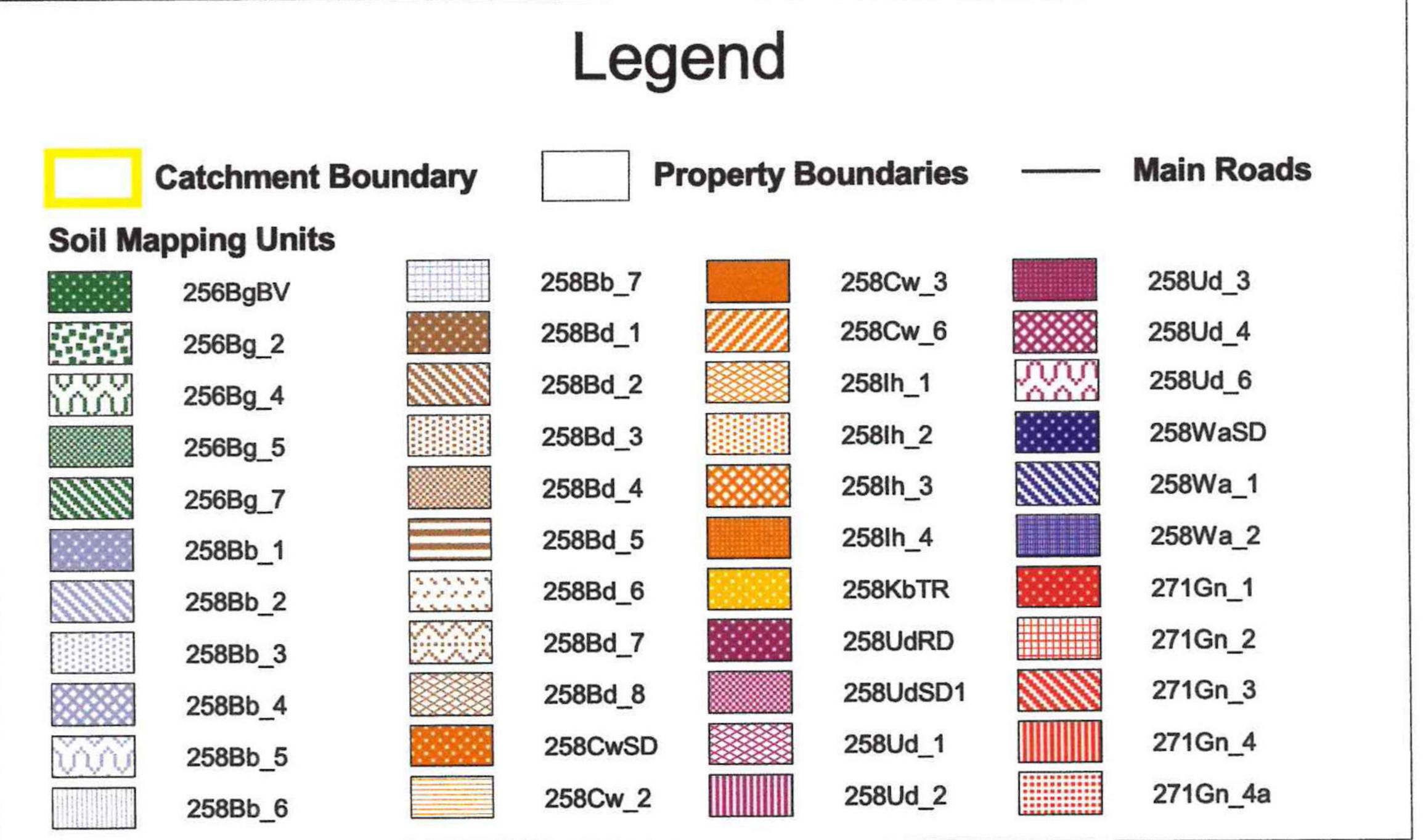
Michael Anspach, Moore Catchment Group

If you are interested in progressing the strategies contained in this document please approach your local Moore Catchment Group member. Up to date contact details are held at each Shire office.

Name	Department	Position	Phone Number	
Maria Lee	Department of Conservation and Land Management	Crown Reserves Officer, Midwest Region	9964-0910	
Ewan Buckley	Department of Conservation and Land Management	GIS officer for the Recovery Catchment	9334-0352	
Shane French	Department of Conservation and Land Management	GIS officer supervising Ewan	9334-0352	
Gordon Wyre	Department of Conservation and Land Management	Acting Director of Nature Conservation Division	9442-0302	
Keith Claymore	Department of Conservation and Land Management	Keiran sent two	9442-0300	
Keith Hockey	Department of Conservation and Land Management	District Manager Moora District	9652-1911	
Paul Roberts	Department of Conservation and Land Management	District Manager Merredin District	9041-2488	
Warwick Roe	Department of Conservation and Land Management	Wildlife Officer, Moora District	9651-1424	
Rachel Bagshaw	Coorow LCDC	Bushcare Officer - Coorow	9952-1236	
Andre Garnaut	Greening Australia	Bushcare Support - Officer	9921-8788	
Russell speed	Department of Agriculture	Hydrologist	9956-8561	
Mike Clarke	Department of Agriculture	Project Leader	9956-8527	

GRADUATIONS IN 1000 METRE INTERVALS

Soil Classifications Buntine-Marchagee Catchment

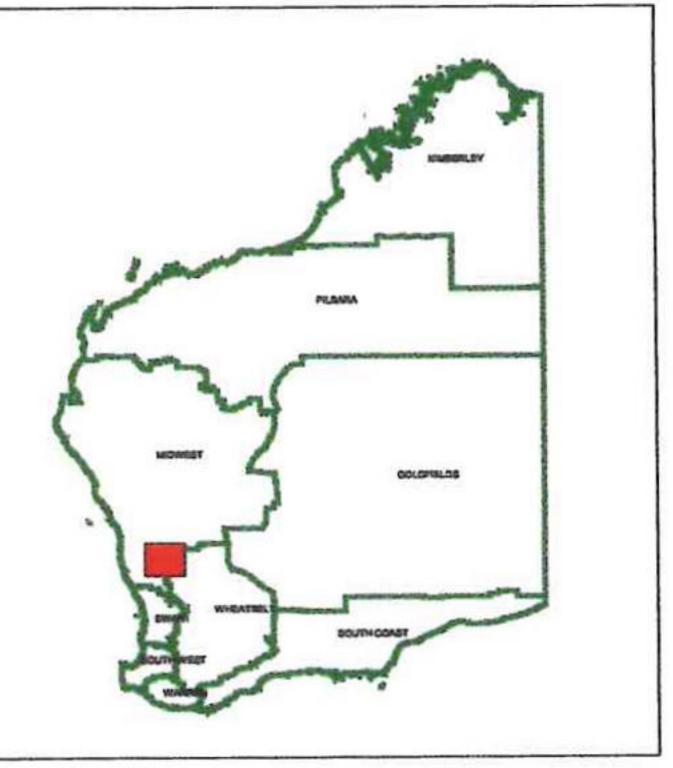


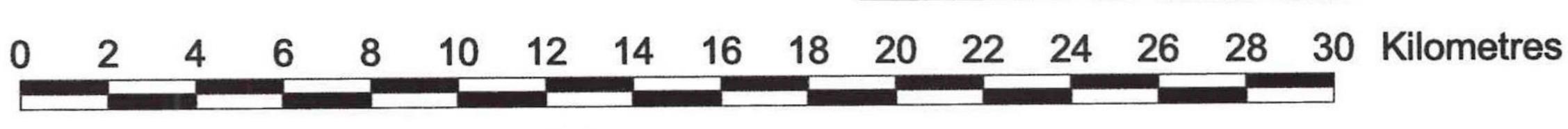
Mapping Unit code	Area (Ha) within catchment	Name	Description
256BgBV	None	Burabidge Hill Berkshire Subsystem	Alluvial plain of major tributaries of Moore River (from Gt), narrower and shallower with less Salmon Gum than Bv1 (dd17); loamy earths, loamy duplexes
256Bg 2	None	Burabidge Hill 2 Subsystem	No description
56Bg_4	None	Burabidge Hill 4 Subsystem	No description
56Bg 5	None	Burabidge Hill 5 Subsystem	No description
56Bg_7	None	Burabidge Hill 7 Subsystem	No description
	20087	Balgerbine 1 Subsystem	No description
258Bb 2	1273	Balgerbine 2 Subsystem	No description
	5135	Balgerbine 3 Subsystem	No description
		Balgerbine 4 Subsystem	No description
258Bb_4	1378	Balgerbine 5 Subsystem	No description
	709		No description
- Net-		Balgerbine 6 Subsystem	
258Bb_7	414	Balgerbine 7 Subsystem	Alluvial plain of major tributaries of Moore River (from Gt) narrower and shallower with less Salmon Gum than Bv1 (dd17); loamy earths, loamy duplexes
258Bd_1	1713	Ballidu 1 Subsystem	No description
258Bd_2	8047	Ballidu 2 Subsystem	No description
258Bd_3	6525	Ballidu 3 Subsystem	No description
	28384	Ballidu 4 Subsystem	No description
258Bd 5	None	Ballidu 5 Subsystem	No description
	4602	Ballidu 6 Subsystem	No description
258Bd 7	None	Ballidu 7 Subsystem	Valley floors, in the central Zone of Ancient Drainage, with alkaline red shallow loamy
230Du_r	140116	Damaa r Gabbyotom	duplex, alkaline grey sandy duplex (shallow and deep), calcareous loamy earth and
			hard cracking clay. Salmon gum-gimlet-wandoo-York gum woodland.
258Bd 8	2515		Areas of tertiary salinity; often heads of drainage lines shallow depressions and
	1		areas of recent salt encroachment. Soils are salt affected variants of red-brown
			hardpan shallow loams and other soils of adjacent systems.
258CwSD	229	Coorow Saline Drainage Subsystem	No description
258Cw_2	4813	Coorow 2 Subsystem	Alluvial slopes, very gently inclined hillslopes and hillcrests, some low dunes; yellow sands, sandy earths, sandy gravels
258Cw_3	None	Coorow 3 Subsystem	Plateau residuals, very gently inclined hillslopes and hillcrests; loamy earths, loamy gravels, clays, pale sands, stony
25005	None	Coorow 6 Subsystem	No description
258Cw 6	None		Hillcrests and upper slope; shallow red stony soils and rock outcrops.
258lh_1	1168		Gently inclined mid and lower slopes of variable length occurring below rocky outcrops
258lh_2	2268	Inering Hill 2 subsystem	
258lh_3	826	Inering Hill 3 subsystem	Level to very gently undulating valley flats often adjacent to saline drainage lines and subject to saline encroachment. Small areas of gilgai micro-relief.
258lh 4	959	Inering Hill 4	No description
258KbTR	None	Trayning Subsystem	Valley floors, in the central Zone of Ancient Drainage, with alkaline red shallow loamy duplex, alkaline grey sandy duplex (shallow and deep), calcareous loamy earth and hard cracking clay. Salmon gum-gimlet-wandoo-York gum woodland.
258UdRD	305	Upsan Downs RD subsystem	Undulating terrain with outcrops of gneiss or more level ground overlying laterite developed from gneissic rocks.
258UdSD1	5263	Upsan Downs Saline Drainage, phase 1	No description
		Upsan Downs 1 subsystem	Gently undulating rises and intervening shallow drainage swales
258Ud_1	20144		Similar to Ud1 but; gravelly soils more dominant.
258Ud_2	20314	Upsan Downs 2 subsystem	No description
258Ud_3	19149	Upsan Downs 3 subsystem	No description No description
258Ud_4	3517	Upsan Downs 4 subsystem	
258Ud_6	1808	Upsan Downs 6 subsystem	Minor valleys, commonly with secondary salinity
258WaSD	6262		Narrow drainage lines to broad level salt plains in broad mature valleys.
258Wa_1	1468	Wallambin 1 subsystem	No description
258Wa_2	10892	Wallambin 2 subsystem	No description
271Gn_1	None	Granada 1 subsystem	Undulating plain to low rises with broad convex gently inclined slopes.
271Gn 2	None	Granada 2 subsystem	Shallow, open depressions.
271Gn 3	6	Granada 3 subsystem	Lateritic breakaways and shallow soils overlying basement granite
271Gn 4	None	Granada 4 subsystem	Level to gently inclined alluvial flats and open depressions
271Gn_4a	None	Granada 4a phase	No description

Total area of catchment = 181,008 Ha



Map Grid of Australia Zone 50 Scale: 1:250,000 1mm = 250m



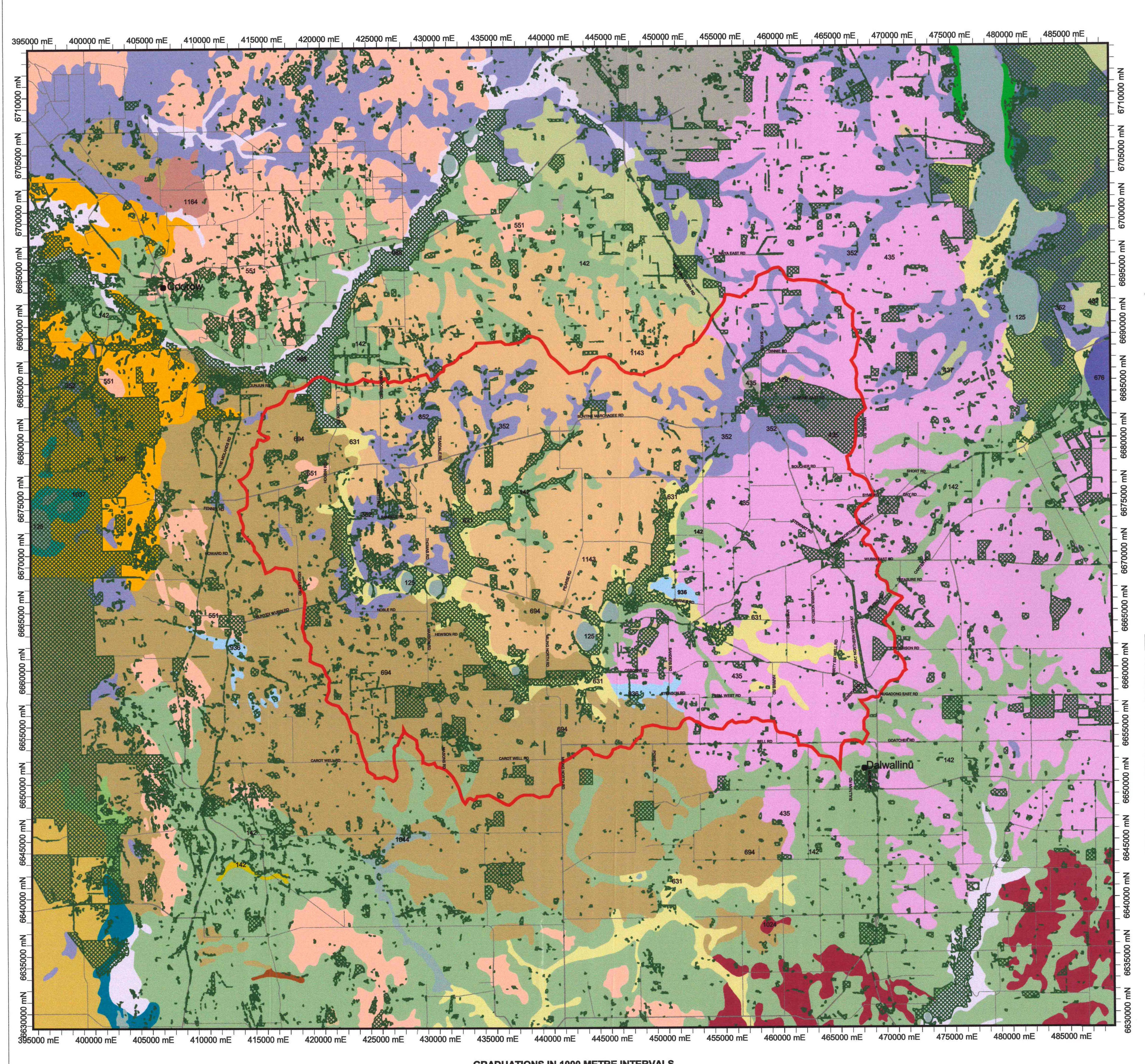




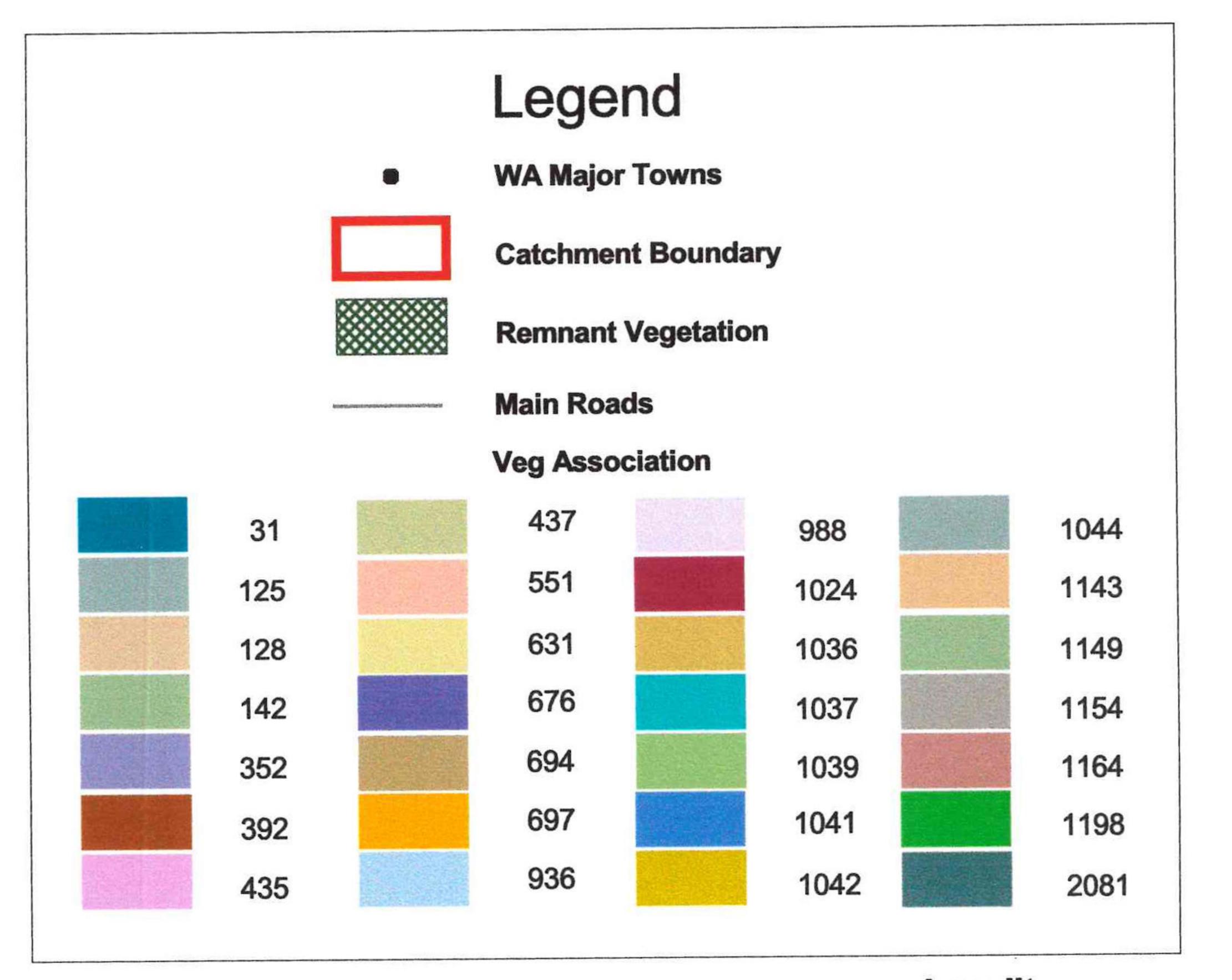
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Under the Direction of
Keiran McNamara Acting Executive Director
Department of Conservation and Land Management
February 26, 2002

Beards Vegetation Descriptions

Veg Association	Description	Area present within catchment (Ha)
31	Shrublands; Melaleuca thyoides thicket with scattered York gum	None
125	Bare areas; salt lakes	166
128	Bare areas; rock outcrops	288
142	Medium woodland; York gum & salmon gum	864
352	Medium woodland; York gum	2258
435	Shrublands; Acacia neurophylla, A. beauverdiana & A. resinomarginea thicket	5863
437	Shrublands; Mixed acacia thicket on sandplain	1
551	Shrublands; Allocasuarina campestris thicket	37
631	Succulent steppe with woodland and thicket; york gum over Melaleuca thyoides & samphire	5361
676	Succulent steppe; samphire	None
694	Shrublands; scrub-heath on yellow sandplain banksia-xylomelum alliance in the Geraldton Sandplain & Avon-Wheatbelt Regions	4993
697	Shrublands; scrub-heath on lateritic sandplain in the southern Geraldton Sandplain Region	None
936	Medium woodland; salmon gum	96
988	Succulent steppe with thicket; Melaleuca thyoides over samphire	488
1024	Shrublands; mallee & casuarina thicket	None
1036	Low woodland; Banksia prionotes	None
1037	Medium woodland; York gum & river gum (incl e6,18Mr?)	None
1039	Shrublands; mallee with scattered York gum	None
1041	Low woodland; Allocasuarina huegeliana & Jam	None
1042	Succulent steppe with low woodland; sheoak over samphire	None
1044	Mosaic: Medium woodland; York gum & salmon gum / Shrublands; Melaleuca thyioides thicket	None
1143	Shrublands; Allocasuarina campestris thicket with patches of heath	3123
1149	Shrublands; scrub-heath Acacia-Ecdeiocolia association in the south-east Geraldton Sandplain Region	139
1154	Shrublands; Acacia thicket with patches of heath	26
1164	Mosaic: Shrublands; scrub-heath on sandplain (banksia-xylomelum alliance) in the Geraldton Sandplain & Avon-Wheatbelt Regions / Shrublands; Allocasuarina campestris thicket	None
1198	Mosaic: Succulent steppe with thicket; Melaleuca thyiodes over samphire / Shrublands; bowgada open scrub	None
2081	Shrublands; bowgada and associated spp. scrub	None



Beard's Vegetation Classification and Remnant Vegetation cover Buntine Marchagee Catchment

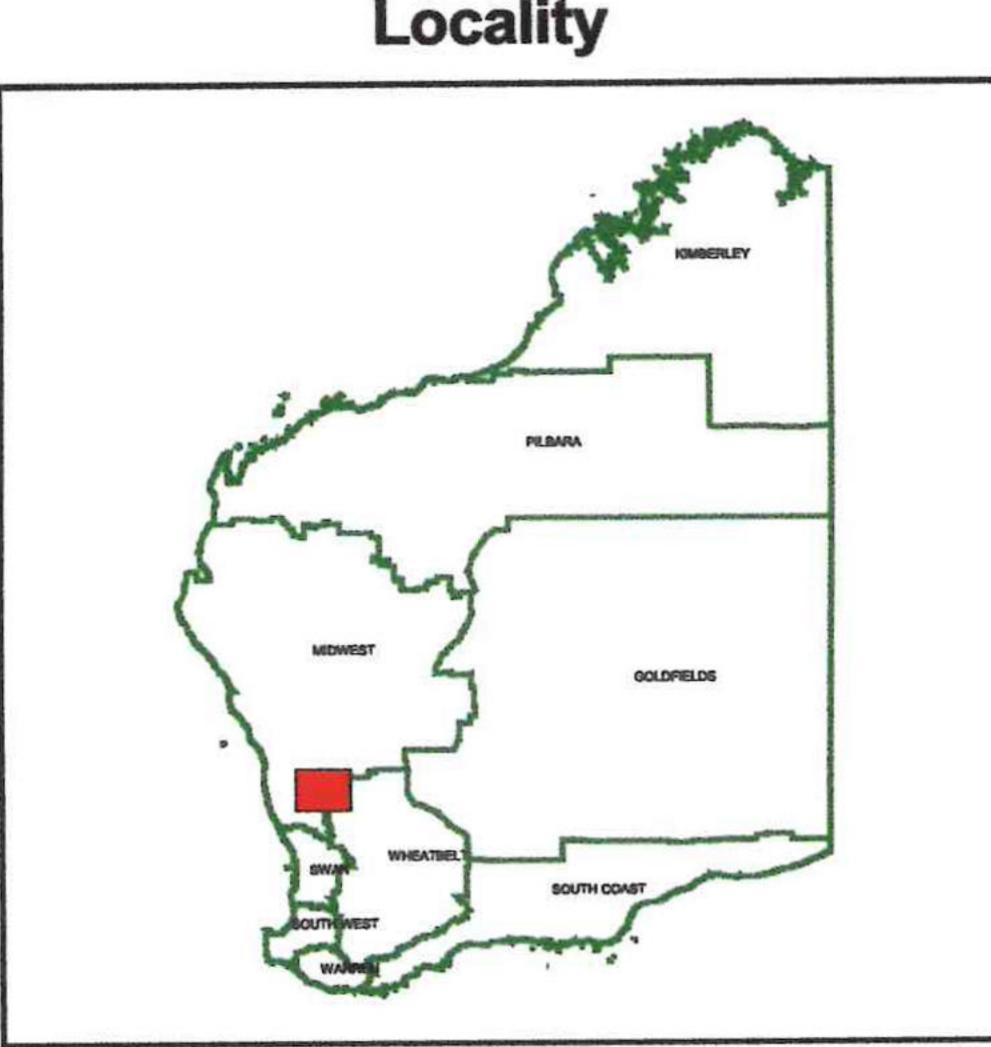




Map Grid of Australia Zone 50
Scale: 1:250,000
1mm = 250m

Beards Vegetation mapping captured at 1:250,000.

Remnant Vegetation Data derived from Landsat imagery at 25m resolution and georeferenced accurately.



Veg Association	essociation		Area present within catchment (Ha)	
31	Shrublands; Melaleuca thyoides thicket with scattered York gum		None	
	Bare areas, salt akas	163		
The state of the s	Bare areas, ruck uulurops	263		
	Medium woodland; York gum & salmon gum	064		
	Medium woodland; York gum	2250		
	Shublands; Acadia neurophylla, A. beauverdiana & A. resinornarginea thicket	5050		
	Shrublands; Mixec acacia thicket on sandolain	1		
	Shrublands; Allocasuarine campestre thicket	37		
631	Succulent stepse with woodlane and thickst; york gum over Me alcues thyoides & samphire	5351		
676	Succulent steppe: camphire	104/00	Nonc	
694	Shruplands; scrub-heath on vellow sandplain banksia-xylomelum alliance in the Geraldton Sandplain & Avon-Wheatbelt Regions	4993		
697	Shrublands; scrub-heath on lateritic sandplair in the southern Geraldton Sandplain Region		None	
936	Medium woodland; salmon gum	96		
	Succulent steppe with thicket; Melaleucs thyoides over samphire	483		
	Shrinlands; mallee & casuarra thicket		Name	
11 Hh	I nw woodland; Hanksia priorofes		Nane	
1037	Medium wordland; York gum & river gum (incl e5,18Vr?)		Nane	
1039	Shrublands; mallee with scattered York gum		None	
1041	Low woodland; Allocasuarira huegel ana & Jam		None	
1042	Succulent steppe with Icw woodland sheoak over samphire		None	
	Musais. Madium woodland, York gam & salmon gum / Shrublands, Melaleuda thyioides thickat		Naue	
1143	Shrublands, Allucasuarina campestris thicket with patches of heath	3123		
1149	Shrublands, scrub-health Acadia-Ecceicco ia association in the sputheast Gerald.cn Sandblain Region	139		
1154	Shublands; Acadia thicket with patches of heath	26		
1154	Mosaic: Shrublancs; scrup-heath on sandpair (banksia-xy or elum alliance) in the Geraldton Sandplain & Avon-Wheatbelt Regions		None	
	/ Ehrublands; Allocasuarina campestris : hicket			
1138	Mosaic: Succuent steppe with thicke:; Melaleuca thyiodes over samphire / Ehrublands; bcwgada oper scrub		None	
2031	Shruplands; bowgada and associated opp. scrub		Nonc	

Please Note: these figures are a guide only.

There will be errors associated with the relative innacuracy of Beard's Veg data, compared with Remnant Veg data.

Total area of catchment = 181,008 Ha



Produced by Information Management Branch
Under the Direction of
Keiran McNamara Acting Executive Director
Department of Conservation and Land Management
February 26, 2002

Growing sandalwood (Santalum spicatum) on farmland in Western Australia



Jonathan Brand and Peter Jones Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, Western Australia 6983

Introduction

The Western Australian sandalwood (Santalum spicatum) is a root hemiparasitic tree that contains fragrant timber. The distinctive sandalwood fragrance comes from oils contained in the heartwood. Sandalwood provides a valuable export industry in Western Australia, with logs shipped to many countries in southeast Asia. In these countries, sandalwood is commonly powdered and used to make joss sticks for the incense trade. Aromatic oils can also be extracted from the heartwood and used in the manufacture of perfumes, soaps and cosmetics.

Sandalwood is a small tree of 4 m (Figure 1) that occurs naturally in the southern half of Western Australia (Figure 2) and on the western border of South Australia. Natural stands of sandalwood were commonly harvested in the Wheatbelt before agricultural clearing, but today harvesting occurs mainly in the rangelands: the Goldfields and the Midwest. Harvesting is strictly controlled by the Department of Conservation and Land Management (CALM), in accordance with the provisions of the Sandalwood Act.

The potential exists to grow sandalwood on farmland and increase the resource base of this valuable industry. The most suitable areas to grow sandalwood are the medium rainfall (400–600 mm) regions of the Wheatbelt and Midwest. Since the early 1980s, CALM and Curtin University have examined methods to grow sandalwood on farmland. Sandalwood trials have been established in many locations, including Narrogin, Katanning, Dandaragan and Northampton. These trials are examining the effects of host species, stocking rate, fertiliser and provenance on sandalwood performance. The results from these trials have been used to formulate this establishment guide.

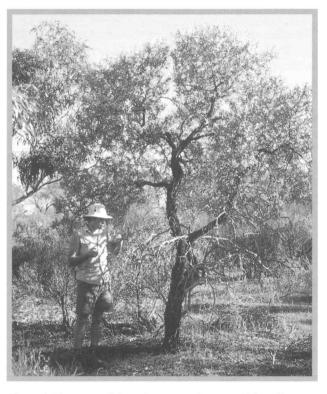


Figure 1. Mature sandalwood tree, growing near Kalgoorlie. Photo by J. Brand.

Site selection

The preferred site to grow sandalwood is a loam over clay, duplex soil type. However, sandalwood will also grow on gravels, yellow sands and red sands. The site should be water-gaining but well drained. Saline, waterlogged or heavy clay soils are not suitable.

Host species

Sandalwood is dependent on nutrients and water from host plants to survive and grow. The best hosts are nitrogenfixing trees, especially the wattles (Acacia species). Extensive trials have shown that jam (Acacia acuminata) is an excellent long-term host for sandalwood (Figures 3 & 4). A fast-growing, short-lived acacia, such as manna wattle (A. microbotrya), is also a good host but may not live long enough for the sandalwood to reach commercial size. Planting either all jam, or a combination of jam and manna wattle, will provide the sandalwood with a good supply of nutrients and water.

Host establishment

The site should be ripped in rows spaced 4 m apart and to a depth of 0.5 m. In early winter, spray the rows with a knock-down and residual herbicide to control weeds for the first year. Two weeks after spraying, plant the host seedlings along the rows at 3 m intervals (833 stems ha⁻¹). Plant rows with either all jam or alternate between manna wattle and jam. A 50 g fertiliser pellet containing NPK can also be applied next to each host to promote growth.

Sandalwood establishment

The most economic and efficient method of establishing sandalwood is by direct seeding. Sow the sandalwood seeds when the host trees are 1-2 years of age. The host trees need to be approximately 1 m tall before introducing sandalwood. In April, plant four sandalwood seeds approximately 0.5-1.0 m from each host. Sandalwood germination rates are about 50%, therefore this sowing density should provide at least one sandalwood seedling per host. Sow the seeds along the rip line, because the host roots will be more concentrated in this region. At each sowing 'spot' loosen the soil with a spade and sow the seeds 2-3 cm below the surface. Sandalwood seeds are available from the Manjimup Seed Centre (see sandalwood contacts), or from private seed suppliers.

Approximately two weeks after the break of the season (e.g. early June), spray each sandalwood 'spot', in a 0.5 m radius, with a knock-down herbicide. Ensure no spray touches the host plants. Weed control is very important before the sandalwood seedlings emerge. Weeds can smother the seedlings and reduce survival and growth. Sandalwood seeds take 4-8 weeks to germinate after good rains in late autumn or early winter. The sandalwood seedlings will emerge in July to August.

Sandalwood to host ratio

At age 5 years, the parasitic requirements of sandalwood trees greatly affect the survival and performance of the host. A ratio of one sandalwood to one host will place too much stress on the host. At age 3 years, the sandalwood to host ratio should be 1:2 or 1:3. Therefore an area with 800 jams ha⁻¹ should have no more than 400 sandalwood ha⁻¹, at age 3 years. This may require selective thinning of sandalwood throughout the area to achieve the right balance.

Grazing & fire

Sandalwood is readily grazed by domestic and feral herbivores. Prevent sheep, cattle, goats, kangaroos and rabbits from grazing the sandalwood. Sheep can be introduced when the sandalwood are 10 years old. Parrot numbers also need to be monitored because they can ringbark seedlings. Sandalwood trees are not fire-tolerant and the plantation will need a fire break.

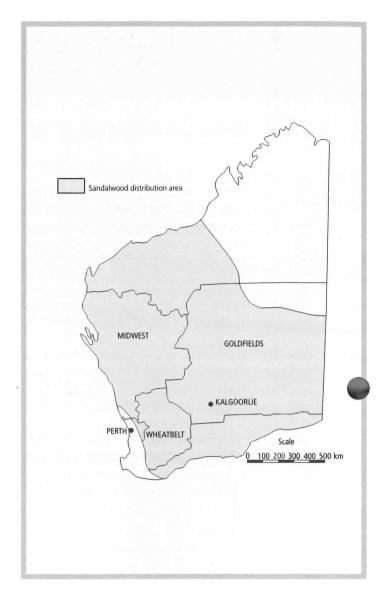


Figure 2. Sandalwood distribution and CALM regions in Western Australia.

Growth rate & fruit production

Sandalwood trees produce fragrant heartwood and oil at age 5-10 years, and the trees should reach a stem diameter of 125 mm (at 150 mm above the ground) at age 20 years. A stocking rate of 200-300 stems ha⁻¹ should yield 2-3 tonnes of commercial timber at age 20 years.

After age 5 years, an individual sandalwood tree can produce up to 200 mature nuts per annum. Each nut is 2-3 cm in diameter and there are approximately 400 nuts kg⁻¹.

Sandalwood seeds from a plantation have a high rate of germination and are therefore a good seed source for further plantings. The sandalwood nuts also contain an edible kernel, similar in composition to commercial nut species, such as as almonds, peanuts and macadamias. Studies by Curtin University show that sandalwood kernels contain 60% fat, 18% protein and 16% carbohydrate. Therefore, the nuts have the potential to provide a source of income while waiting for the timber to reach commercial size. Sandalwood trees flower in March–May and the fruits mature in August–November.

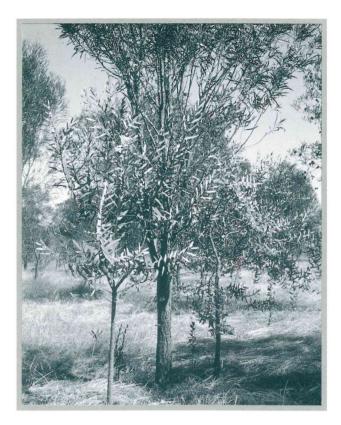


Figure 3. Three-year-old sandalwood growing beneath an eightyear-old jam (A. acuminata). CALM sandalwood trial near Katanning. Photo by J. Brand.

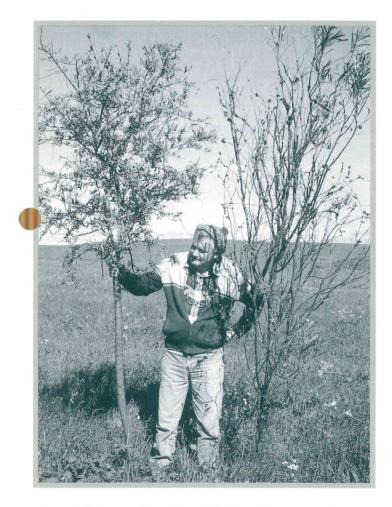


Figure 4. Eight-year-old sandalwood (left) growing next to a nine-year-old jam (right). CALM sandalwood trial near Northampton. Photo by J. Brand.

Provenance selection

Provenance trials have been established by CALM to identify superior types of sandalwood, and its preferred host *A. acuminata*. The aim is to examine the range in sandalwood and select the trees that are fast growing and produce high quantities of fragrant oil.

The effect of different *A. acuminata* provenances on sandalwood growth is also being studied to identify the best type of *A. acuminata*. The seeds from the superior sandalwood and *A. acuminata* will be used in future plantings.

Further reading

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Sandalwood contacts

The information contained here is up to date at the time of printing. For the latest developments or for information on other sandalwood matters please contact the following CALM branches:

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Katanning District Office

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Geraldton District Office

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he Wheatbelt of Western Australia stretches from Kalbarri to east of Esperance. It contains all or significant parts of six (Geraldton sandplains, Swan Coastal Plain, Avon-Wheatbelt, jarrah forest, mallee and Esperance sandplains) of the eight biogeographic regions recognised in temperate southwestern Australia. The south-west is an area of megadiversity for flowering plants on a world scale.

Rising saline groundwater—the result of clearing—threatens about 30 per cent of the agricultural area of Western Australia (see 'Halt the Salt', *LANDSCOPE*, Spring, 1997). This will have major impacts on the region's native plants and animals. To help plan to protect them, the Salinity Strategy needed detailed information. As a result, a four-year systematic survey of Wheatbelt plants and animals is being undertaken by CALMScience Biological Survey Group, together with scientists from a range of agencies and specialists.

WILDFLOWER WONDERLAND

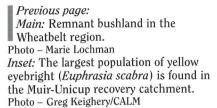
The survey has established more than 660 survey sites (quadrats) throughout the Wheatbelt to record terrestrial flora. Another 200 sites have been established as part of a community survey on private and local government lands.

The agricultural zone has an estimated 4,000 species of flowering



plants, and more than 60 per cent of these grow nowhere else. The region is the centre of diversity for many of the species-rich genera of trees and shrubs (such as *Acacia*, *Dryandra*, *Eucalyptus*, *Grevillea* and *Verticordia*) that characterise the south-west of Western Australia.

More than 850 flowering plant species are found only in fresh or naturally saline lowlands, which are directly threatened by groundwater and salinity. Several hundred other species found only in woodland sites will also be threatened in the longer term. One aim of the plant survey is to identify native species with potential for revegetation. A database of species that grow in naturally saline areas of the agricultural zone is being compiled, together with lists of all flowering plants in the area and their conservation status.



Below: The biological diversity of the Wheatbelt has been shown to be much higher than was previously thought.

Photo – Jiri Lochman

It is already abundantly clear that the biodiversity of the agricultural zone is much higher than was previously thought. For example, detailed surveys of the Lake Muir-Unicup reserves have documented almost 1,000 species of flowering plants (considerably higher than the wildflower-rich Mount Lesueur area). The small Quairading Shire Reserve (surveyed by community volunteers) has more than 500 plant species, including two that are new to science and the largest populations of two critically endangered taxa.

Quadrats in the agricultural zone contain at least 20 and sometimes more than 90 species, the equal to most heathland areas, normally considered the most species-rich sites. This richness is often found in the small herbs of the low-lying woodlands, rather than in the shrubs, as seen in the northern and southern heathlands.

The biological survey has rediscovered one presumed extinct aquatic plant, and found four previous unknown species. Genetic studies of Wheatbelt species are showing high levels of variation between populations of widespread species.

PLANTS AT RISK

The survey has also established that naturally saline areas have very high biodiversity values. At least 64 threatened and priority taxa (species, subspecies or varieties) are restricted to these areas and several new taxa have been discovered during the survey. Priority taxa are those whose conservation status is of concern, and many are likely to be formally classified as threatened once there has been sufficient survey to determine their true status. These plants, and the communities in which they occur, are at major risk from rising water tables as



Right: Increasing salinity threatens the endangered long-leaved myrtle (Hypocalymma longifolium).
Photo – Greg Keighery/CALM

Below right: The largest known population of Chapman's acacia (Acacia chapmanii subsp. australis) is being destroyed by a spreading saline seep in a nature reserve near Bolgart. Photo – Greg Keighery/CALM

they are adapted to fresh water flushing in winter and to summer drought, not to flooding with saline water. The survey is revealing major regional floristic differences in the salt lake chains occupying ancient drainage stems. Conserving these areas will be particularly challenging.

More than 1,500 of the 4,000 species in the agricultural zone grow low in the landscape, in riverine valleys, fresh water or primarily saline lands. Of these, 450 grow only in the Wheatbelt and are in grave danger of extinction as a result of the encroaching salt. Another 400 to 500 species, subspecies or varieties are centred in the agricultural zone, but not confined to it. These taxa are subject to major genetic erosion, as salinisation and hydrological changes may wipe out many of their populations.

affected Areas by secondary salinisation also show major declines in biodiversity. Rich and complex plant mmunities are replaced by a few succulents and weeds. Most lowland communities, including tall woodlands, mallee and melaleuca shrublands, freshwater and naturally saline wetlands, will be lost unless remedial action is taken. The Wheathelt will lose much of its landscape character with the loss of these communities and paddock trees.

The subterranean cave communities, areas of species-rich heathland and temporary wetlands of the northern sandplains and Swan Coastal Plain are threatened by both rising fresh and saline groundwaters. Paradoxically, the increased fresh water is threatening these heathlands because they contain many plants susceptible to dieback (*Phytophthora* species).

Members of the WA Wildflower Society have surveyed about 200 sites





on private and local government lands. More importantly, they have helped farmers (and scientists) see the incredible and often unique biodiversity in their own bush. Allowing city and country people to meet and share knowledge in these relaxed but wonderful settings provides some immensely satisfying networking. Detailed reports and field herbaria on the areas surveyed are provided to the landholders and major libraries.

WILDLIFE

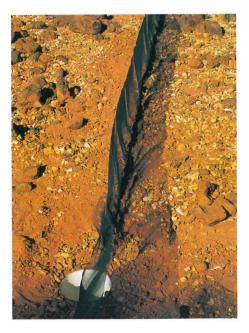
To survey the wildlife, more than 300 biodiversity quadrats (where animals and plants are sampled) have been established across the Wheatbelt. Like the flora sites, they are placed in less disturbed examples of the main landscape types, as well as on a

salt-affected example where this has occurred. Lines of pitfall traps are used to sample ground-dwelling invertebrates (spiders, scorpions and centipedes) and vertebrates (small mammals, reptiles and frogs). All these animals are relatively immobile and have to cope with salinity, rather than fly to a more hospitable home.

The central band of the agricultural zone was sampled in 1997–98, and all animals have been identified. The northern band was sampled in 1998–99 and the vertebrates and most of the invertebrates identified. The southern band was sampled during 1999–2000. The remaining areas around Dandaragan and Esperance are being sampled in 2000–01. During 2000–01, Birds Australia is also surveying birds on a selection of the biodiversity sites.









The study has already dramatically increased knowledge of the distribution, status and habitat of small Wheatbelt animals. For example, the survey of the central band identified 33 scorpion species (only 13 had been previously recorded for the entire Wheatbelt), 24 centipedes (23 previously recorded) and 329 spiders (128 previously recorded). Sixty to 70 per cent of spiders were undescribed.

In the northern and central bands, 113 species of small ground-dwelling reptiles, mammals and frogs were recorded, compared with Museum records of 130 species for the whole agricultural region.

ANIMALS AT RISK

The distributions of at least 40 per cent (210 of more than 500 species) of the region's spiders, centipedes and scorpions and 25 per cent (31 of 125 species) of its small ground-dwelling vertebrates are centred on the agricultural region or endemic to it. Different communities of species occur on different soil types within survey areas (sands, clays, loams and so on).

Secondarily saline quadrats (even partially affected) have around 30 per cent fewer species than their non-salinised counterparts. The fall is more dramatic when one realises that widespread 'weedy' spiders replace some of the localised specialists normally found in these habitats.

WETLANDS

The full range of wetland types within the study area will be sampled, ranging from rivers to fresh and

Top left: Andrew Storey sampling for aquatic invertebrates in the Lake Muir recovery catchment.

Photo – Greg Keighery/CALM

Above left: Members of the Wildflower Society of WA and local volunteers have surveyed about 200 sites on private and local government lands. Photo – Greg Keighery/CALM

Far left: Small animals are sampled using pitfall traps.
Photo – Marie Lochman

Left: Animals such as the numbat are relatively immobile and have to cope with the effects of salinity.

Photo – Jiri Lochman

naturally saline wetlands to secondarily saline wetlands. The 225 wetlands sampled for aquatic invertebrates had about 650 quadrats established on them to document the flora of these wetlands. Another 30 wetlands and about 100 quadrats are being sampled this year.

Many new records, and major range extensions, of rare and priority flora have already been uncovered. Several new samphires (*Halosarcia* spp.) have been discovered.

Only 16 of the 61 more common waterbird species in the south-west prefer strongly saline or hypersaline conditions. A 1981-85 survey showed that an average of five waterbird species used hypersaline wetlands, compared with 20 in saline wetlands and 40 in fresh wetlands with live trees and shrubs. The death of shrubs and trees in many Wheatbelt wetlands due to salinity caused a 50 per cent decrease in the number of waterbird species using them. If salinity continues to increase, only 16 species, plus three or four species that use freshwater dams, will persist in the Wheatbelt out of an original waterbird fauna of more than 60 species.

AQUATIC LIFE

About 700 invertebrate species have so far been collected from Wheatbelt wetlands. About 50 per cent appear to be described and about 15 per cent (some 105 species) are only known from the Wheatbelt. Numerous species appear to be restricted to naturally saline wetlands, including fairy shrimps, snails, ostracods and copepods (tiny crustaceans). If all wetlands in the Wheatbelt became saline, up to 218 species (31 per cent of the aquatic fauna) would disappear from the Wheatbelt.

Species richness declines with salinity. Most fresh wetlands contain about 50 invertebrate species, compared with only four in the most hypersaline areas. As a rule of thumb, doubling salinity halves the number of aquatic invertebrate species.

ROAD TO RECOVERY

The biological survey will identify at least 10 potential natural diversity recovery catchments by 2001. Eight areas have so far been selected for their biodiversity and level of risk from

salinity. These catchments are to be managed (through revegetation, remedial engineering work and so on) to protect their biodiversity from salinity, with dedicated staff and budgets. Work is already well advanced on the Esperance Lakes, Toolibin Lake and the Muir-Unicup wetlands. Action commenced in April 1999 to protect Lake Bryde, especially its lakebed community (already listed by CALM as a threatened ecological community) and

Below: The crested grebe is one of many waterbird species that may disappear from the Wheatbelt if salinity continues to increase.

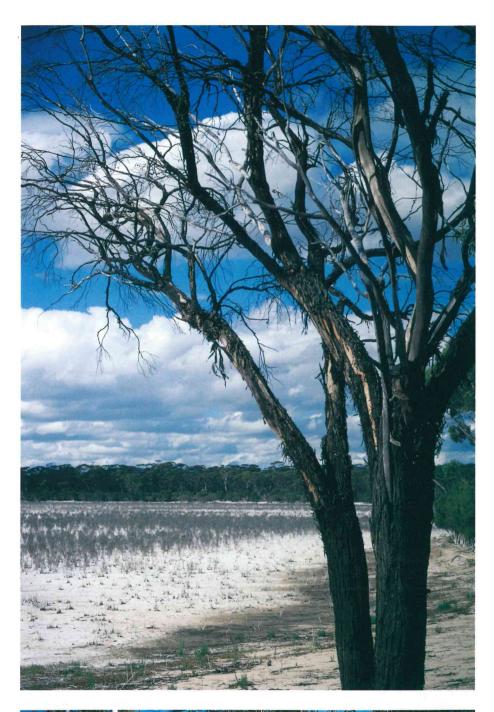
Photo – Babs & Bert Wells/CALM

surrounding vegetation. The values of the fifth recovery catchment, a series of naturally saline braided channels in the Watheroo area, have been documented and work is commencing. A report on biodiversity values has been prepared on a small-scale recovery catchment around Drummond Nature Reserve near Bolgart. Preliminary work has also been done on two other potential recovery catchments to protect wandoo woodlands and naturally saline areas.

Bottom: The survey recorded 33 species of scorpion in the central zone, 20 of which had not been found before in the Wheatbelt.
Photo – Jiri Lochman









Left: The lakebed community at Lake Bryde is listed as a threatened ecological community. Photo - Greg Keighery/CALM

Below left: A temporary fresh water creek lined with sundews (Drosera species) in Wheatbelt wandoo (Eucalyptus capillosa) woodland at a reserve near Bruce Rock. Photo - Greg Keighery/CALM

At the same time, CALM, in partnership with landowners across the Wheatbelt (see 'A Crop of Forests', LANDSCOPE, Spring 1999), has been planting areas of cleared and often unproductive farmland with maritime pine to lower the water table and help fight salinity. Such plantings provi returns for farmers while helping them care for their land and hence are a positive step in protecting catchments and ultimately threatened ecological communities.

The survey will provide an overview of the distribution and conservation needs of the terrestrial plants and animals of the Wheatbelt, Almost 1,000 sites will have been established that can be used for monitoring well into the future.

Longer-term studies of individual recovery catchments, and more detailed surveys of communities and regions identified, will be needed after the survey is completed in 2001. Monitoring of actions to recover catchments, and control and rever salinity, will be needed to fine tune management actions, especially in regard to potential weeds, drainage, gypsum mining and other disturbances.

Hopefully, it is not too late to intervene and save the unique plants, animals and landscape of the remarkable Wheatbelt area.

Greg Keighery is a Principal Research Scientist with CALMScience, based at CALM's Wildlife Research Centre at Woodvale. He can be contacted on (08) 9405 5100 or by email (gregk@calm.wa.gov.au).

The complete results of the survey will be published in a wide variety of formats (both scientific and popular) to ensure that the information is available to anyone who needs it.

Help Save The Malleefowl!

Have you seen one of these?

The malleefowl is a large, attractive bird, best known for the remarkable incubation mounds it builds for its eggs.

These rounded mounds are often used year after year, growing in size up to 5 metres in diameter and 1.5 metres high.

The malleefowl was once common and widespread throughout southern Australia, providing food for Aborigines, early explorers and settlers.

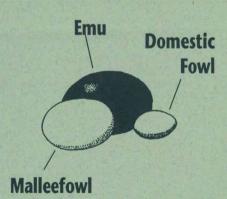
In the last century, numbers have declined dramatically and the malleefowl is now recognised as a threatened species in WA.

As part of the *Project Eden* wildlife conservation program, CALM is planning to boost malleefowl numbers on Peron Peninsula.

To do this, eggs need to be found in the Midwest or Gascoyne areas, incubated, and the chicks released onto the peninsula.

You can assist the conservation of the malleefowl by reporting any sightings of the birds, alive or dead, and their nesting mounds, to the nearest CALM office.

For more information, or to report a sighting, phone CALM Geraldton on (099) 21 5955 or CALM Denham on (099) 48 1208.





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