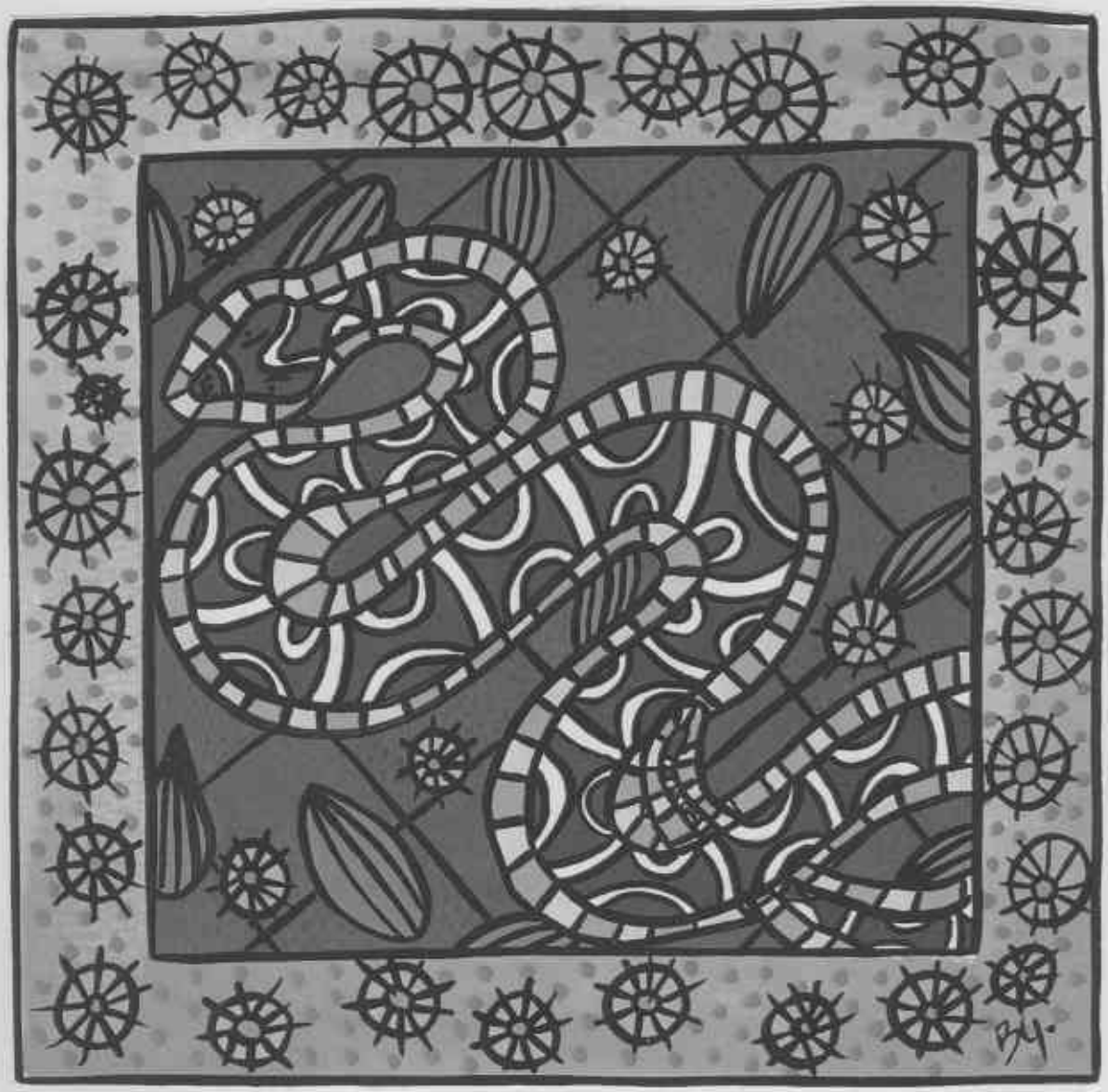
Terrestrial Fauna of the South Coast – a review



SOUTH COAST MANAGEMENT GROUP

Coasts & Clean Seas

Natural Heritage Trust
Helping Communities Helping Australia

Terrestrial Fauna of the South Coast – a review

a supporting document to

Southern Shores
- a strategy
to guide coastal and marine planning and management
in the south coast region of Western Australia

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May 2000

SUMMARY

This report reviews the existing knowledge of the terrestrial vertebrate fauna of the south coast of Western Australia, from Nornalup to Eucla, with the aim of providing a synthesis of this knowledge. Sources of information are summarised in terms of type of information, taxa, land category and geographical area. Gaps in the existing knowledge are identified and recommendations for future research and investigation are put forward. Broad faunal assemblages and threatened species are also discussed.

The south coast is an important area for faunal biodiversity owing to its varied biogeography and its role as a stronghold for relict populations of a number of threatened species.

The major gaps identified in the knowledge of south coast fauna are: basic regional distribution data on two groups, the bats and invertebrates; basic ecological information on most non-threatened species; the effects of fire and *Phytophthora cinnamomi* on single species and communities; information relating to community structure and function and faunal biodiversity of off-reserve (non-CALM managed) land (particularly corridors of native vegatation).

ACKNOWLEDGEMENTS

Funding has been provided through the Natural Heritage Trust Coast and Clean Seas program.

Many thanks to Nic Middleton of the South Coast Regional Information Centre for producing maps and to Jude Allen, Sarah Barrett and Alan Danks for commenting on a draft of this report.

Thanks also to Peter Collins, Sarah Comer, Alan Danks, Tony Friend and Sylvia Leighton for their help and advice in obtaining information.

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1. INTRODUCTION

1.1 Overview

This review was undertaken to provide information on the existing knowledge of terrestrial fauna of the south coast of Western Australia. The information contained in the report is to be used by the South Coast Management Group (SCMG) for the preparation of a South Coast Regional Coastal Strategy. The SCMG is a regional body consisting of members from State Government, Local Government and community representatives. The SCMG's primary aim is to promote best practice coastal planning and management throughout the south coast region of Western Australia, from Denmark in the west to Eucla in the east. The South Coast Regional Coastal Strategy's aim is to produce a regionally integrated approach to coastal planning and management, involving all interested and effected bodies.

It is hoped that the review will also be of interest and benefit to anyone involved in fauna conservation on the south coast and surrounding areas.

1.1 Review area

1.1.1 Boundaries

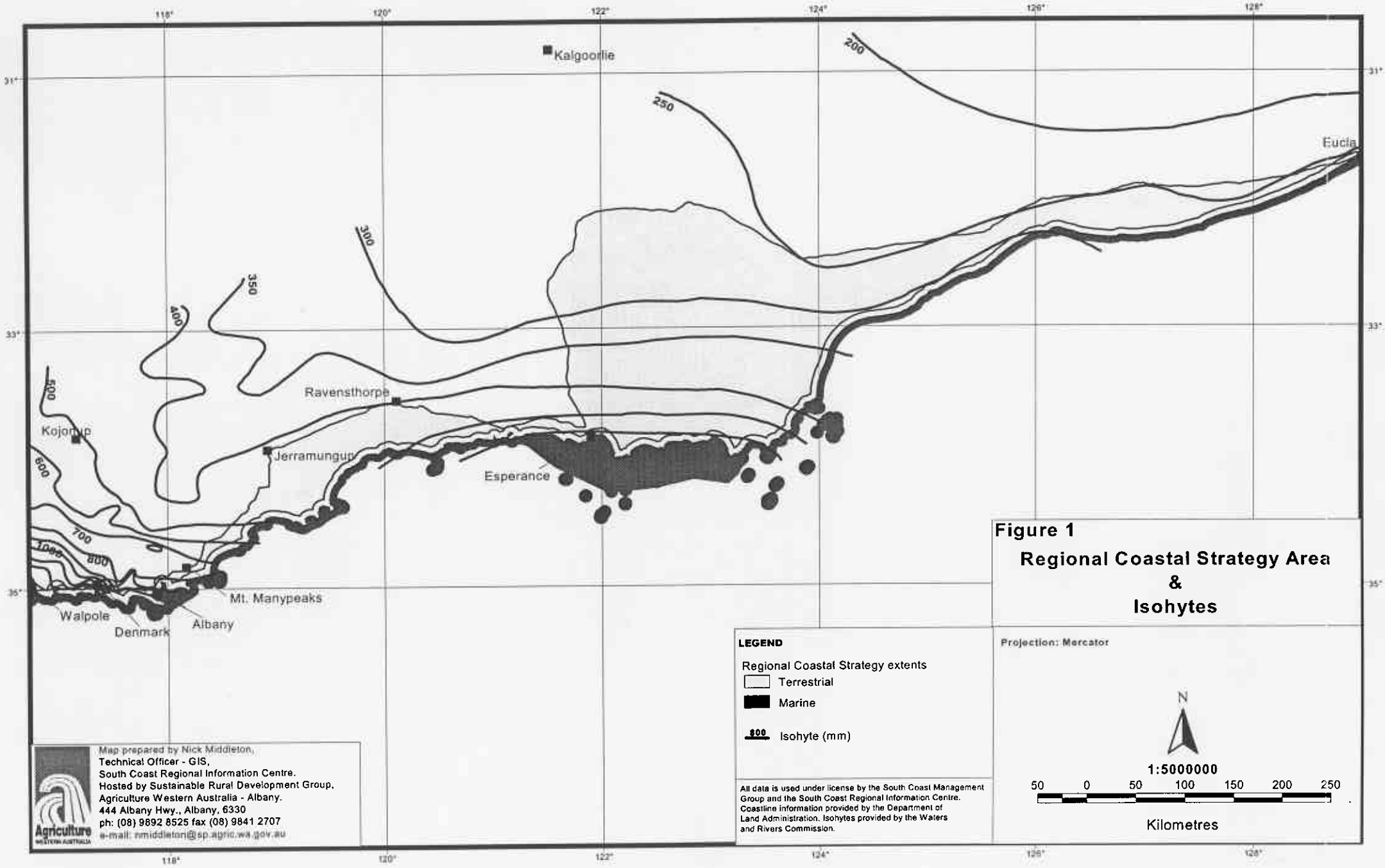
The review area encompasses the mainland south coast of Western Australia, from the eastern shore of Nornalup Inlet in the west, to Eucla (on the WA / SA border) in the east. It extends inland to the major coastal highways, and thus forms a narrow strip of no more than 70 km inland from the coast from it's eastern boundary to Esperance, and then a larger inland area, bounded by Esperance, Norsemen and Eucla (Figure 1).

1.1.2 Climate

The majority of the area has a Mediterranean climate, characterised by mild wet winters and hot dry summers. The eastern portion of the area experiences a semi-arid climate, however, in the coastal belt, extremes of aridity and temperature are modified by oceanic influences. The rainfall varies considerably, decreasing eastwards from 939 mm annual average in Albany to 263 mm at Eucla. Rainfall occurs predominantly in the winter months (> 50%), with occasional heavy summer falls (Department of Conservation and Land Management 1992). (Figure 1).

1.1.3 Biogeographical zones within the review area

The review area is biogeographically diverse. Two broad zoogeographical zones occur. There is a central arid zone with irregular and variable rainfall and a South West temperate zone with reliable winter rainfall and dry summers. Some species can be categorised as being broadly adapted to conditions in one or the other of these zones. Thus, the Eyrean faunal element consists of species adapted to arid conditions, and the Bassian faunal element consists of species adapted to winter rainfall conditions. The distribution of some species enables them to be categorised into one of these elements, however some species with wide distributions cannot be categorised into either element.


118°
120°
122°
124°
126°
128°
31°
33°
35°
Kalgoorlie
200
250
300
350
400
500
600
700
800
Eucla
Ravensthorpe
Kojonup
Jerramungup
Esperance
Mt. Manypeaks
Walpole
Denmark
Albany
Figure 1
Regional Coastal Strategy Area
&
Isohytes
LEGEND
Regional Coastal Strategy extents
Terrestrial
Marine
500 Isohyte (mm)
Projection: Mercator
N
1:5000000
50 0 50 100 150 200 250
Kilometres
All data is used under license by the South Coast Management Group and the South Coast Regional Information Centre. Coastline information provided by the Department of Land Administration. Isohytes provided by the Waters and Rivers Commission.
Agriculture
Western Australia
Map prepared by Nick Middleton,
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Three broad phytogoegraphic provinces and five districts as defined by Beard (1980) are also represented within the review area as follows;

South West Province (Nornalup to Toolina Cove (Nuytsland Nature Reserve)). This province occupies the wetter south-west corner of WA and is characterised by heath, thicket, mallee, woodland and forest. Three Botanical Districts within the South West Province are represented in the review area (Darling, Eyre and Roe). The Eyre District covers a major portion of the review area.

South West Interzone (Toolina Cove to Eyre) This province is a transitional zone between the South West Province and the Eremeaean Province (below). This province consists of open Eucalyptus woodland with a saltbush-bluebush understorey on the more calcareous soils and scrub-heath and *Allocasuarina* thickets on the sandplains. The Coolgardie Botanical District is represented in the review area.

Eremaean Province (Eyre to Eucla). This province comprises hummock grassland, scrub and low woodland. The Eucla Botanical District is represented in the review area.

The review area comprises all, or part of, seven of the 80 Bioregions in Australia as defined by the Interim Biogeographical Regionalisation for Australia (IBRA) (Thackway and Cresswell 1995). The regions, or parts thereof, represented in the review area are shown in Figure 2 and are as follows;

Warren Region. Mainly Marri-Wandoo woodlands, paperbark (*Melaleuca* spp.) /sedge swamps, peppermint (*Agonis flexuosa*) woodlands and scrub heath on coastal dunes

Jarrah Forrest Region. Jarrah-Karri and Jarrah-Marri forest, Jarrah-*Casuarina* low forest, mixed heath and scrub-heath on coastal dunes, Peppermint (*A. flexuosa*) low woodland and mallee-heath to the east.

Esperance Plains Region. Proteaceous scrub and mallee-heaths (*Eucalyptus tetragona*) on sandplain overlying Eocene sediments.

Mallee Region. The part of this region represented in the review area consists mainly of a mosaic of mixed eucalypt woodlands, with spinifex ground layer or sclerophyll shrub understorey, and mallee with a myrtaceous-proteaceous understorey.

Coolgardie Region. Diverse woodlands rich in endemic eucalypts with a mainly acacia shrub layer in the review area.

Hampton Region. Mallee, eucalypt woodlands and Myall (*Acacia papyrocarpa*) open low woodlands.

Nullarbor. The peripheral areas consist of low open woodlands of Myall over bluebush (*Maireana sedifolia*) steppe.

REVIEW AREA AND IBRA REGIONS

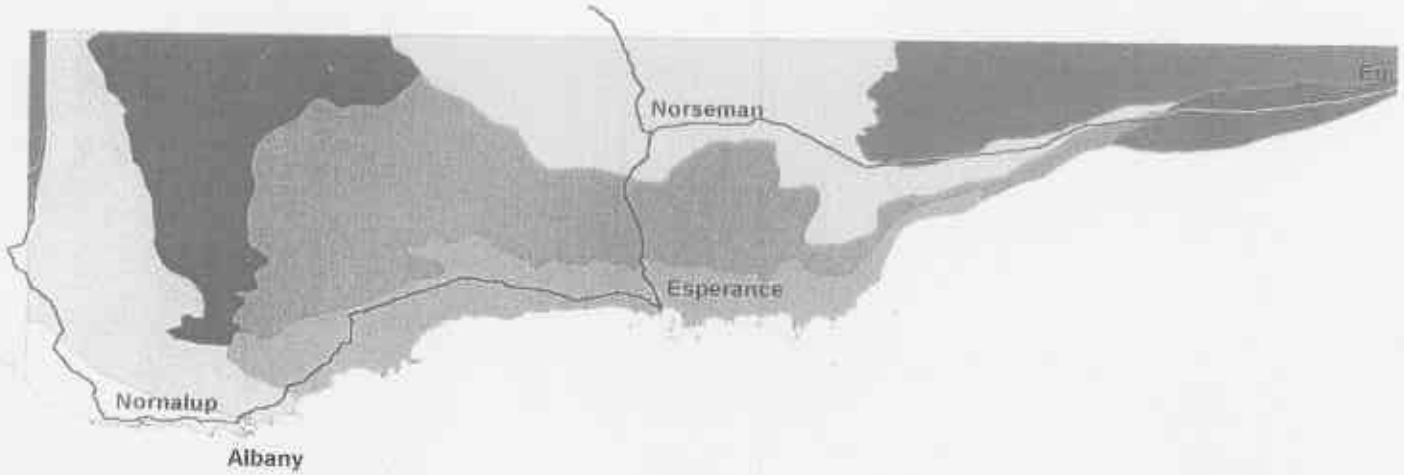


Figure 2: Interim Biogeographic Regionalisation for Australia

Highway 1
Biogeograhic Regions
Avon Wheatbelt
Coolgardie
Esperance Plains
Hampton
Jarrah Forest
Mallee
Nullabor
Swan Coastal Plain
Warren
Coastline

400 0 400 800 Kilometers

N
W E
S

The relationship between the above three systems of ecological classification is shown in Table 1.

Table 1: Relationship between three ecological classifications within the review area.

Zoogeographical Zone	Phytogeographic Province (Beard 1980)	Bioregion (Thackway and Cresswell 1995)
Bassian	South West	Jarrah Forest
		Warren
		Mallee
		Esperance Plains
Interzone	South West Interzone	Coolgardie
		Hampton
Eyerean	Eremaean	Nullarbor

A detailed description of the vegetation within the review area can be found in Craig (2000)

1.1.4 Faunal habitats

As a consequence of the varied biogeographical regions described above, the review area comprises many faunal habitats. These include forests, woodlands, mallee, mallee-heath, coastal heath, permanent and seasonal Yate (*Eucalyptus occidentalis*), peppermint (*Agonis flexuosa*) and paperbark (*Melaleuca* spp.) swamps, sedgelands and some bluebush steppe.

1.3 Scope and intent of report

While knowledge of the fauna of the south coast is by no means comprehensive, considerable information is available. This report is intended to compile, synthesise and identify gaps in this knowledge. It is not intended to provide comprehensive species lists of fauna of the area, but to guide the reader as to where that information is available.

The report summarises the extent and scope of the knowledge of the fauna of the south coast in terms of geographical area, land category, taxa (or particular species of threatened fauna), and the type of information available (eg. ecology, biology, distribution, abundance). This information can then be used as a guide for management decisions to aid in the conservation of biodiversity on the south coast. Where appropriate, extrapolation from existing knowledge to other areas is made, however this is often spurious and does not negate the need for on the ground collection of information in these areas.

The fauna covered in this review includes all terrestrial vertebrates and invertebrates, plus reptiles, frogs and waterbirds associated with freshwater wetland systems (all are referred to as terrestrial fauna in the text). Information on the fauna of estuaries and coastal lagoons in the review area may be found in Hodgkin and Clark (1987, 1988

a,b,c, 1989,1990 a,b). A review of the fauna inhabiting streams in the south-west can be found in Pen (1999).

Abbreviations of localities frequently used in the text are shown in Appendix 1.

2. OVERVIEW OF THE TERRESTRIAL FAUNA OF THE SOUTH COAST

2.1 Faunal biodiversity - general

Biodiversity refers to the variety of species, the genetic information they contain and the communities of those organisms and associated ecosystem processes. A central focus of conservation biology is the maintenance of biodiversity by preventing the extinction of species (Hobbs and Mooney 1998). This focus is critical because species extinctions are irreversible. In many cases however, species do not go extinct but are lost from a large part of their former range through habitat loss and fragmentation. These population extinctions or range contractions, which may lead to the loss of functional groups from ecosytems, are also important for biodiversity conservation (Hobbs 1992, Lambeck 1992).

In Western Australia, mammals have suffered both a high extinction rate and extensive range contractions (Burbidge and McKenzie 1989). The state has the highest extinction rate for mammals in the world (10 species), which is highest among the critical weight range mammals (CWR: non-flying mammals with a mean body weight between 35g and 5.5 kg). These species are particularly vulnerable to environmental change because of their limited mobility coupled with a relatively high daily metabolic requirement (Burbidge and McKenzie 1989). An exception among mammals is the bats, which have not suffered any extinctions since European settlement due to their ability to fly and therefore forage widely and recolonise areas following food shortage (Start and McKenzie 1988).

Two species of birds, *Dasyornis broadbenti litoralis* (Rufous Bristlebird) and *Rallus pectoralis clelandii* (Lewin's Water Rail), are presumed to be extinct in WA, and many species have undergone significant range contractions, ie. population extinctions, at a local and regional scale (eg. Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Smith 1987, Garnett 1992). No species of reptile or frog has become extinct in Western Australia and little is known about range contractions of these taxa. Reptiles are less vulnerable to modifications in the environment due to their low energy requirements and physiological adaptations (Recher and Lim 1990), and can persist in remnant patches and corridors of vegetation (Kitchener *et al.* 1980a). Biological and ecological information about frogs is quite limited (Tyler 1997), but there is some evidence that WA frog species have followed the global trend of a decline in numbers and species diversity (Ferraro and Burgin 1993), through habitat destruction, and susceptibility to pollution (eg. *Geocrinia alba*, Majors *et al.* 1991).

2.2 Important areas for terrestrial faunal biodiversity on the south coast

2.1.1 Department of Conservation and Land Management (CALM) Managed Lands (Reserve System)

CALM managed public lands are protected under the Conservation and Land Management Act (1984) and vested in the National Parks and Nature Conservation Authority (NPNCA). They form a system of reserves that are primarily managed for nature conservation (Figure 3). Historically, these areas were created after broadscale clearing of native vegetation for agricultural use, which accelerated in the 1950's and 60's, resulted in many remnants of natural vegetation scattered within cleared farmland (Alan Danks, CALM. pers com). Most of the reserves were therefore created to protect remnants that remained after clearing, and were not identified *a priori* as areas of high conservation value (eg. high species diversity, presence of rare or threatened species, representation of biotic communities). However, by the mere fact that they are remnants they represent valuable areas for the conservation of biodiversity because of their role as refuges.

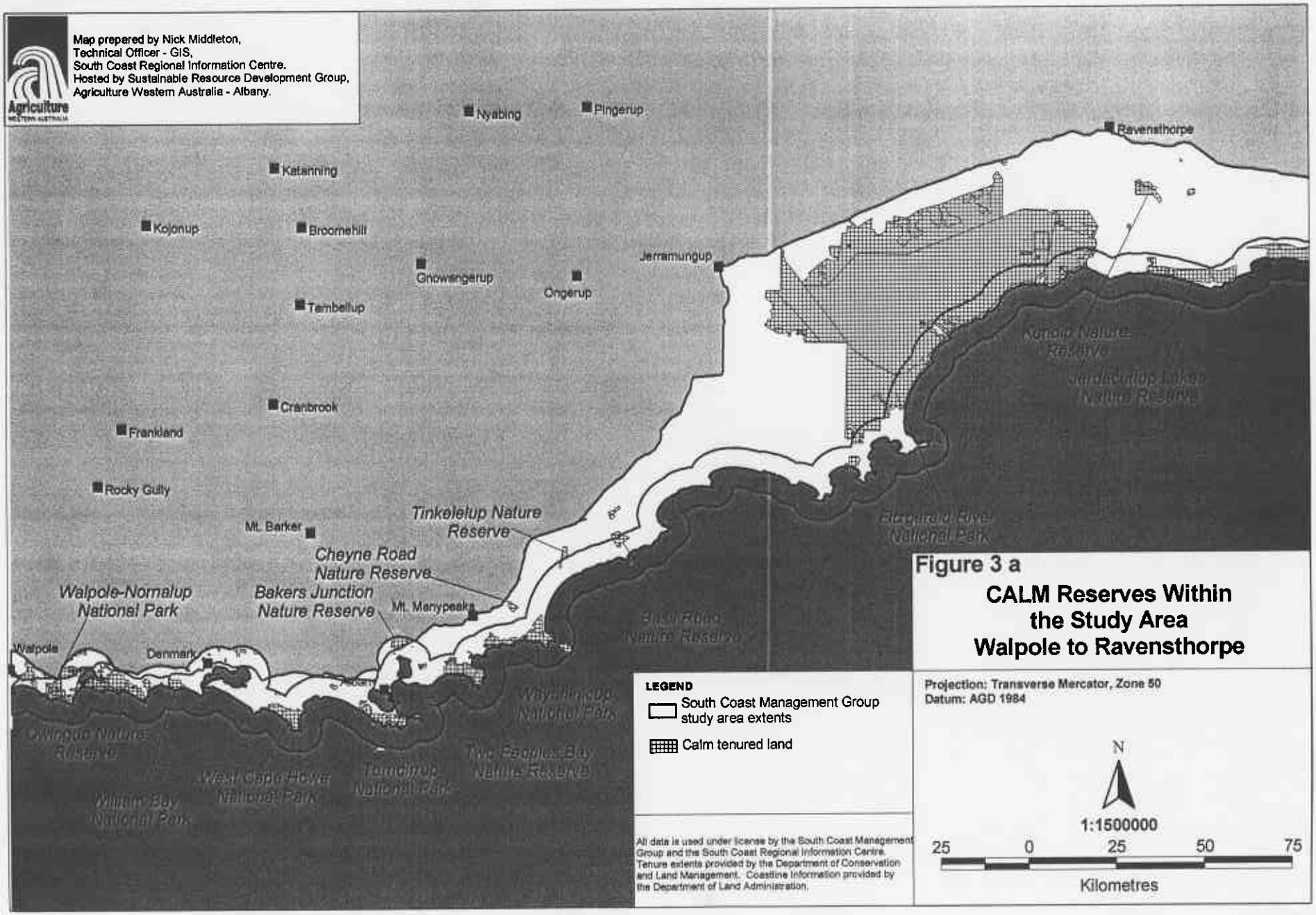
Some reserves on the south coast *were* set aside with specific conservation purposes in mind. Two Peoples Bay Nature Reserve was created in 1967 solely for the protection of the threatened Noisy Scrub-bird (*Atrichornis clamosus*) and its habitat (Department of Conservation and Land Management 1995b) and Mt Manypeaks Nature Reserve was created as a site for relocation of this species. Although the bulk of the area now known as the Fitzgerald River National Park was left uncleared because of its unsuitability for agriculture, its reserve status was created in 1954 mainly because of recognition of its uniquely diverse flora (Chapman and Newbey 1995).

2.1.2 Areas outside the reserve system

While the system of protected areas is valuable in contributing to the conservation of faunal biodiversity, it is generally agreed that these nature conservation reserves alone do not adequately represent the full array of ecosystem diversity (Bennett 1990, Shea *et al.* 1997). Bennett (1990) outlines reasons why reserve systems may be inadequate for the effective conservation of biodiversity:

- the size of many are too small to support long-term viable populations
- movement patterns of many animals cross boundaries of reserves
- some animals use resources that occur in markedly different habitats
- ecological, environmental and disturbance processes operate at scales that may be much greater than the size of reserves
- numerous species whose populations occur mainly outside nature reserves.

In Western Australia, the current reserve system as a whole is seen to be inadequate for the conservation of biodiversity, as evidenced by, for example, high mammal extinction rates and the occurrence of 70 % of threatened flora populations outside this system (Shea *et al.* 1997). Some threatened fauna species also occur on private or non CALM managed lands in the review area, for example, *Leipoa ocellata* (Mallee Fowl), *Atrichornis clamosus* (Noisy Scrub-bird) and *Pseudocheirus occidentalis* (Western Ringtail Possum). As a consequence of these inadequacies, one of CALM's present objectives is to develop a *Comprehensive, Adequate, Representative* (CAR)


Map prepared by Nick Middleton,
Technical Officer - GIS,
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Agriculture
Nyabing
Pingerup
Ravensthorpe
Katanning
Kojonup
Broomehill
Jerramungup
Gnowangerup
Ongerup
Tambellup
Cranbrook
Frankland
Rocky Gully
Mt. Barker
Tinkelelup Nature Reserve
Cheyne Road Nature Reserve
Bakers Junction Nature Reserve
Walpole-Nornalup National Park
Mt. Manypeaks
Walpole
Denmark
Figure 3 a
CALM Reserves Within the Study Area Walpole to Ravensthorpe
LEGEND
South Coast Management Group study area extents
Calm tenured land
All data is used under license by the South Coast Management Group and the South Coast Regional Information Centre. Tenure extents provided by the Department of Conservation and Land Management. Coastline information provided by the Department of Land Administration.
Projection: Transverse Mercator, Zone 50
Datum: AGD 1984
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Kilometres

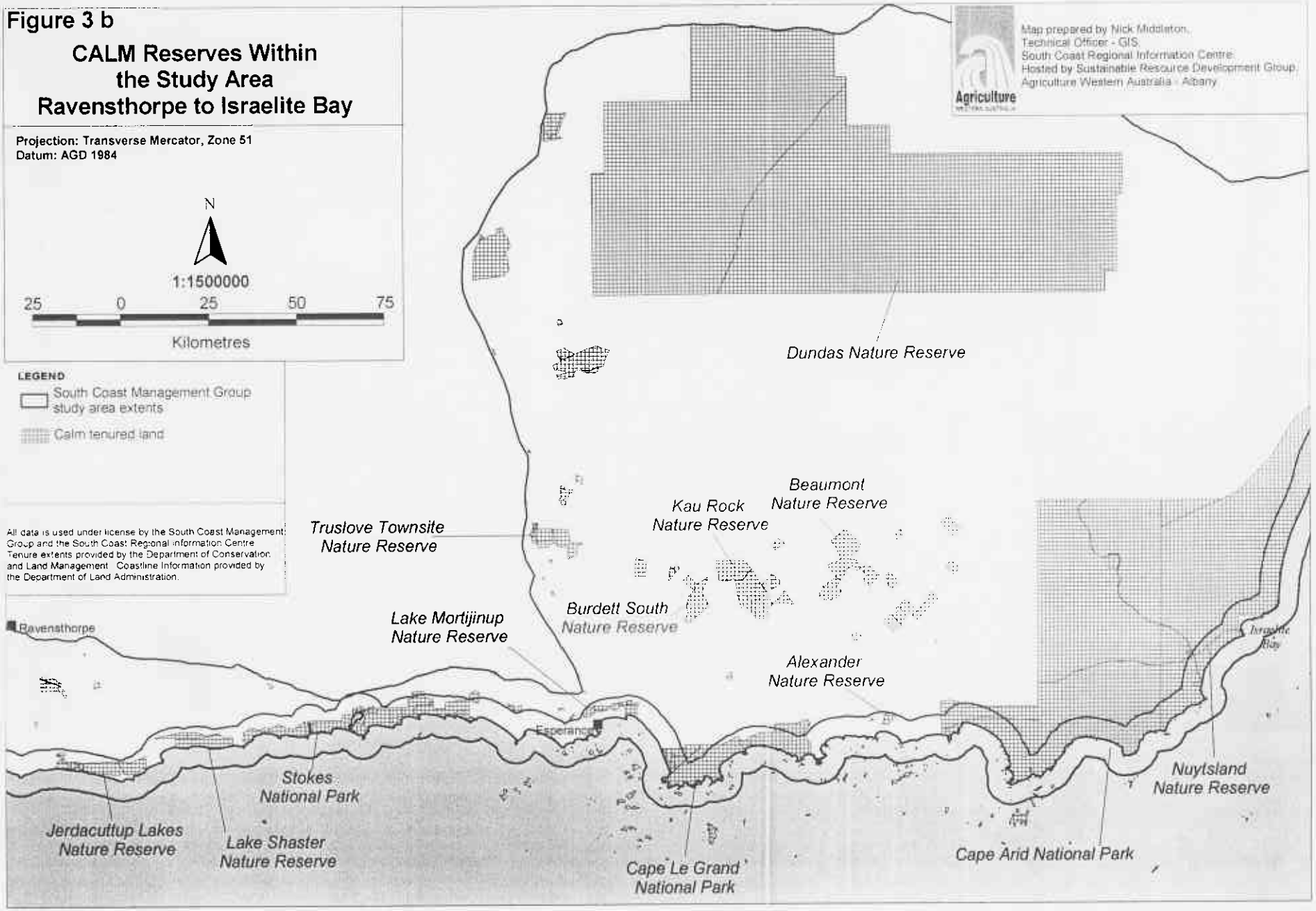
Figure 3 b
CALM Reserves Within the Study Area Ravensthorpe to Israelite Bay
Projection: Transverse Mercator, Zone 51
Datum: AGD 1984
N
1:1500000
25 0 25 50 75
Kilometres
LEGEND
South Coast Management Group study area extents
Calm tenured land
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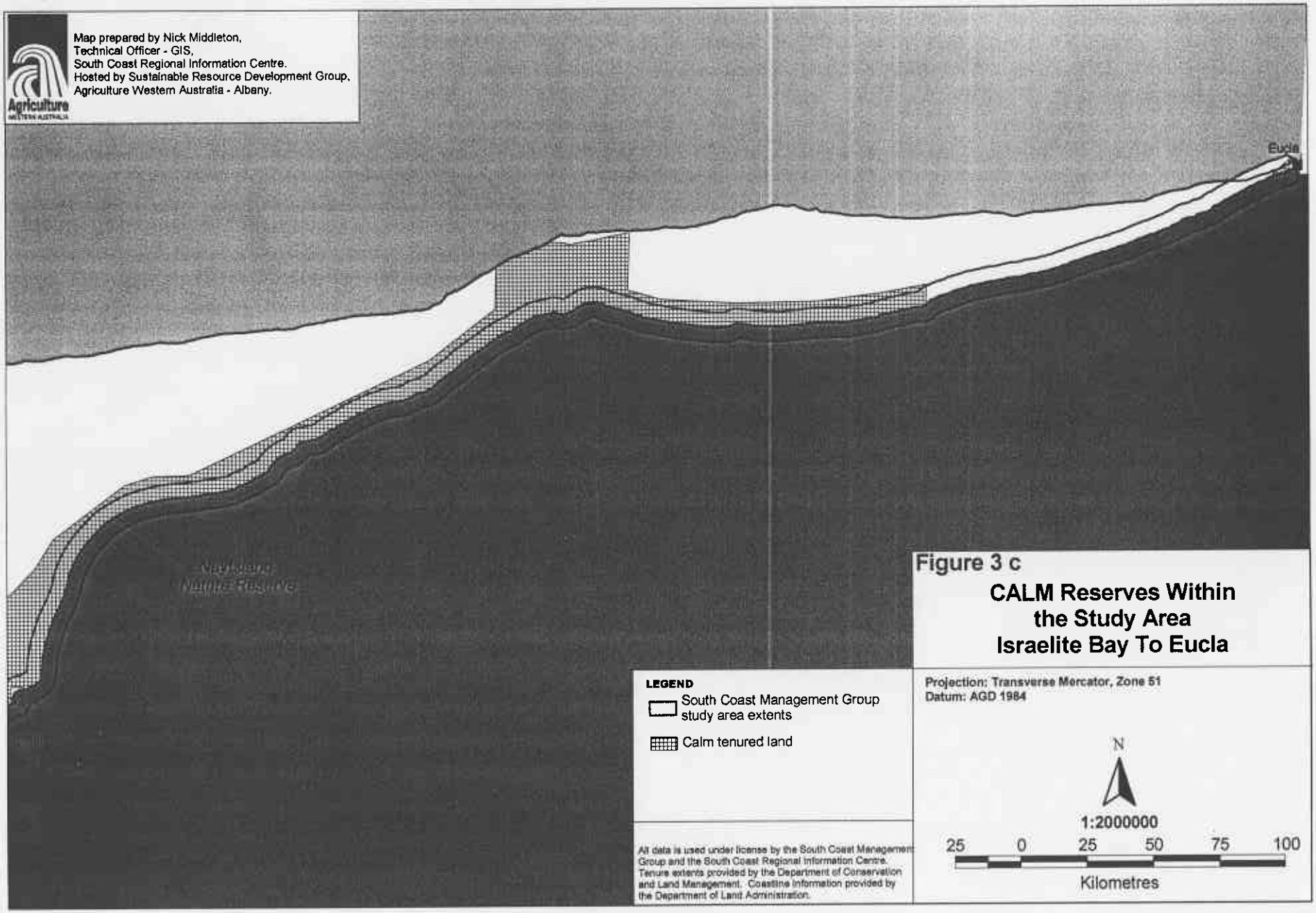
Map prepared by Nick Middleton, Technical Officer - GIS, South Coast Regional Information Centre. Hosted by Sustainable Resource Development Group, Agriculture Western Australia - Albany
Agriculture
Dundas Nature Reserve
Truslove Townsite Nature Reserve
Kau Rock Nature Reserve
Beaumont Nature Reserve
Burdett South Nature Reserve
Lake Mortijinup Nature Reserve
Alexander Nature Reserve
Ravensthorpe
Esperance
Stokes National Park
Jerdacuttup Lakes Nature Reserve
Lake Shaster Nature Reserve
Cape Le Grand National Park
Cape Arid National Park
Nuytsland Nature Reserve


Map prepared by Nick Middleton,
Technical Officer - GIS,
South Coast Regional Information Centre.
Hosted by Sustainable Resource Development Group,
Agriculture Western Australia - Albany.
Agriculture
WESTERN AUSTRALIA
Eucla
Nuytsland
Nature Reserve
LEGEND
South Coast Management Group study area extents
Calm tenured land
All data is used under license by the South Coast Management Group and the South Coast Regional Information Centre. Tenure extents provided by the Department of Conservation and Land Management. Coastline information provided by the Department of Land Administration.
Figure 3 c
CALM Reserves Within the Study Area Israelite Bay To Eucla
Projection: Transverse Mercator, Zone 51
Datum: AGD 1984
N
1:2000000
25 0 25 50 75 100
Kilometres

Reserve System (based on the Interim Biogeographic Regionalisation of Australia (IBRA), Thackway and Cresswell 1995) and research is currently underway by the CALM Science Division to provide the knowledge to achieve this aim.

The "representativeness" of the reserve system in the review area can be seen in Table 2 (see table for criteria used to determine "representativeness"). The wheatbelt region, where vast tracts of land have been cleared for agriculture and only small isolated remnants of native vegetation remain, is included for comparison. It can be seen that within the review area, "representativeness" is quite high, with all but one of the IBRA regions having greater than 10% reservation status and low to moderate indices of bias. This is a reflection of the existence of reserves such as the Fitzgerald River National Park (FRNP) and Nuytsland Nature Reserve (NNR) that comprise very large areas of relatively undisturbed habitat.

Table 2: "Representativeness" of reserves in each of the IBRA regions of the review area (adapted from Thackway and Cresswell 1995).
***Reservation status** = a measure of the percentage of land area within an IBRA region which is dedicated as protected area (> 10 % is the highest category); **Index of bias** = a measure of how well the reserve network samples known environmental variation in the same proportion as it occurs within an IBRA region.*
The Avon Wheatbelt region is included for comparison.

IBRA Region	Reservation status	Index of bias
Warren	>10%	Low
Jarrah Forest	>10%	Mod
Esperance Plains	>10%	Low
Mallee	>10%	Mod
Hampton	>10%	Mod
Coolgardie	5-10%	Mod
Avon Wheatbelt	<1%	High

Despite the existence of a fairly representative reserve system, there are areas on the south coast that are important for the conservation of biodiversity which are not represented within this system. These areas may constitute corridors of native vegetation, isolated remnant native vegetation and wetlands.

Corridors

The loss and fragmentation of native vegetation is a major concern for the conservation of biodiversity. However, habitat corridors in the form of linear strips of uncleared native vegetation exist in most landscapes. The reserve system within the review area, essentially consists of isolated vegetation "islands" within a landscape cleared for agriculture (Department of Conservation and Land Management 1992). However, in some cases well-defined corridors remain linking major reserves (Watson 1991). A project is underway by CALM to identify these macro-corridors, with the aim of developing a landscape approach to biodiversity conservation (Peter Wilkins, CALM, pers. com.). The main macro-corridors in the review area, that comprise a combination of CALM Reserve, Shire Reserve, unallocated crown land and private land are: *Hassel NP, Pallinup River / Corackerup Creek, Fitzgerald River, Phillips River, Ravensthorpe Range, Oldfield River, Munglinup River, Young River,*

Lort River (Watson and Leighton 1992, Department of Conservation and Land Management 1992b).

Another important macro-corridor from a biodiversity conservation perspective is the coastal corridor that forms an almost continuous corridor of vegetation extending from Oyster Harbour, near Albany, to the uncleared regions east of Esperance. This corridor consists of CALM Reserves, Shire Reserves, vacant crown land, and some private land. However, all of the vegetation types that occur within this corridor are represented within the reserve system (Peter Wilkins, CALM, pers. com.).

Watson and Leighton (1992) surveyed four macro-corridors that are present or extend into the review area (Corackerup Creek, Fitzgerald River, Young River, Lort River). Their work provides valuable baseline data on the presence of faunal species in these corridors, however, little work has been carried out investigating faunal use of corridors. Where corridors provide links between isolated habitats for the interchange of individuals between populations, they may reduce the vulnerability of small populations to local extinction (Bennett 1990), and are therefore very important for an integrated approach to biodiversity conservation. An example within the review area is the role of corridors in allowing the dispersal, decolonisation and genetic exchange between sub-populations of the Noisy Scrub-bird, *Atrichornis clamosus,* at Two Peoples Bay Nature Reserve (TPBNR) (Danks 1991).

The ideal corridor for animal movement is a continuous corridor. A number of "stepping stone" corridors exist within the review area ie. areas linking major patches of vegetation that consist of discontinuous patches of smaller remnant vegetation. However, the value of these corridors to fauna is not known. A project currently underway by CSIRO is investigating the faunal use of plantations of bluegums which are either isolated or adjacent to remnant vegetation (Richard Hobbs, CSIRO, pers. com.). This study may elucidate the role of discontinuous corridors in fauna conservation.

Remnant native vegetation

Fifty-two percent and 44 % of the two main phytogoegraphic districts (Eyre and Roe respectively) represented in the review area has been cleared for agriculture (Beard and Sprenger 1984). While this clearing is not as dramatic as the wheatbelt area to the north (Avon District; 93%), it does constitute a large loss of faunal habitat. The land east of Esperance is largely intact, and the role of remnants in the conservation of biodiversity is not as relevant for this area. As well as clearing of vegetation, habitat fragmentation can occur through fire creating patches of differing successional stages and thus isolating fauna that require particular seral stages (Bennett 1990). Some threatened species that occur within the review area depend on long-unburnt patches of vegetation (eg. *Atrichornis clamosus* (Noisy Scrub-bird) Smith 1985a), and it may be that populations are essentially isolated within them.

Fragmentation and isolation of habitat has a profound effect on fauna. Three main consequences of habitat loss are (from Bennett 1990):

- changes to the number of species in fragments
- changes to the composition of faunal assemblages
- changes to ecological processes in fragments

The effects of habitat fragmentation on fauna has been quite extensively studied in the wheatbelt region (Kitchener *et al.* 1980a,b, 1982). No similar studies have been carried out in the review area, however, information does exist on the role of habitat loss in the decline of a number of threatened species (eg. *Potorous gilbertii* (Gilbert's Potoroo) (Courtney *et al.* 1998) and *Dasyurus geoffroii* (Chuditch) (Orell and Morris 1994)) (see Appendix 7 for further information).

While much of this remnant vegetation is represented in the reserve system, there are significant patches that occur outside the system. Shire road reserves often contain vegetation that is a good representation of previously existing ecosystems, which are now limited in extent (Napier 1997). These are valuable in isolation, particularly for flora, however, they may also be important as corridors for animals to 'move' over time. Remnant vegetation exists on private land, generally in areas unsuitable for agriculture (eg. swamps and sandy soils)

A significant area of habitat located outside the reserve system is that contained within the Fitzgerald Biosphere Reserve Buffer Zone. In 1978 the FRNP was designated as one of 12 Australian Biosphere Reserves under UNESCO's Man and the Biosphere program. The FRNP represents the core of this reserve, and the surrounding remnant vegetation included in the buffer zone is a combination of shire reserve, unallocated crown land and private land. The purpose of the buffer zone is to act as an area where threatening influences on the core area are minimised (Sanders 1996). A survey of the vertebrate fauna of the remnant vegetation within the Fitzgerald Biosphere Reserve Buffer Zone was carried out in the mid nineties to evaluate the conservation value of this zone (Sanders 1996). This is one of only a few biological surveys carried out on non-reserve system land in the review area (see section 3.5).

Wetlands

The Directory of Important Wetlands (Australian Nature Conservation Agency (ANCA) 1996) lists all wetlands in Australia that have a uniqueness or representativeness according to biological, historical and cultural criteria set out by the Australian and New Zealand Environment and Conservation Council (ANZECC) Wetlands Network. To reduce the difficulty in applying these criteria, the Directory attempts to increase the representation of wetlands in each of the bioregions outlined by Thackway and Cresswell (1995). Nine non-estuarine wetlands occur within the review area. Most of these are under the jurisdiction of CALM , however, some do occur outside the reserve system (eg. Yellilup Yate Swamp near Bremer Bay, and parts of the Lake Gore System near Esperance, which are under freehold title).

Community involvement in fauna conservation

Valuable information on fauna outside the reserve system comes from various community groups; Malleefowl Preservation Society, Friends of the Ground Parrot, Frogwatch, Birds on Farms Project, Land for Wildlife. These groups consist of volunteer land-holders or community members with an interest in fauna conservation, and their contribution to the knowledge of the fauna on the south coast is highly beneficial to biodiversity conservation.

2.3 Terrestrial faunal assemblages

Faunal endemism is low in Mediterranean climates through out Australia. This is particularly so for birds and mammals but less so for reptiles. Frogs are an exception to this trend with a greater than 50 % level of endemism (Lambeck 1992). The low level of endemism suggests that the distribution of many vertebrate species in the region may be largely a consequence of historical and biogeographic factors, rather than a result of adaptations to local ecological conditions (Lambeck 1992).

In terms of distribution, the fauna within the review area can be categorised as one of the following:

Endemic: As the review area covers three botanical provinces and two broad zoogeographical zones, it is not surprising that there are no species which are endemic to the review area as a whole. Only two species, the reptiles *Lerista baynesi* and *Aprasia inaurita*, which occur on the Roe Plain near Eucla, have ranges totally confined within the review area. However, there are a number of species that have very restricted distributions, parts of which extend into the review area. For example, *Pseudomys occidentalis*, which has a small distribution in a triangle from Tambellup, Bendering to Ravensthorpe, the snakes *Rhinoplocephalus bicolor* and *Notechis minor*, which are restricted to coastal areas in the far south-west (Christensen *et al.* 1985) and the lizards *Ctenotus brooksi euclae* and *Lerista arenicola*, which are restricted to the eastern coastal area but extend into SA (Storr *et al.* 1999).

Relict : These species are now restricted to areas within the review area but once had wider distributions, for example, TPBNR supports relict populations of *Potorous gilbertii* (Gilbert's Potoroo) and *Atrichornis clamosus* (Noisy Scrub-bird).

Restricted to south-west WA but also occurring in south-eastern Australia: A higher rainfall on the south coast of Australia in the past enabled a more continuous distribution of mesic adapted fauna. Present day south-west and south-east Australia are now separated by extensive arid and semi-arid plains. This results in distjunct distributions of the same or similar species on both lower extremes of continent (Wilson 1984). Examples include *Isoodon obesulus* (Southern Brown Bandicoot), *Pseudomys shortridgei* (Heath Rat), *Notechis scutatus* (Tiger snake) and the pygopod *Aprasia striolata.*

Widespread: There are several species that occur in the review area, particularly birds, which have wide distributions over WA or the whole of Australia, for example, *Charadrius ruficapillus* (Red-capped Plover) and *Tachyglossus aculeatus* (Echidna).

Broad faunal assemblages within the review area change from west to east, mainly as a result of climate (particularly rainfall amount and timing) and proximity to other biogeographic regions which act as source areas. This is particularly so for mammals and reptiles. These changes can be investigated by synthesising results of surveys or reviews that have been carried out in each of the IBRA bioregions represented in the review area. These are as follows:

Warren (Christensen *et al.* 1985: How *et al.* 1987; Smith 1990; Regan 1996, 1997, 1998; Abbott 1999)
Jarrah Forrest (TPBNR (Bannister 1970, Hopper 1981)
Esperance Plains (FRNP (Chapman and Newbey 1995, Sanders 1996, 1997); SNP (Newbey and Bradby 1989); CLGNP (Kitchener *et al.* 1975); Harold 1996; Anon (a)).
Mallee and Coolgardie (McKenzie *et al.* 1993)
Hampton (McKenzie and Robinson 1987, Eastern Goldfields)
Hampton / Mallee border (Eyre Bird Observatory Reports (RAOU 1980, 1982, 1985, 1988, 1989)
Mallee, Coolgardie **and** ***Hampton*** (Storr *et al.*1981a, Great Australian Bight)

2.3.1 Mammals

The *Warren* bioregion within the review area was represented in a major survey of the southern forests (Christensen *et al.* (1985)). These authors identified five faunal zones with distinct assemblages of fauna. They found a fairly distinct mammal fauna of the southern coastal banksia woodland and heathland areas of the forest region (including the *Warren* bioregion) which included *Tarsipes rostratus* (Honey Possum) and *Cercartetus concinnus* (Western Pygmy Possum) (Christensen *et al.* 1985). However, no mammals are restricted to the part of the *Warren* bioregion that occurs in the review area. Much overlap occurred between zones and many species of the coastal areas are generally those which also occur in the southern forests (eg. *Phascogale tapoatafa* (Brush-tail Phascogale), *Rattus fuscipes* (Bush Rat), and *Antechinus flavipes* (Yellow-footed Antechinus)). How *et al.* (1987) surveyed the coastal areas between Busselton and Albany, however, mammal captures were too infrequent to ascertain the complete assemblages at the subregional level. They recorded the southern most live record of *Pseudomys albocinereus* (Ash-grey Mouse) in WA, within the part of the *Warren* bioregion represented in the review area.

Further towards Albany, but still in the*Warren* bioregion , Smith (1990) recorded a similar assemblage of mammals in Torndirrup NP (TNP) to that of Christensen *et al.* (1985)'s Fauna Zone 1, as did Regan (1998) at Qurram NR and William Bay NP. The exception was the presence of the threatened species *Parantechinus apicalis* (Dibbler), and the absence of *Cercartetus concinnus* (Western Pygmy-possum) at TNP. *Parantechinus apicalis* was probably never present in the forest region and are not expected to occur west of TNP (Baczocha and Start 1997).

Species which occur in the wetter parts of the south-west reach the eastern limit of their ranges at various points along the coast. Further east at TPBNR and Mt Manypeaks, in the *Jarrah Forest* bioregion, the mammalian fauna is predominantly south-western but contains some species that are at or near the eastern limit of their range (Bannister 1970, Hopper 1981) eg. *Pseudocheirus occidentalis* (Ring-tailed Possum) (Jones *et al.* 1994a, Barrett 1996) and *Setonix brachyurus* (Quokka) (Tony Friend pers. com.).

In the central area of the *Esperance Plains* bioregion, the mammal fauna of the FRNP represents a transition from the influence of the wetter southern forests to a stronger influence from the drier wheatbelt to the north. Mammals of the wetter south-west still occur here (eg. *Bettongia pencillata* (Woylie)), but some are at the eastern limit of their range (eg. *Hydromys chrysogaster* at the Gairdner River (Chapman and

Newby 1995)). The FRNP supports a highly diverse mammal fauna, and contains more species (20) than any other conservation reserve in the south-west, owing to a blending of semi-arid and mesic components (Chapman and Newbey 1995). Many of these species are remnants of a much more widespread and rich fauna of the wheatbelt. These include, *Macropus eugenii* (Tammar Wallaby) and two threatened species, *Phascogale calura* (Red-tailed Phascogale or Wambenger) and *Parantechinus apicalis* (Dibbler), whose best long-term survival prospects lie in the FRNP. At Cheyne Bay, west of FRNP only 9 species of native mammals were recorded (Anon.a). The only species recorded here and not at FRNP was *Antechinus flavipes* (Yellow-footed Antechinus), and this may represent the eastern most range of this species.

Still within the *Esperance Plains* bioregion but further east of FRNP, another survey at Stokes NP (SNP) recorded a quite impoverished mammal fauna (five native species, excluding bats) compared to FRNP (20). At Lake Monjingup, near Esperance, Harold (1996) recorded only three native species (excluding bats), but listed four additional species that may be expected to occur here.

The area north-east of Esperance, bounded by Norseman in the north, Eucla in the east and the coastline in the south encompasses four IBRA bioregions, and includes part of the SW Interzone Botanical Province. This area represents a transition zone between the faunas of the moist south-west and the arid interior. For the purpose of this discussion the area north-east of Esperance can be divided into the coastal region which contains sections of the *Esperance, Mallee, Coolgardie* and *Hampton* bioregions (largely Nuytsland NR (NNR) with Cape Arid NP (CANP) and Cape Le Grand NP (CLGNP) at the western end), and the inland region covering the *Mallee* and *Coolgardie* bioregions.

Within the coastal region, CLGNP falls into the same rainfall belt as FRNP (500-600 mm), but the southern end of CLGNP receives as much as 200 mm more on average because it is a headland. The number of mammal species recorded here is also less than that at FRNP (8 *vs.* 20), probably due to the lack of blending of semi-arid and mesic components seen in the latter park. Thus, the higher rainfall of CLGNP results in the absence of drier country species such as *Notomys mitchellii* (which occurs in FRNP) and *Sminthopsis crassicaudata* (Kitchener *et al.* 1975). The widespread species of wetter south coastal areas, *Isoodon obesulus* (Southern Brown Bandicoot), is quite common in CLGNP and has its eastern most range here.

The NNR and Israelite Bay area in particular represents the southern boundary of the overlap zone between the faunas of the moist south-west and the arid zone (Burbidge 1976). The mammal fauna of the NNR has a dominant Eryean element and a low diversity (Burbidge 1976), which may result in part from the loss of medium sized mammals from semi-arid communities (see section 2.1). Many south-west species have their eastern most distribution in the NNR. For example *Rattus fuscipes* (Southern Bush Rat) extends to Bilbunya Dunes, and *Tarsipes rostratus* (Honey Possum) extends to Eyre (Watkins 1989).

A major biological survey of the Nullarbor Region (McKenzie and Robinson 1987) included sites within the coastal region east of Esperance. These sites contained mammal species that are widespread across southern WA (eg. *Cercartetus concinnus*

(Western Pygmy-Possum), *Notomys mitchelli* (Mitchells Hopping Mouse), and *Sminthopsis gilbertii* (Gilbert's Dunnart), which has outlying populations in this area with a main distribution in the wheatbelt. In a regional survey of the Eastern Goldfields, one survey study area between Norseman and Balladonia (largely the Dundas NR), falls into the inland region east of Esperance (McKenzie *et al.* 1993). The mammal assemblage here is a mixture of semi-arid (eg. *Pseudomys bolami* (Bolam's Mouse), *Ningaui yvonneae* (Southern Ningaui)) and mesic adapted species (eg. *Cercartetus concinnus* (Western Pygmy Possum). *Lasiorhinus latifrons* (Southern Hairy-nosed Wombat) occurs in the far north-east of the review area (McKenzie and Robinson 1987, Wells 1995)

Bats

The bats have never been systematically documented within the review area, and therefore not much can be concluded about assemblages of this group of mammals in south coastal areas. Commonly recorded and widespread bats in the forest region (*Warren* bioregion) recorded by Christensen *et al.* (1985) were *Vespadelus regulus* (as *Eptesicus regulus*, King River Eptesicus) and *Falsistrellus mackenziei* (Western False Pipistrelle) (as *Pipistrellus tasmaniensis*, Great Pipistrelle). The range of *F. mackenziei* probably does not extend out of the forest region, it forages under the forest canopy but above the understory (Tony Start, CALM, pers com). *Vespadelus regulus* however has a wide distribution throughout south-west and south-east Australia.

Bat species recorded from the south coast lodged in the Western Australian museum are listed by Anon (a); *Chalinolobus morio* (Chocolate Wattled Bat), *C. gouldi* (Gould's Wattled Bat), *Nyctophilus geoffroyi* (Lesser Long-eared Bat), *Nyctinomus australis* (White Striped Freetail Bat) and *Mormopterus planiceps* (Southern Freetail Bat). All these species occur throughout southern Australia.
McKenzie *et al.* (1993) recorded a similar assemblage at Dundas NR in the Eastern Goldfields, with the addition of *Nyctophilus timoriensis* (as *N. major*), which is widespread throughout southern and central Australia, and *Scotorepens balstoni* (as *Nycticeius balstoni*) which is restricted to drier, inland regions throughout Australia. In the Nullarbor region survey, McKenzie and Robinson (1987) recorded similar species as McKenzie *et al.* 1993, and Eyre Bird Observatory records also consist of a similar bat assemblage.

Therefore, all the species recorded in surveys are likely to be distributed throughout the review area, except *S. balstoni.* All these species are members of the Microchiroptera (microbats) which are small, mostly insectivorous bats and use echolocation to locate their prey (Strahan 1995). New bat species are still being recognised, and it is likely that many species still await discovery (Start and McKenzie 1988).

2.3.2 Birds

Taken as a whole, the south-west of WA has a broad intermingling of Bassian, Eyerean and some Torresian (high tropical rainfall parts of Australia) elements within the avifauna, suggesting that present bioclimatic zones have had only a minor influence on species distributions in this taxa (Smith 1987, Abbott 1999). Most birds

have broad distributions, and within the review area there is only one species confined to the Bassian zone (*Atrichornis clamosus* (Noisy Scrub-bird)) and only two species restricted to the Eyrean zone, (*Pachycephala inornata* (Gilbert's Whistler) and *Aphelocephala leucopsis* (Southern Whiteface)(Smith 1987). Thus, most regions within the review area contain a mixture of Bassian and Eyrean species.

In the west of the review area (*Warren* bioregion), a 50 % sharing of bird species in Christensen *et al.* (1985)'s faunal zones suggests a lack of zoning of avifauna (Abbott 1999) in the forest region. Although birds of Bassian origin are predominantly forest dwelling, some are found on the mallee-sandplain and several range east along the southern coast, possibly because of the humidifying effects of the sea (eg. east to Esperance (*Platycercus spurius* (Red-capped Parrot)), east to Israelite Bay (*Stipiturus malachurus* (Southern Emu Wren)) and east to Eucla (*Pachycephala pectoralis* (Golden Whistler)). The coastal strip between Israelite Bay and Eucla is well wooded and *Banksia* and proteaceous shrubs occur as far east as Twighlight cove, resulting in a rich assemblage of bush birds. In the more open country east of Eyre (*Hampton* bioregion) the number of species declines rapidly (Storr 1987). The mallee community of the SW Interzone functions as a zone of intergradation between Bassian and Eyrean avifaunas (Burbidge 1976), with the Nullarbor Plain acting as an effective barrier to the distribution of Bassian birds (McKenzie and Robinson 1987).

Habitat type also contributes greatly to the distribution of birds. The FRNP supports more species of birds than any other conservation reserve in south-west WA because of the wide variety of habitats it contains (coastlines, rivers, inlets, and wide variety of terrestrial landforms) and its large size (Chapman and Newbey 1995). Honeyeaters (Meliphagidae) are prominant owing to the high floriferous nature of vegetation (eucalypts and proteaceous species) providing a year round source of nectar for nectivorous birds. Other proteaceous heath habitats on the south coast also contain high species richness of honeyeaters (eg. Faunal Zone I of Christensen *et al.* 1985). Woodlands are also important for bird diversity, and in certain localities, some species are restricted to this habitat type. In the FRNP, ten out of 54 species recorded in woodlands were not recorded in other habitats, and, in addition some of these species were restricted to either mallee or very open mallee (Chapman and Newbey 1995).

Many species of seabirds nest on offshore islands along the south coast (eg. *Thalassarche melanophrys* (Black-browed Albatross) and *Pterodroma macroptera* (Great-winged Petrel) (Lindsay 1996). These species breed exclusively on off-shore islands but can forage close to the mainland (Peter Collins, CALM, pers. com.). An exception are Little Penguins (*Eudyptula minor*) which nest in rock falls at the base of cliffs in the Israelite Bay – the only area in Australia where this species nests on the mainland ((Burbidge 1976). Minor studies have been undertaken regarding seabird distribution on some south coast islands, although these are often not comprehensive (see Burbidge *et al.*1993).

Wetlands and waterbirds

Waterbirds on the south coast include some resident species, however, many are migrants that breed in northern Asia during the boreal summer (Johnstone and Storr 1998). A number of wetlands within the review area are important for waterbird numbers and breeding . Owingup swamp (*Warren* bioregion) and The Moats Lake System (*Jarrah Forest* bioregion) support a significant number of the vulnerable

Australasian Bittern (*Botaurus poiciloptilus*), and the Lake Pleasant View System is one of the few known breeding areas for this species. In the *Esperance Plains* bioregion Lake Warden System is a major dry season refuge for waterbirds. This is the only RAMSAR (Wetlands of International Importance) listed wetland within the review area. Lake Gore (*Esperance Plains* bioregion) is the single most important wetland yet known for numbers of the resident species *Charadrius rubricollis* (Hooded Plover) throughout its range (Newbey 1996). Mortijinup Lake System is a good example of an undisturbed coastal lake in south-west WA and is the principal known refuge for the Freckled Duck (*Stictonetta naevosa*). YellillupYate Swamp System is a major breeding area for waterbirds, especially the Rufus Night Heron (*Nycticorax caledonicus*).

2.3.3 Reptiles

In a survey of TPBNR (*Jarrah Forest* bioregion), Storr (in Bannister 1970) outlined a characteristic reptile fauna of "wet south coastal" areas with TPBNR at the eastern limit of this subfauna. The characteristics of this subfauna are:

- poverty of the arid adapted families, Geckonidae and Agamidae, which occur on the drier coastal plains immediately to the east and north-east
- among skinks, richness in *Egernia* spp. but poverty in *Ctenotus* species
- occurrence of *Egernia luctosa*, *Lerista microtis microtus* (as *L. microtis*) and *Elapognathus minor*
- absence of genera otherwise distributed throughout the state eg. *Gehyra*, *Menetia* and *Pseudechis*.

This assemblage can be used as a benchmark to compare assemblages in other coastal areas. To the west of TPBNR in the *Warren* bioregion the reptile fauna of Torndirrup NP, William Bay NP and Wilson Inlet is typically "wet coastal" (*sensu* Storr (in Bannister 1970)) (Smith 1990, Regan 1996, 1997). The Long-necked turtle (*Chelodina oblonga*) has been recorded in this area (Regan 1997). This species is common throughout the forest region to the north (Christensen *et al.* 1985) and in the fresh waters of the south-west coastal belt east to FRNP (Chapman and Newbey 1995). The Carpet Python (*Morelia spilota imbricata*) is a protected species (see section 2.4) that occurs throughout the south- west. It is found in *Banksia* heath and Peppermint (*Agonis flexuosa*) woodland in TNP (Smith 1990), and is also found in FRNP and potentially in areas of remnant vegetation with suitable habitat (Cogger *et al.* 1993).

West of Denmark, the reptile faunal assemblage of the south coastal area is impoverished compared to areas further east (How *et al.* 1987) and contains many elements of the southern forest region. The diversity and abundance of reptiles is greatest in the coastal areas of the forest region (Christensen *et al.* 1985). Again, geckos are poorly represented and agamids are absent. This part of the review area falls into Christensen *et al.* (1985) Faunal Zone I, which contains a unique assemblage of species restricted to the south-west coastal areas, eg. the snakes *Elapognathus minor* (Little Brown Snake) and *Rhinoplocephalus bicolor* (Muellers Snake). To the east of TPBNR, at FRNP, the reptile fauna is impoverished compared with arid regions (Chapman and Newbey 1995), but more diverse than coastal areas further west. The arid-adapted families Geckonidae and Agamidae are still poorly represented, but with a greater number of species of these families than at TPBNR.

This is also the case further along the coast at Lake Monjingup Botanical Park (Harold 1996) and CLGNP (Kitchener *et al.* 1975). Thus, some influence of the drier conditions on the reptile faunal assemblage is evident in this area. CLGNP also represents the eastern most limits of several common wetter coast species eg. the skinks *Acritoscinus trilineatum* (=*Leiolopsima trilineatum*) and *Egernia kingii*, and the pygopod *Aprasia striolata*.

Along the coast east of Esperance, the reptile fauna of the coast of the Great Australian Bight (from Israelite Bay to Eucla) is moderately rich compared with coastal areas to the west (Storr *et al.* 1981a). This probably results from the diversity of habitats; bluebush steppe, semi-arid woodlands and scrub and coastal dunes and sandplains. The treeless plain of the Nullarbor Region acts as a barrier to the dispersal of many reptile species, resulting in an endemic element in the reptile fauna of the eastern coast. Endemics include the lizards *Ctenotus brooksi euclae* and *Lerista arenicola,* which extend into SA, and the lizard *Lerista baynesi (*as *Lersita picturata baynesi)*and the pygopod *Aprasia inaurita* which are restricted to this region (Storr *et al.* 1981a, McKenzie and Robinson 1987). There is also a much more diverse element of arid-adapted species from the Geckonidae and Agamidae families, than that found in coastal areas further west. Many south-west species reach their eastern limit in the Israelite Bay area eg. the pygopod *Delma fraseri* and *Notechis scutatus occidentalis* (Tiger Snake) (Storr *et al.* 1981a).

Two distinct reptile faunal assemblages have been delineated in the area around Esperance (from Israelite Bay to Ravensthorpe and north to Kalgoorlie). The coastal heaths support one assemblage and the semi-arid and arid inland areas support another, with the change occurring just north of Salmon Gums (Bush 1981). In the inland mallee region the reptile fauna has an affinity with the Eyrean zone, with many species occurring that are widespread in arid areas, and a dominance of genera that have speciated extensively in arid environments eg. the skinks *Ctenotus*, and *Lerista* and the geckos of the genera *Diplodactylus* (Menkhorst and Bennett 1990). In this region McKenzie *et al.* (1993) recorded a high proportion of normally allopatric species, reflecting its location within the SW Interzone.

2.3.4 Frogs

The broad distribution of frogs in WA closely follows rainfall zones with very little overlap. (Tyler *et al.* 1994). Thus, within the review area, there is a winter rainfall zone (Bassian Fauna) and an arid (low, irregular rainfall) zone (Eyrean fauna), with the boundary in the review area at Salmon Gums and across to Israelite Bay. The Eyrean and Bassian faunas can be readily recognised on the basis of life history data and ecological preferences. Thus, Bassian species are those that have access to permanent water and breed when suitable conditions occur and Eyrean species are opportunistic breeders requiring specific conditions of temperature (Main 1965).

Therefore, in contrast to mammals and reptiles, assemblages of frogs change little over the review area, except for the transition from winter rainfall to arid zone faunas. Most frog species inhabiting the forest region also extend along the south coast and into the wheatbelt region, although population densities are generally lower in the latter area (Dale Roberts University of WA, pers. com.).The eastern limit of six south-west frog species coincides with the eastern limit of granitic outcrops in the coastal

region east of Esperance (Storr *et al.* 1981a) (eg. *Lymnodynastes dorsalis* (Banjo Frog) and *Litoria adelaidensis* (Slender Tree Frog)) and CLGNP is eastern limit of *Crinia georgiani* (Quacking Frog) (Kitchener *et al.*1975).

Richness in frogs species is characteristic of "wet south coastal" areas, with six to eight species recorded at various sites along the coast (TPBNR (Storr (in Bannister 1970)), SNP (Newbey and Bradby 1989), CLGNP (Kitchener *et al.* 1975), Lake Monjingup (Harold 1996)). Eleven species were recorded in FRNP, more than any other conservation reserve in the south-west, owing to a blending of winter rainfall and arid adapted species (Chapman and Newbey 1995).

Most species occurring within the review area are ground-dwelling or burrowing species but two are capable of climbing vegetation (*Litoria moorei* (Bell Frog) *and L. cyclorhynchus* (Spotted- thighed Frog)). Most species do not require the presence of permanent water for survival, however pond water (ephemeral or permanent) is essential for some part of the life cycle in all species except *Myobatrachus gouldii* (Turtle Frog). Species of frogs occurring in the semi-arid and arid regions have adaptations to prevent dessication (behaviour, increased amounts of body water and rapid rehydration) (Main 1965)

2.3.5 Invertebrates

Within Australia as a whole there is a lack of knowledge of taxonomic, ecological and distributional baseline data on invertebrates, and this taxa is often not included in biological surveys in conservation areas (Major 1987a). This is certainly the case on the south coast, with only nine out of 67 (13 %) of surveys including invertebrates in their sampling (Appendix 4). Most of these are far from comprehensive and often only list orders of invertebrates with no discussion on faunal composition. Because of the lack of comprehensive species lists on distributions of invertebrates within the review area, little can be said about assemblages of this taxa.

Only one comprehensive survey, detailing faunal composition and community structure, has been carried out on any group of invertebrates. Anderson and Burbidge (1992) surveyed the ant fauna of CANP. They found that this area has a rich ant fauna as a result of an overlap between arid (Eyrean) species and cool temperate (Bassian) species. The arid genera, *Camponatus*, *Iridomyrmex* and *Melophorus* dominated but there was also a significant element of Bassian genera, for example, *Prolasius, Notoncus, Colobustruma* and *Dolichoderus.* The dominance of arid fauna within the ants at CANP is the opposite to the vertebrate fauna assemblage which is dominated by Bassian species. They concluded that this assemblage was typical of the mesic fringe of the southern arid zone (400-500mm) throughout Australia.

Invertebrates play such a vital role in the functioning of ecosystems, it is hard to justify omitting them from surveys due to the difficulty of sampling or identifying them. Their potential in playing an important role as indicators of habitat quality (Major 1987b) should be an incentive to increase knowledge of this poorly known taxa.

2.3.6 Summary

Thus, broadly speaking, the mammal and reptile faunas of the western, higher rainfall, end of the review area have affinities with the forest region to the north, those of the central area have affinities with both the wetter south-west and the drier semi-arid wheatbelt to the north, and those of the drier eastern portion have a greater affinity with the semi-arid and arid zone. Obviously there are exceptions to this general pattern, with some species being distributed throughout the review area, and a gradual gradation in faunal assemblages. The transition zone between the two main phytogeographic provinces (the SW Interzone) is an important area for biodiversity as it contains a high species diversity due to a blending of arid and mesic faunas. Most species of bats, birds and frogs range widely across the review area, and therefore zonation in these taxa is less evident.

2.4 Threatened species

The conservation status of threatened fauna in Western Australia is assessed according to the IUCN Red List categories (1994) (IUCN 1994) and listed under the *Western Australian Wildlife Conservation Act 1950*. Recommendations are made by CALM to the Commonwealth Government (Environment Australia) which lists threatened fauna under the *Commonwealth Endangered Species Protection Act 1992.*

The IUCN Red List Categories (1994) are as follows:

Extinct (EX): No reasonable doubt that the last individual has died

Extinct in the Wild (EW): Known only to survive in cultivation, in captivity or as a naturalised population (or populations well outside the past range)

Critically Endangered (CR): Facing an extremely high risk of extinction in the wild in the **immediate future** as defined by criteria A-E outlined by the IUCN.

Endangered (EN): Not Critically Endangered but facing a very high risk of extinction in the wild in the **near future** as defined by criteria A-E outlined by the IUCN

Vulnerable (VU): Not CR or EN but facing a high risk of extinction in the wild in the **medium-term future**, as defined by criteria A-E outlined by the IUCN

Two other categories of conservation status are recognised by CALM "other specially protected" and "priority". These categories do not have any legal status but list species considered to potentially be at risk and whose status is reviewed annually.

The conservation status of threatened species within the review area, according to both the state and commonwealth acts, is shown in Appendix 2. A total of fifteen species of terrestrial vertebrates are considered threatened by the State list. These comprise seven mammals and eight birds. There are no endangered or vulnerable species of reptiles or amphibians within the review area.

Other "priority" or "other specially protected" fauna within the review area include *Isoodon obesulus fusciventor* (Quenda), *Macropus irma* (Western Brush Wallaby), *Falco peregrinus* (Peregrine falcon), *Morelia spilota imbricata* (Carpet Python), the gecko *Phyllodactylus* sp. "Cape Le Grand" and the elapid snake *Rhinoplocephalus spectablis bushi.* Recently down listed species are *Pseudomys occidentalis* (Western Mouse), downlisted from vulnerable to "priority 4"as there are now more than 10,000 mature individuals in the wild (Morris in prep.) and *Bettongia pencillata* (Woylie) which has been removed from the State and Commonwealth lists due to a dramatic recovery in numbers as a result of fox baiting (see section 2.5.2) (Armstrong 1998).

The Commonwealth list is almost identical to the State list ie. species on the State list fall into same categories as the Commonwealth list except that; a critically endangered category is not recognised on the Commonwealth list (*Potorous gibertii* is listed in Endangered category); and the Australasian Bittern (*Botaurus poiciloptilus*) is not listed on the Commonwealth list.

Important information relating to the conservation of these species is also outlined in Appendix 2. Threatened species occur in a range of habitats and possess varied ecological requirements. Management to conserve these species therefore requires many different approaches, and an integration of management plans to ensure recovery actions for a particular species are not detrimental to another species or to the ecosystem as a whole.

The main current management actions that benefit many, if not all, threatened species are the management of fire, the control of foxes and the prevention of the spread of *Phytophthora.* Work is underway for many threatened species to monitor existing populations and to locate new populations. Translocations of both captive and wild animals to suitable habitats where foxes have been controlled are being carried out for a number of species. Research into the ecology of threatened species is also a priority, but much is still unknown. Recovery actions are ongoing and change as knowledge is increased.

Compared to Western Australia as a whole the review area has a high proportion of extinct mammals (60 %), critically endangered mammals (50 %, one out of two), endangered mammals (29%) and birds (75 %), and vulnerable birds (36 %) (Table 3).

Six species of mammals that once had ranges within the review area are presumed extinct (5 marsupials and 1 rodent), however no species of birds, reptiles, amphibians or invertebrates are presumed extinct within the review area. Within the mammals, the Dasyurids and the bats are the only two major groups with no extinctions.

Although there is a fairly high proportion of threatened species within the review area this is due to the fact that many of these species represent a relict fauna which once had a much wider distribution. From the present distributions outlined in Appendix 2 it can be seen that the reserve system on the south coast represent a stronghold for a number of threatened species, in particular TPBNR and FRNP. These are extremely important areas for the conservation of remnant fauna.

Table 3: Number of terrestrial vertebrates listed as threatened in the review area and all of WA.
State list = *Western Australian Wildlife Conservations Act 1950*

Threatened taxa		Number of species in review area (State list)	Number of species in WA (State list)
Extinct			
	Mammals	6	10
	Birds	0	2
	Reptiles	0	0
	Amphibians	0	0
Critically Endangered			
	Mammals	1	2
	Birds	0	1
	Reptiles	0	1
	Amphibians	0	0
Endangered			
	Mammals	2	7
	Birds	3	4
	Reptiles	0	1
	Amphibians	0	1
Vulnerable			
	Mammals	4	23
	Birds	5	14
	Reptiles	0	8
	Amphibians	0	2

2.5 Threatening processes

From Appendix 2 it can be seen that the main threats to species in the review area are: land clearance leading to habitat fragmentation and destruction; changed fire regimes; predation by introduced predators; and changes in vegetation structure or loss of food plants by the fungal pathogen *Phytophthora*. Competition from, and change in vegetation structure caused by introduced herbivores, particularly the rabbit, has not been implicated, however these effects should be investigated further. For every species there is probably no one single cause of decline or extinction. These processes almost certainly did, and do not, occur in isolation and it is difficult to separate their effects (Recher and Lim 1990).

2.5.1 Fire

Fire has been implicated as having a major impact on fauna, both historically and as an ongoing threat. Low intensity frequent burning carried out by Aborigines for hunting resulted in considerable areas of dense unburnt vegetation. With European settlement, the fire regime changed to one of infrequent hot fires which resulted in the loss of dense stands of vegetation . These changing fire regimes have been implicated as the main cause of the decline of *Atrichornis clamosus* (Noisy Scrub-bird), *Dasyornis longirostris* (Western Bristlebird) and *Psophodes n. nigrogulrais* (Western Whipbird) (Smith 1985a, Smith 1987).

Fire is now used in selected areas as a faunal habitat management tool. Detailed investigations into the use of fire as management tool with particular respect to fauna have been carried out outside the review area in Dryandra Forest (Burrows *et al.* 1987) and Perup Forest (Christensen and Maisy 1987). These studies emphasise the importance of translating research findings into management practice. Major reserves within the review area are managed for fire with the ecological requirements of threatened species as one of a number of priorities (FRNP, W-NNP, TPBNR, WCHNP, (Department of Conservation and Land Management, 1991,1992a,1995a and b respectively).

Despite its use as a management tool, research into the response to fire of many species is lacking. A review of the short and long-term responses of vertebrates to fire in temperate heathland and woodlands throughout Australia, strongly indicated a high degree of consistency between species post fire response and their life history parameters (Friend 1993). Within the review area, Chapman and Newbey (1994) have investigated the response of vertebrates to a large summer wildfire at FRNP. They found that small mammals had a broad spectrum of vegetation fire-age tolerance, with several species surviving in vegetation at 5 years post fire (*Sminthopsis griseoventor* (Grey-bellied Dunnart), *Cercartetus concinnus* (Western Pygmy Possum), *Pseudomys albocinereus* (Ash-grey Mouse) and *Rattus fuscipes* (Bush Rat)), but with the rare small mammals *Parantechinus apicalis* (Dibbler), *Sminthopsis granulipes* (White-tailed Dunnart), *Pseudomys occidentalis* (Western Mouse) and *P. shortridgei* (Heath Rat) requiring 30+ years post fire to survive. Reptiles generally survived the fires by using non-flammable refuges, and some sedentary passerine birds survived in pockets of unburnt vegetation. Research is also currently underway in FRNP to investigate the fire response of the threatened Ground Parrot (*Pezoporus wallicus flaviventris*) (Allan Burbidge, CALM, pers. com).

Smith (1985a,1987) investigated the effect of fire on the three rare bird species at TPBNR (*Atrichornis clamosus* (Noisy Scrub-bird), *Dasyornis longirostris* (Western Bristlebird) and *Psophodes n. nigrogularis* (Western Whipbird)) by considering the changes in population in relation to changing fire patterns. He found that these species generally require long unburnt vegetation to maintain viable populations. Smith (1987) emphasised the compromises needed between the requirements of all species present, the protection of rare species and the maintenance of an acceptable fire risk, when using fire as a management tool. The challenge to managers and researchers is to balance these while conserving biodiversity. Clearly, research into species habitat requirements, life history parameters and fire responses are essential for effective management of fire.

2.5.2 Feral Predators

Predation by the European red fox (*Vulpes vulpes*) has been implicated as a factor in the decline of the CWR mammals (see section 2.1) and some ground birds in Western Australia (Burbidge and McKenzie 1989, Garnett 1992). Experimental removal of foxes has been shown to increase populations of native mammals (eg. *Petrogale lateralis*, Kinnear *et al.* 1988).

The impact of predation by the feral cat (*Felis catus*) can be strongly inferred from historical, circumstantial and observational evidence. On the mainland, feral cats

impact most heavily on mammals weighing less than 220 g and have been implicated in decline and extinction of species of Western Australian rodents (Morris in prep., Dickman 1996). Ground foraging and nesting birds weighing less than 200 g are also vulnerable to cat predation (Dickman 1996).

Fortunately, baiting for foxes and cats with 1080 is successful in Western Australia because these species are highly susceptible to the toxin, whereas many native Western Australian mammal species are extremely tolerant to it (King 1993).

Western Shield Monitoring

An important program underway is the monitoring of mammal populations under the *Western Shield* Program. This program is an initiative of CALM, with the aim to increase numbers and populations of threatened species through the control of the fox and the feral cat in Western Australia's conservation lands. Broadscale fox baiting is now used as an effective tool for the management of populations of threatened species on the south coast by aerial delivery of dried meat baits at 5 baits per km^2 (Armstrong 1998). Baiting for cats is not yet conducted on an operational basis, but research is underway to develop the best technique for the delivery of 1080 baits to feral cats. The 1080 bait for cats is palatable to the native carnivorous Chuditch (*Dasyurus geoffroii*), and therefore cannot be trialed where Chuditch are present. A feline specific toxin (FST) is also being developed which only affects feral cats and is therefore safe to use in the presence of Chuditch.

Western Shield Monitoring – preliminary results

Published data on results of Western Shield monitoring in the review area is not yet available. The following information was obtained as a personal comment from Peter Collins (Wildlife Officer, CALM.) and Klaus Tiddeman (Esperance District Manager, CALM).

Western Shield Monitoring sites:
Albany District
WNP in the Mount Manypeaks Nature Reserve, Bakers Junction (just north of the Hassell Hwy), FRNP (Twertup and Moir Track)

Esperance District
CLGNP, CANP, Helms Forestry Reserve (just north of Esperance).

A monitoring program recording the abundance of small to medium sized mammals commenced at all sites within CALM's Albany District in mid 1997. This corresponded to the commencement of the Western Shield fox baiting program, however fox baiting was already underway since 1991 at the FRNP sites twice a year, as part of another study prior to the start of fauna monitoring (see below). Baiting occurs 4 times a year. Fauna monitoring is carried out twice a year, in Autumn and Spring, and is ongoing. The most significant results to come out of the monitoring program to date have occurred in the FRNP. The threatened species, the *Dasyrus geoffroii* (Chuditch) was captured in September 1998 for the first time in FRNP since 1980. There has also been a marked significant increase in the capture rate (14 % to 40 %) of *Trichosurus vupecula* (Brush-tail possum) at the Twertup site, and a recent

increase in numbers of another threatened species, *Parantechinus apicalis* (Dibbler). Trapping at the Bakers junction and WNP sites have not yielded a significant change in the fauna since the start of monitoring. This is also the case at the Esperance District sites. The fact that these increases were not recorded until 6 to 7 years after initial fox baiting indicates that recoveries may not be evident for some time after the impact of foxes is reduced.

Recent experimental work by Jack Kinnear in FRNP investigated the impact of twice yearly aerial baitings for foxes on medium sized mammals from 1991-1996. The park was partitioned into two areas, one of which was baited. Possums and tammars increased dramatically in baited area. The FRNP offers a great opportunity to increase our understanding of the role of exotic predators on a suite of habitats and their habitat requirements (Jack Kinnear, CALM pers. com)

Clearly the fox has been, and continues to be, one of the greatest threats to CWR mammals. The dramatic recovery of a number of threatened species (eg. *Betongia pencillata* (Woylie)) under broadscale fox baiting is an unequivocal indication of this.

2.5.3 Phytophthora cinnamomi

Phytophthora cinnamomi is a soil-borne fungal pathogen occurring in the south-west in areas with greater than 400 mm annual rainfall. It causes the plant disease "dieback" in Proteaceous and Myrtaceous species, leading to the death of the plant and subsequent change in the vegetation floristics and structure of the community. *Phytophthora cinnamomi* impacts on fauna species by removing the structural components of vegetation (and hence refugia), and the seed and nectar food sources of many mammal, bird and insect species (Wilson *et al.* 1994). This constitutes the removal of a functional group from an ecosystem, which effects ecosystem function (Hobbs 1992).

No quantitative data exists on the impacts of *P. cinnamomi* on fauna within the review area. In the forest region to the north the impacts of *P. cinnamomi* on invertebrates, frogs and reptiles have been investigated. The results were inconclusive but suggested lower species richness and abundance in diseased forest (Nichols and Burrows 1985, Nichols and Bamford 1985). Studies in south-east Australia are more conclusive. Wilson *et al.*(1990) found the percentage of vegetation modified by *P. cinnamomi* in coastal heaths in Victoria to be a significant variable in explaining small mammal diversity and abundance. Further, it was found that changes in vegetation structure rather than invertebrate food supply between diseased and non-diseased areas was the main factor contributing to the abundance of the dasyurid marsupial *Antechinus stuartii* (Brown Antechinus).

It can be speculated that *P. cinnamomi* is having, and will continue to have, a major impact on species which rely specifically on Proteaceous and Myrtaceous species for food (eg. *Tarsipes rostratus* (Honey Possum) and on any species which require particular vegetation structures that are effected by *P. cinnamomi.* Prevention of the spread of *P. cinnamomi* is a management priority on all CALM managed lands (see Management Plans for FRNP, W-NNP, TPBNR, WCHNP, FRNP, (Department of Conservation and Land Management, 1991,1992,1995a and b respectively)).

2.5.4 Habitat fragmentation

The devastating role of habitat fragmentation and destruction on faunal species has been discussed previously in section 2.2.

While land clearing has had a major impact in the past, threatened species occurring within the reserve system are no longer under direct threat from this process. However, the presence of some threatened species on non-protected land (eg. Noisy Scrub-bird (*Atrichornis clamosus*)) requires careful liaison with private landholders and other managing bodies to ensure the protection of habitat.

2.5.5 Introduced herbivores

The European rabbit (*Oryctolagus cuniculus*) can occur in very high numbers on deep sandy soils in remnant vegetation on agricultural land, and have been recorded on mountain tops in southern WA (Barrett 1996). While the rabbit has not been directly implicated in the decline of threatened species in the review area its potential impact, both past and present, cannot be ignored. Almost no quantitative data exists on the critical level of unacceptable damage to fauna caused by the rabbit. This damage is commonly chronic and subtle, and difficult to measure and differentiate from damage done by other threatening processes (Armstrong 1998). One recent study attempted to measure the impact of reduced rabbit numbers through Rabbit Calicivirus Disease (RCD) on the vegetation and fauna in an area of Stirling Range National Park (Gilfillan 1999). No sustained changes in rabbit numbers occurred and therefore the long-term impacts could not be assessed. The potential impacts of rabbits on fauna include direct competition, changes in vegetation structure through grazing and the maintenance of a prey base for feral predators.

Rabbits are the primary prey of foxes and cats (Catling 1988) in many parts of Australia where rabbits are common. Any sustained reduction in rabbits may be expected to cause a decline in the abundance of foxes and cats, after an initial increase with increased supply of carcases (feast effect). However, any reduction in rabbits needs to be carefully monitored, especially in areas where only small populations of native species exist, as initial prey switching from rabbits to native species may occur (Pech and Hood 1998).

3. SOURCES OF INFORMATION ON TERRESTRIAL FAUNA OF THE SOUTH COAST

3.1 Historical and fossil records

Historical and fossil records are important for identifying changes in distribution, contraction of range, or local extinctions of species.

3.1.1 Historical records

The south coast was visited by maritime expeditions in the late eighteenth and early nineteenth century. These expeditions had professional naturalists aboard who made collections of plants and animals, and were made mostly around regional centres. In 1801-1803 an expedition by the French explorer Nicolas Baudin, with the zoologist Francois Peron aboard, made extensive collections around King George Sound. King George Sound was a focus for collecting, it was the site of the first rodent collected in WA, by Charles Darwin in 1836 (Walton 1988), and *Pseudomys occidentalis* (Western Mouse) was first collected here by John Gilbert in the 1840's (Kitchener 1992). John Gilbert, a significant collector of birds, also made discoveries of the *Atrichornis clamosus* (Noisy Scrub-bird), *Psophodes n. nigrogrularis* (Western Whipbird) and *Dasyornis longirostris* (Western Bristlebird) (Serventy 1979). Gilbert collected the type specimens for almost half of the species of recent marsupials occurring in the south-west of WA, which were described by John Gould. (Serventy 1979). Another significant expedition for the region was the Balston Expedition of 1904-1905 led by Oldfield Thomas, a mammalogist from the British Museum. The collector on this expedition, G.C. Shortridge, made significant contibutions to distributional knowledge of birds and mammals (Shortridge 1909).

Rediscoveries

Later collections and surveys led to rediscoveries of species thought to be extinct: *Atrichornis clamosus* (Noisy Scrub-bird Gould 1844) in 1961 at TPBNR (Webster 1962, a in NSC RP); *Parantechinus apicalis* (Dibbler Gray 1842) in 1967 at Cheyne Beach (=Hassel Beach), east of Albany (Morcombe 1967), and *Potorous gilbertii* (as *P. tridactylus*) (Gilbert's Potoroo(Gould 1841)) in1994 at TPBNR (Sinclair *et al.* 1996).

Historical information can be used to determine range contractions or population extinctions of species since European settlement, and help to determine the primary reasons for these declines. Recently, historical records have been used in a major study assessing the changes in distribution of forest birds since European settlement in the south-west of WA (Abbott 1999).

3.1.2 Fossil records

Recent fossil records are valuable in assessing distributions of species immediately prior to the arrival of Europeans in Australia, as much of the comprehensive historical collecting of species was carried out after the extinction of many ground-dwelling mammals (Baynes and Baird 1992). Remains on the surfaces of cave deposits are important sources of fossil records. Within the review area original faunal assemblages, as assessed by examination of fossil records, are known from areas with large numbers of caves. The region from Esperance to Eucla (Baynes 1987) has been assessed for cave deposits (Baynes 1987). The original coastal mammalian fauna of this region consisted entirely of species with southern distributions. For mammals, the Hampton Tableland represents an ecotone with arid zone, southern and arboreal elements all present in the original fauna. The boundary of the South-Western Botanical Province and the South-Western Interzone represents the original eastern limit of south-western Australia sand-plain mammals such as *Parantechinus apicalis*

(Dibbler), *Tarsipes rostratus* (Honey Possum), *Pseudomys albocinerus* (Ash-grey Mouse) and *P. shortridgei* (Heath Rat).

Examples of documents that provide past fossil distributions of species include Strahan (1995) (for Australian mammals), Recovery Plans for threatened species (eg. Orell and Morris 1994, Danks *et al.* 1996, Courtney *et al.* 1998), Action Plans for threatened species (eg. Cogger *et al.* 1993, Maxwell *et al.* 1996, Tyler 1997) and rediscoveries (eg. Morcombe 1967).

3.2 Museum records

A search of museum records of mammals, reptiles and amphibians in the review area was carried out (and is available). However, the listing of all species recorded in the area is not purpose of this review. Also, the number of records and the number of species lodged with the museum for a large area such as the area under review does not give a true indication as to the abundance, diversity or distribution of species in that area. Museum records are biased towards either areas where specimens are easily found (roadside collections), or areas where biological studies have been carried out (generally within the reserve system) (Mazzer and Ellis 1997). Museum records are useful, however, in providing, for example, information about species which occur in specific areas, or to speculate as to which species may occur when constraints of resources inhibit ground surveys. A number of documents contain species lists derived from museum records for specific areas (Table 4).

Table 4: Documents containing species lists for specific areas derived from museum records

Taxa	Locality	Reference
Mammals, birds, reptiles, frogs	Cape Riche to Beaufort Inlet	Anon. (a)
Mammals, birds, reptiles, frogs	Nullarbor Region	McKenzie and Robinson, (1987)
Mammals, birds, reptiles, frogs	Pallinup / Beaufort Inlet Area	Newbey (1987)
Mammals (includes bats)	Albany shire, Pallinup River to Green Range	Leighton (1996)

3.3 Documents providing detailed information on single species ecology (Appendix 3)

These documents provide detailed information on one or more of the following on a single species; (population demography, reproduction, diet, habitat selection, impact of fire, environmental effects on abundance).

There has been few detailed ecological studies carried out on populations of single species in the review area. Those that exist are confined mostly to mammals and birds, with only one relatively limited study on a species of reptile (*Tiliqua rugosa*). *Tarsipes rostratus* (Honey Possum) has been the focus of much ecological work, as have the threatened bird species at TPBNR.

3.4 Documents providing information on community ecology (Appendix 4)

These documents provide information on one or more aspect of the ecology of a community of either one taxa (eg. reptiles) or the interactions of several taxa.

As with single species ecology studies, studies investigating the ecology of communities of animals are also limited. Only two studies deal with the ecology of whole vertebrate communities; one investigates the effects of fire on the numbers and diversity of vertebrates in open scrub mallee habitat (*Eucalyptus decipiens* and *Banksia baxteri*) at FRNP (Chapman and Newbey 1994), and the other, currently underway, is focusing on the use of plantation trees by the faunal community in mallee habitat (R. Hobbs pers. com). A number of studies focus on the environmental factors affecting the breeding or abundance of birds associated with wetlands (Godsell 1990, Halse *et al.* 1989)

3.5 Documents providing information on fauna surveys (Appendix 5)

Biological surveys provide basic information about species distributions and are a prerequisite for developing meaningful biodiversity conservation programs (Biological Surveys Committee 1984). The surveys outlined here include those that either provide information on the presence of species, or more comprehensive surveys that outline detailed data on distribution, abundance or general habitat associations of species. Included in the table are studies that provide species lists arising from the survey results.

Only six comprehensive biological surveys have been carried out in the review area. Four of these deal with areas entirely within the review area (FRNP (Chapman and Newbey 1995, Sanders 1997); CLGNP (Kitchener *et al.* 1975); SNP (Newbey and Bradby 1989)), and two are major regional surveys encompassing part of the review area (Nullarbor region (McKenzie and Robinson 1987) and Eastern Goldfields region McKenzie *et al.* 1993). There has also been a considerable amount of work carried out at the Eyre Bird Observatory which provides valuable information on the presence, distribution and abundance of mammals, birds and reptiles (RAOU 1980, 1982, 1985, 1988, 1989).

There has been a number of less extensive surveys undertaken. Some of these surveys cover a much wider area than the review area (eg. frogs in south-west WA (Jaensch 1993)), survey for particular species (eg. *Thinornis rubricollis*, Hooded Plover (Newbey 1996)) or are confined to particular habitats over a wide area (eg. wetlands (Halse *et al.*1990), mountain tops (Barrett 1996)).

Surveys that have been undertaken off the reserve system have generally been performed by community members and / or environmental consultants.. A survey at Cheyne Bay (Cape Riche to Pallinup River) was conducted by the Wellstead Land Conservation District (Anon.a). Permanent trapping grids were set up and monitoring is on-going. Surveys such as these are valuable in increasing knowledge of biodiveristy outside the reserve system.

3.6 Species lists (Appendix 6)

Species lists exist for a number of specific areas. These lists are compiled from various sources of knowledge of a particular area, rather than a list arising specifically from an on-ground survey. These are predominantly related to birds.

3.7 Documents outlining general distributions of species in WA (Appendix 7)

Considerable work has been carried out by the Western Australian Museum on the distribution of species over large regions, either the whole of WA or sub-regions. Relevant publications dealing in part with the review area are listed in Appendix 7.

4. GAPS IN THE KNOWLEDGE OF THE TERRESTRIAL FAUNA OF THE SOUTH COAST

While much valuable work has been undertaken, the knowledge of south coast fauna remains limited. A summary of the number of documents outlining information on fauna within the review area in terms of study type, taxa and land category can be seen in Table 5. Gaps in the knowledge of fauna in terms of these attributes is discussed below:

4.1 Study type

Scant ecological work has been carried out within the review area, the majority dealing with threatened fauna. This is reflected in the high proportion of ecological studies on single species of mammals and birds (all but one), the only two vertebrate taxa containing threatened species. Ecological work investigating communities has received little attention. Knowledge of community ecology is important for identifying the functional significance of species within a community. This knowledge is important if functional biodiversity is to be maintained (Hobbs 1992)

4.2 Taxa

Ecological knowledge of bats, frogs and reptiles is lacking, and even broad distribution patterns of bats are unknown. The distribution, abundance and ecology of bats are poorly known throughout Australia, probably as a result of only the recent development of effective survey techniques (Mills *et al.*1997). Apart from a few specific groups (eg. Maglomorph spiders and ants), the ecology and regional distribution patterns of terrestrial invertebrates are also virtually unknown

4.3 Land category

The majority (71 %) of studies have been carried out within the reserve system. This is understandable to some degree as these areas contain the natural systems which are generally the foci of research and it is easy to obtain permits to work in these areas since part of the reason for their creation is for scientific research (Mazzler and Ellis 1997). However, even some reserves have not had basic biological surveys carried out on them (eg. WCHNP, Department of Conservation and Land Management 1995). Also, the importance of off-reserve areas for biodiversity conservation has been discussed, and steps should be taken to increase baseline biological knowledge, and faunal use of major corridors and patches of remnant vegetation. Community surveys on off-reserve land are few (examples include the Wellstead Land Conservation District survey and the Birds on Farms project) and should be encouraged.

4.4 Geographical area

Surveys have been carried out in each of the bioregions represented within the review area, but there is still many areas in which knowledge of biodiversity is virtually unknown. The continual coastal corridor extending from Oyster Harbour to Esperance has only information from reserve surveys and a few small off-reserve surveys. In particular, the coastal area immediately west of FRNP is unknown, and contains some

intact habitat which may be important for biodiversity (Angela Sanders, Tony Friend pers. com). The vast coastline from CANP to Eucla (NNR) has had limited survey work carried out on it, as has the area from Albany to Denmark.

Table 5: Summary of the number of studies for each study type, taxa and land category.

RS = Reserve System (CALM managed land), Non RS = Non Reserve System

Study type	Taxa	RS	Off RS		
			Corridor	Remnant vegetation	Wetland
Single species ecology	mammals	6	0	3	0
	birds	15	0	0	0
	reptiles	1	0	0	0
	frogs	0	0	0	0
	invertebrates	0	0	0	0
Community ecology	vertebrates	1	0	2	0
	invertebrates	0	0	0	0
	vertebrates and invertebrates	0	0	0	0
	mammals	0	0	0	0
	birds	5	1	1	1
	reptiles	1	0	0	0
	frogs	0	0	0	0
Surveys	vertebrates	10	2	2	2
	invertebrates	3	0	0	0
	vertebrates and invertebrates	5	3	1	0
	mammals	6	1	0	0
	birds	14	2	3	1
	reptiles	2	0	0	2
	frogs	2	0	0	2
Total		**71**	**9**	**11**	**9**

5. EXTRAPOLATION OF INFORMATION TO OTHER AREAS

Where suitable habitat exists within the known pre-European or fossil range of a species, there is a reasonable chance that populations of that species may still exist in that area. For example, suitable habitat for *Parantechinus apicalis* (Dibbler) occurs at CANP and NNR, which are within the known fossil range of this species (Start 1998). Surveys for populations of *P. apicalis* in these areas form part of the recovery action for this threatened species. In fact, surveys for new populations form an important part of all recovery actions for threatened species, and the selection of release sites for the translocation of threatened species is also primarily based on the identification of suitable habitat within the known range of species.

Museum records may be used to speculate as to which species may occur in a particular area (see section 3.2). There are still many areas that have not been surveyed, so the potential for the discovery of new populations of threatened species, or extensions of the known ranges of species in little known taxa, for example, bats and invertebrates, is high.

Some studies outside the review area that investigate broad patterns in species distributions or ecology may be applied to populations within the review area. For example, a review of the impact of fire on small vertebrates in mallee woodlands and heathlands in temperate Australia identified broad trends in species long and short-term responses to fire (Friend 1993). These general trends can probably be applied to populations in similar habitat types within the review area.

Ecological studies on populations of species with wide distributions often reveal differences in ecological attributes of populations across their range. For example, a recent ecological study of a population of *Trichosurus vulpecula* (Common Brushtail Possum) near Busselton in the extreme south-west found marked differences in the demography of this population compared with that of a semi-arid population. This species shows demographic flexibility with populations responding to different habitats by changing demographic responses (How and Hillox 2000). Therefore extrapolation of results from studies on populations outside the review area to populations within is not wholly reliable and does not negate the need for studies on populations *in situ*.

6. SPECIFIC ACTIONS AND RECOMMENDATIONS

The following actions and recommendations have been identified through the production of this review. They are not considered exhaustive and provide initial guidance for the development of the South Coast Regional Coastal Strategy in regard to the conservation and protection of fauna within the coastal area of the region.

- Ensure all vegetation communities are adequately represented in the reserve system, with the aim of providing sufficient habitat for viable populations of all representative faunal species.

- Continue investigation of the distribution and ecology of threatened species.

- Investigate the response of species or communities to fire and *Phytophthora cinnamomi.*

- Document the regional distribution of poorly known taxa (invertebrates and bats) and focus ecological studies on communities to increase our understanding of community function, with the aim of maintaining functional biodiversity.

- Document site-specific faunal assemblages in areas of the reserve system that are poorly known (eg. West Cape Howe National Park)

- Increase knowledge of faunal biodiversity of off-reserve land, particularly the coastal corridor, which provides the strongest east west link in the landscape at present.

- To substantially increase the resources to undertake these actions, community members could be encouraged to participate in the collection of information under the direction of a Regional Nature Conservation Facilitator. The focus of these fauna surveys could be on taxa that can be sampled non-invasively, including invertebrates, frogs and bats. Invertebrates, which are easy to collect and handle and play an important role as indicators of habitat quality, could be an invaluable tool in increasing knowledge of south coast ecosystems.

- Ensure a central location is established for the collation, collection, storage and dissemination of spatial and aspatial information relating to the natural coastal environment of the South Coast region.

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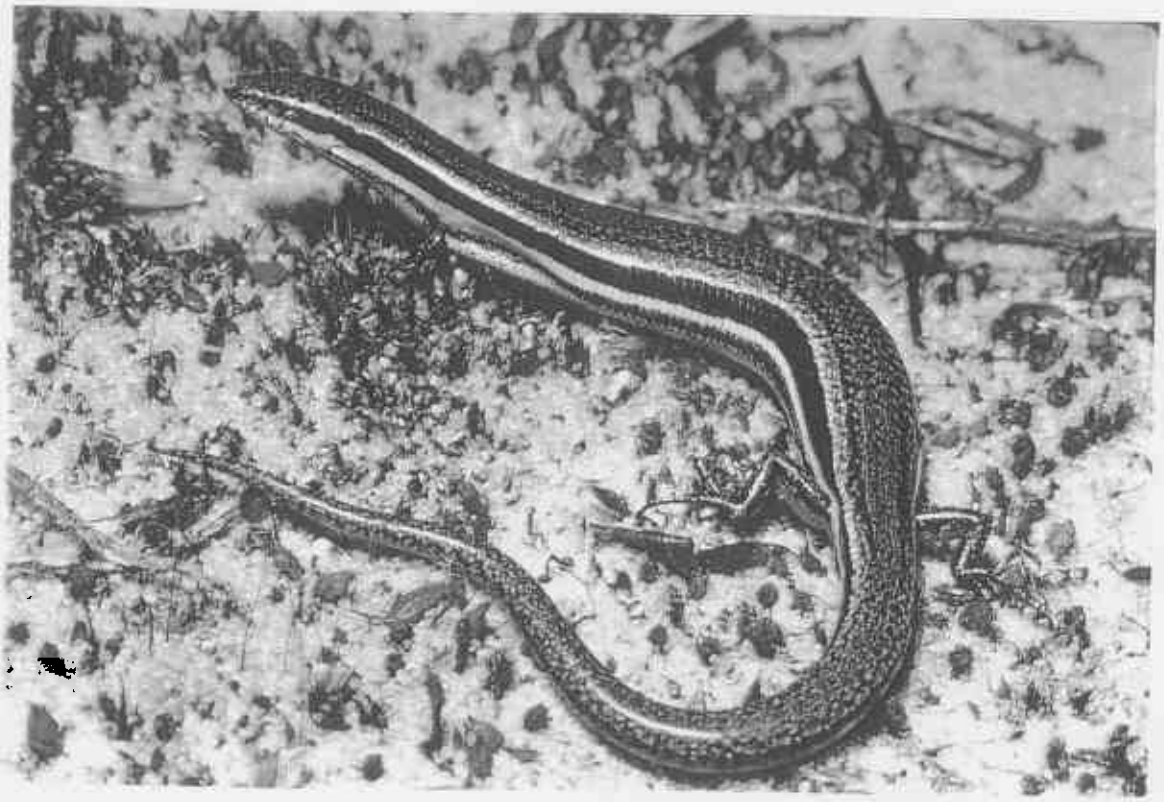
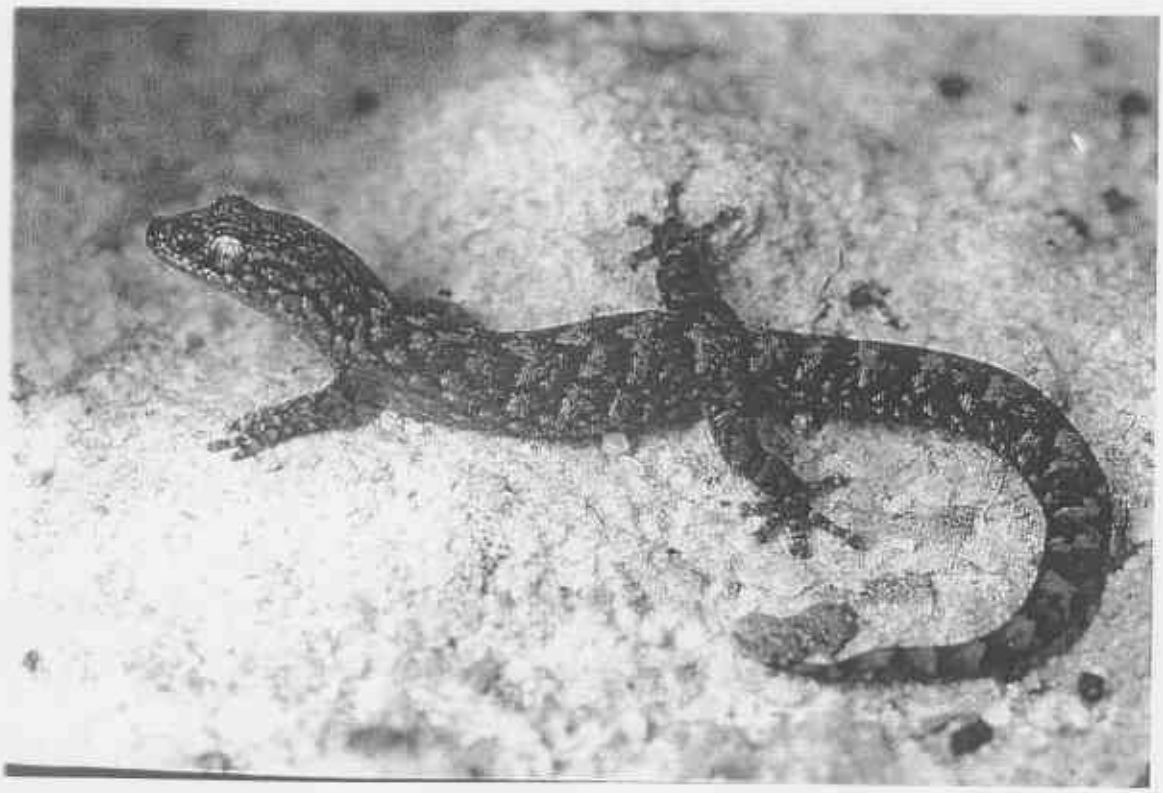
PLATES

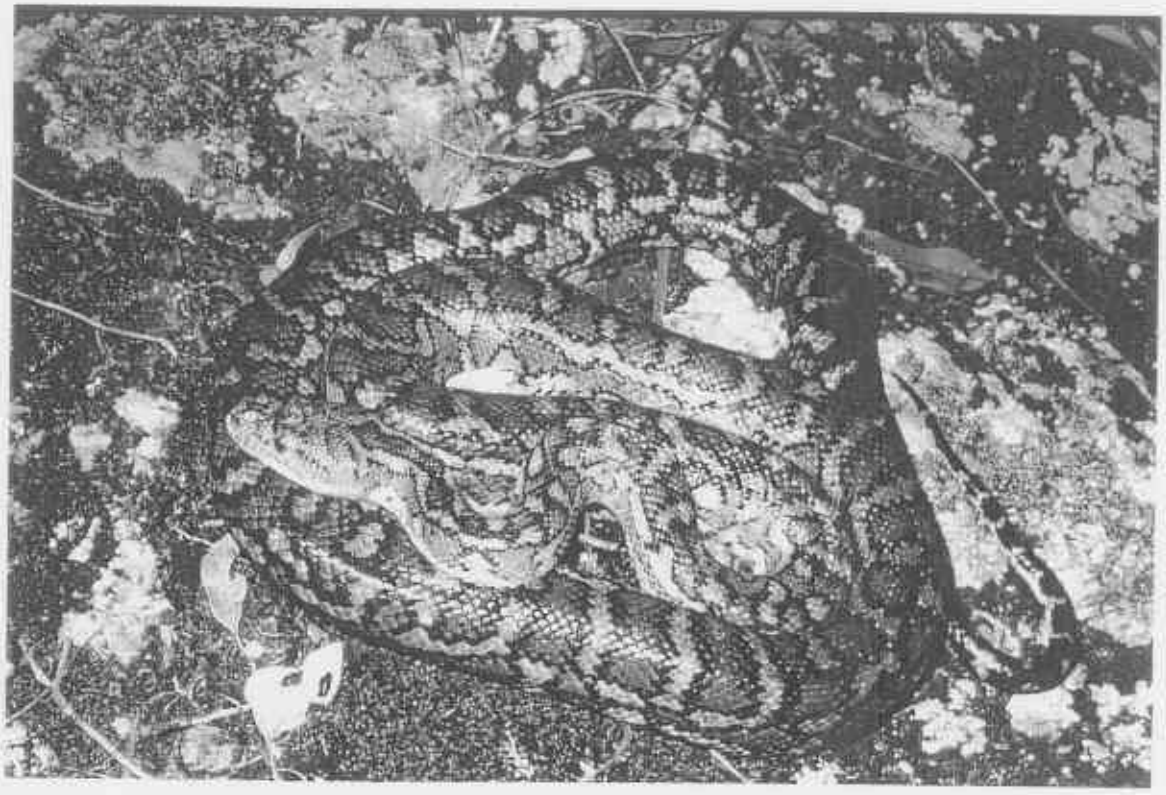


Lersita m. microtus (Skink) Photo: Greg Harold, courtesy of S. Barrett

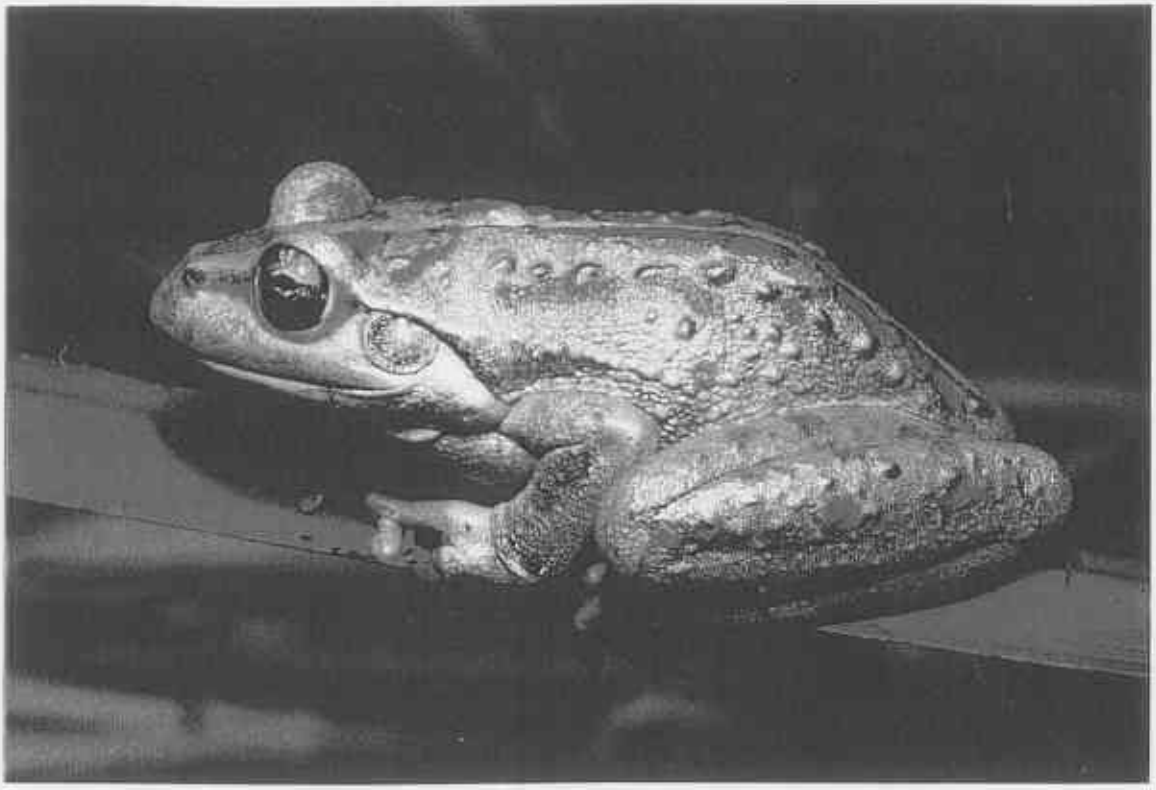


Phyllodactylus m. marmoratus (Marbled Gecko) Photo: Greg Harold, courtesy of S. Barrett

Rhinopocephalus bicolor (Square-nosed Snake) Photo: Greg Harold, courtesy of S. Barrett



Moreila spilotus imbricatus (Carpet Python) Photo: Greg Harold, courtesy of S. Barrett



Litoria moorei (Moores Tree Frog) Photo: Greg Harold, courtesy of S. Barrett

Heleioporus eyrei (Moaning Frog) Photo: Greg Harold, courtesy of S. Barrett

APPENDICES

Appendix 1: Table of abbreviations of localities used frequently in the text

Name	Abbreviation
Cape Arid National Park	CANP
Cape Le Grande National Park	CLGNP
Dundas Nature Reserve	DNR
Eucla National Park	ENP
Fitzgerald River National Park	FRNP
Lake Shaster Nature Reserve	LSNR
Nuytsland Nature Reserve	NNR
Quarrum Nature Reserve	QNR
Stokes National Park	SNP
Torndirrup National Park	TNP
Two Peoples Bay Nature Reserve	TPBNR
Walpole-Nornalup National Park	W-NNP
Waychinicup National Park	WNP
West Cape Howe National Park	WCHNP
William Bay National Park	WBNP

Appendix 2: Information relating to threatened fauna on the south coast

Commonwealth listing = *Commonwealth Endangered Species Act 1992*
State listing = *Western Australian Wildlife Conservation Act 1950*
Present distribution = known locations within the last 10 years

Species and status (State listing)	Common wealth listing	Distribution	Preferred Habitat	Specific ecological requirements	Specific threatening processes	Recovery actions carried out to date	Reference
CRITICALLY ENDANGERED (CR) **Mammals**							
Potorous gilbertii, Gilbert's Potoroo	E	**Past:** High rainfall areas of SW corner of WA **Present:** TPBNR (Mt. Gardner)	Thick heath, often with open patches. Often dominated by *Melaleuca striata*	Vegetation with open patches; presence of underground fungi	Availability of underground fungi, fire, feral predators, *Phytophthora*	Captive breeding colony; survey work to locate new populations; analysis of diet	Courtney *et al.* 1998
ENDANGERED (E) **Mammals**							
Parantechinus apicalis, Dibbler	E	**Past:** Shark Bay to Israelite Bay and inland to Peak Charles (not forested areas of wet SW) **Present:** Boulanger and Whitlock Is. Hassel (Cheyne) Beach (1985) Only in FRNP since 1995	Probably vegetation structure rather than floristics. Long unburnt mallee heath and heath, dense canopy < 1m high and + 10 yrs fire age.	Probably sufficient cover for protection from predation and thick vegetation for nesting	Fox predation appears to be the main threat as populations have increased dramatically at FRNP under fox baiting; potential threat of changes to vegetation caused by the fungus *Phytophthora*, and fire	Fox control, fire management and prevention of the spread of *Phytphthora* at FRNP. Captive breeding colony of mainland animals	Baczocha and Start (1997) Start (1998) Tony Friend (CALM, pers. com.)
Phascogale calura, Red-tailed Phascogale	E	**Past:** Widespread throughout the wheatbelt	Long unburnt tall and dense vegetation of the *Eucalyptus wandoo / Eucalyptus*	Sufficient nest sites; sufficient cover for protection from predation	Fire, feral predators	Research into effects of fire; surveys within marginal and recent range; BIOCLIM	Friend and Friend (1993)

		Present: southern wheatbelt; western end of FRNP	*accedens* and *Allocasuarina huegeliana* alliances			analysis of potential habitat	
Birds							
Calyptorhyncus latrostris, Carnaby's Cockatoo	E	**Past:** SW WA, Murchison River to Esperance and inland to Coorow, Kellerberrin and Lake Cronin, with breeding occurring between 350 – 700 mm annual rainfall, non-breeding birds in coastal areas east to Esperance **Present:** Disappeared from over one third of its former range with local extinctions and reduced densities in occupied areas	Breeds in eucalypt woodlands (primarily Salmon Gum *Eucalyptis salmonophloia* and Wandoo *E. wandoo*); feeds in heath and shrub	Hollows in large eucalypts for nesting; seeds of *Hakea, Grevillia, Banksia* and *Eucalytpus* for food (also *Pinus* plantations)	Loss of feeding habitat from areas close to breeding habitat (potential threat of *Phytophthora*); loss of breeding hollows; competition form invasive species such as the gallah	Captive colony; public awareness program; Recovery Plan just released, future recovery actions include monitoring of populations and habitat management	Saunders *et al.* (1985); Saunders and Ingram (1987, 1995); Cale (2000)
Pezoporus wallicus flaviventris, Ground Parrot (WA subspecies)	E	**Past:** coastal plains of SW WA with mean annual rainfall of 400-1300 mm, between Perth and Dongara and between Israelite Bay and Augusta **Present:** FRNP (7 pops); CANP (2 pops); WNP – Manypeaks area (3 pops); unconfirmed Near WCHNP	Floristically diverse heathlands, various fire ages (5-35 years post fire); densest pops in 20 years post fire habitat	Diet of fruits, leaves and seeds; availability of habitat for dispersal; little known about this sub species	Land clearing in the past; fire is main current threat; potential threats are predation by foxes (recent discovery of high density pops in FRNP in long unburnt areas with fox baiting, Allan Burbidge (pers. com.)) and changes to heathland vegetation by the fungus *Phytophthora*	10,000 ha of northern boundary of FRNP incorporated into park for protection of sub-pops; identification of additional pops; pop monitoring; fox control; prevention of the spread of *Phytophthora*; vegetation monitoring at FRNP for response to fire;	Burbidge *et al* . 1997 and refs therein

Psophodes nigrogularis nigrogularis, Western Whipbird (western heath subsp.)	E	**Past:** subspecies not distinguished **Present:** TPB and Mt Manypeaks; possible further east and west near WCHNP	Thicket or ecotone between low Eucalypt forest and heath; dense to mid-dense understorey of shrubs, tussock grasses with a low open to mid-dense canopy	Little known	Historically, habitat loss, changes in fire frequency and grazing by sheep; potential current, fire, fox predation and *Phytophthora*	Most recovery actions not underway because of confusion over sub-species status (Allan Burbidge, CALM, pers. com.)	Cale and Burbidge (1993); Dpt. Conseravtion and Land Management 2000
VULNERABLE (V) **Mammals**							
Dasyurus goeffroii, Chuditch or Western Quoll	V	**Past:** widespread over 70 % of Australian continent **Present:** SW WA from Moora in the north, FRNP in the east and Cape Leeuwin in the south. Translocated population in CANP	Variety including forest (particularly riparian), woodland, and desert	Adequate numbers of suitable den and refuge sites and sufficient prey biomass (large invertebrates, reptiles and small mammals)	Land clearing; competition and predation by foxes and feral cats. Dramatic increase in numbers after fox baiting emphasises the specific threat of fox predation and competition	Fox control; captive breeding colony; research into effects of prescribed burning regimes and rehabilitation after surface mining	Orell and Morris (1994); Morris and Johnson (1997); Morris (1998)
Pseudocheirus occidentalis, Western Ringtail Possum	V	**Past:** patchy from 120 kms SE of Geraldton to the southern edge of the Nullarbor Plain **Present:** coastal areas from Australind to WNP plus two inland populations at Collie River valley and Perup NR	Peppermint (*Agonis flexuosa*) woodland and peppermint / tuart (*Eucalyptus gomphocephala*) woodland; possibly mallee -heath	Adequate numbers of nest sites	Fox predation (increase in numbers with fox baiting); land clearing	Assessment of potential impact of development proposals: translocation of derelict animals into peppermint woodlands where fox control has been undertaken; research into impact of logging and associated activities	Burbidge and De Tores (1998)
Setonix brachyurus, Quokka	V	**Past:** SW WA (including Rottnest and Bald Islands) from Moore River to Albany, possibly as far as Esperance (fossil	Swamps with dense vegetation; low scrub, thickets and dense heath.	Suitable habitat	Fox predation	Fox control; taxonomic study; surveys for pops; determination of pop size in Jarrah forests; research into impact of fox predation	Maxwell *et al.* (1996)

		bones in FRNP) **Present:** Rottnest and Bald Islands, mainland possibly from Perth in north, Stirling Range NP inland and WNP in the east					
Pseudomys shortridgei, Dyang or Heath Rat	V	**Past:** Southern wheatbelt and eastern coastal area. **Present:** Rediscovered in FRNP in 1987, now only known from FRNP and small area to the north	Recently burnt heath in Victoria, maybe not so in WA	Insufficiently known	Insufficiently known	Some survey work undertaken	Cockburn (1995); Morris (in prep.)
Birds							
Leipoa ocellata, Malleefowl	V	**Past:** Large area from Geraldton to the Nullarbor Plain **Present:** restricted to semi-arid ranglends and remnants, coastal areas around Cheyne Bay, Bremer Bay and FRNP	Mallee, mallee-heath, Moort (*Eucalyptus p. platypus*) and Yate (*E. occidentalis*) swamp	Availability of suitable habitat for mound building	Fox predation; land clearing	Survey for active mounds; fox baiting; habiat assessment; community awareness	Harold and Dennings (1998); Dennings (1998);Anon (a); Chapman and Newbey (1995).
Calyptorhyncus baudinii, Baudin's Cockatoo	V	**Past:** higher rainfall areas of SW WA , mostly between Perth, Albany and Margaret River **Present:** range probably been	Temperate forest dominated by the tall eucalypts Jarrah, Karri and Marri	Hollows in mature eucalypts for nesting; seeds and flowers of Marri and seeds of the Proteaceae for food	Potentially loss of nest sites through logging (effects unknown)	Location and characterisation of nest sites	Saunders (1974); Saunders *et al.* (1985), Saunders and Ingram (1995)

		stable since European settlement, populations may have declined since 1950's					
Atrichornis clamosus, Noisy Scrub-bird or Tjimiluk	V	**Past:** recorded from three locations before disappearance – Mt William – Drakesbrook, Ausgusta-Margaret River and Albany area **Present:** TPBNR (Mt Gardner); Gull Rock (Mt. Taylor); Bald Island; WNP; Mt Manypeaks; two populations east of WNP; Darling Range	Dense, long unburnt (+10 yrs) low forest (5-15 m), scrub / thicket and rarely heath (core areas of male territories)	Pliable long-leaved sedges for construction of nests; dense clumps of sedges, shrubs or piles of debris for nest sites; rich leaf litter invertebrate fauna for food in open areas with thick leaf litter	Land clearing in the past; main current threat is fire (maintenance of long unburnt vegetation)	Translocations of birds to Darling Range (site selection, translocation, post-release monitoring of population numbers); prevention of the spread of *Phytophthora*; fire managemnent; research into movements, diet and prey availability	Danks *et al.* (1996) and references therein
Dasyornis longirostris, Western Bristlebird	V	**Past:** coastal SW WA near Perth and Albany **Present:** between TPBNR and east of Waychinicup River, four locations within FRNP	Closed dense heath, sometimes with scattered patches of mallee; unburnt swampy vegetation may be important as refugia after fire	Long unburnt vegetation (not more than 50 years post fire)	Land clearance in the past, main present threat is fire	Surveys of populations; protection of populations from fire; research in effects of fire at FRNP; translocation of birds to Nuyts Wilderness (W-NNP	Cale and Burbidge (1993) and references therein
Botaurus poiciloptilus, Australasian Bittern	Not listed	**Past:** SW WA between Moora in the north and Mt Arid in the south, also eastern Australia **Present:** restricted with large concentration near Lake Muir.	Shallow, vegetated freshwater of brackish swamps, usually dominated by reeds or sedges	Availability of suitable wetlands	Draining and salinization associated with land clearing; loss of drought refuges; overgrazing of swamp vegetation	Survey of abundance in wetlands on reserves	Jaensch *et al.* (1988); Garnett (1992)

Spiders							
Austrarchaea mainae, Western Archaeid Spider	Not listed	Only known from TNP	Possibly long unburnt vegetation	Unknown	Unknown	None	Julianne Waldock, WA Museum (pers. com.)

Appendix 3: Documents providing information on single species ecology.

* threatened species; Land category : RS = Reserve system (CALM managed land), Non RS = Non reserve system

Species	Locality	Land category	Type of information							References
			Habitat	Interaction with plants	Population numbers	Diet	Abundance in relation to environmental variables	Reproduction / life history	Fire effects	
Mammals										
Tarsipes rostratus, Honey Possum	FRNP	RS					✓			Wooller *et al.* (1993)
	FRNP	RS					✓			Wooller *et al.* (1998)
	near TPBNR	Off RS- Remnant vegetation						✓		Renfree *et al.* (1984)
	near TPBNR	Off RS- Remnant vegetation				✓	✓			Wooller *et al.* (1984)
**Parantechinus apicalis*, Dibbler	FRNP	RS	✓		✓				✓	Baczocha and Start, (1997); Start (1998);
**Potorous gilbertii*, Gibert's Potoroo	TPBNR	RS				✓		✓		Courtney *et al.* (1998)
	TPBNR	RS				✓				Bougher (1998)
Rattus fuscipes fuscipes, Southern Bush Rat	CLGNP	RS						✓		Kitchener *et al.* (1975)
Pseudocheirus occidentalis, Western Ringtail Possum	12 sites from Wilson Inlet to TPBNR	RS Off RS – Remnant vegetation					✓			Jones *et al.* (1994a and b)

Birds										
**Atrichornis clamosus*, Noisy Scrub-bird	TPBNR	RS				✓				Smith and Claver (1984)
	TPBNR	RS	✓			✓				Welbon (1992)
	TPBNR	RS							✓	Smith (1985a)
	TPBNR	RS	✓		✓					Smith (1985b)
	TPBNR	RS				✓				Danks and Calver (1993)
	TPBNR	RS	✓							Smith (in prep b)
**Pezoporus wallicus*, Western Ground Parrot	TPBNR, FRNP	RS	✓			✓		✓		Cale and Burbidge (1993) and references therein

**Dasyornis longriostris*, Western Bristlebird	TPBNR	RS	✓			✓		✓		Cale and Burbidge (1993) and references therein
	TPBNR	RS	✓							Smith (in prep b)
	TPBNR	RS							✓	Smith (1985a)
**Psophodes nigrogularis nigrogularis* ,Western Whipbird	TPBNR	RS	✓			✓		✓		Cale and Burbidge (1993) and references therein
	TPBNR	RS							✓	Smith (1985a)
	TPBNR	RS	✓							Smith (in prep b)
Phylidonyris novaehollandiae, New Holland Honeyeater	FRNP	RS	✓							Burbidge *et al.* (1979)
Sericornis frontalis, White-browed srubwren	Eyre, NNR	RS	✓			✓		✓		Ambrose (1985)
Reptiles										
Tiliqua rogosa, bobtail	Eyre, NNR	RS	✓		✓					Bamford (1982)

Appendix 4: Documents providing information on community ecology

Land category : RS = Reserve system (CALM managed land), Non RS = Non reserve system.

Community	Locality	Land Category	Type of information	Species list?	Reference
mammals, birds, reptiles, frogs	FRNP	RS	no.s of each species in burnt and unburnt quadrats, and at intervals (9,23,35 months) after fire	yes	Chapman and Newbey (1994)
mammals (including bats), birds, reptiles, frogs	Between Albany and Mt.Barker	Off RS – Remnant vegetation	a number of sites in different positions in relation to remnant vegetation and bluegum plantations.	No	Hobbs (pers. com) survey in progress
Birds and mammals	Cheyne Beach	Off RS- Remnant vegetation	pollen loads of *Banksia* species on various species of birds and mammals	no	Hopper (1980)
reptiles	Eyre, NNR	RS	habitat associations	yes	Bamford (1988)
birds	Eyre, NNR	RS	movements of birds	yes	RAOU (1981, 1982, 1985, 1988, 1989).
birds	TNP	RS	Banding study>distances travelled, sex and age data	yes	Morrison and Hunt (1998/1999)
birds	TPBNR	RS	Recolonisation and changes in community structure after fire	no	Hopkins and Smith (in prep)
birds	Albany coast	Off RS- Remnant vegetation, corridor	species related to size, and exposure of sites;	yes	Abbott (1980)

			differences between island and mainland sites		
waterbirds	Nornalup to Esperance	Off RS - wetland	which characteristics of wetlands effect their use by waterbirds	yes	Halse *et al.* (1993)
waterbirds	Albany to Esperance	RS	species of birds breeding in relation to wetland salinity and pH	yes	Godsell (1990)
waterbirds	Nornalup to Esprerance	RS	breeding in relation to rainfall, temperature, photoperiod and depth of lakes	yes	Halse and Jaensch (1989)

Appendix 5: Documents providing information on fauna surveys

Land category : RS = Reserve system (CALM managed land), Non RS = Non reserve system

Species	Locality	Land category	Type of information	Species list?	Reference
Mammals, reptiles, frogs, litter invertebrates	Mt Many Peaks (565m) WNP, Thumb Peak (508m) Barren Ranges FRNP, Mt Ragged (585 m) CANP	RS	presence of mammals, reptiles, frogs; seasonal abundance of litter invertebrates; species richness; impacts of fire and *Phytophthora* on fauna; baseline data on invertebrates; basic inventory of vertebrates	yes (annotated)	Barrett, S. (1996)
mammals (including bats), reptiles frogs, arthropods, spiders, land molluscs	TPBNR	RS	Species presence	yes (annotated)	Bannister, J.L. (1970)
Mammals, reptiles, frogs, invertebrates	Cape Riche to Beaufort Inlet	Off RS - Corridor	permanent trapping grids > ongoing; lists threatened species: abundance and vegetation associations	yes	Anon. (a)
Mammals, reptiles, frogs, ants	FRNP	RS	species presence and abundance	yes (annotated)	Clavin, B. (1983)
mammals, birds, reptiles, frogs, invertebrates	FRNP and Buffer Zone	RS Off RS – Remnant vegetation, corridor	species distribution and abundance	yes	Sanders (1997)
mammals, birds, reptiles, frogs,	FRNP and Buffer Zone	RS Off RS – Remnant vegetation, corridor	species distribution and abundance	yes	Sanders (1996)
mammals, birds,	TNP	RS	species presence	yes (annotated)	Smith (1990)

reptiles, frogs					
mammals, birds, reptiles, frogs, litter invertebrates	WBNP and QNR	RS	species presence	yes	Regan (1996)
Mammals (including bats) birds, reptiles, frogs, invertebrates	Corackerup Ck, Fitzgerald River, Young River and Lort River	Off RS- Corridor	species abundance and distribution (vegetation association)	yes	Watson and Leighton (1992)
mammals, birds, reptiles, frogs, inland fish	FRNP and Fitzgerald Biosphere Reserve Buffer Zone	RS Off RS – Remnant vegetation, corridor	species presence and habitat associations	yes (annotated)	Chapman and Newbey (1995)
mammals, birds, reptiles, frogs	FRNP	RS	species presence	yes	Tingay, A.
mammals, birds, reptiles, frogs, fishes	SNP	RS	species presence, numbers of mammals	yes	Newbey and Bradby, (1989)
mammals, birds, reptiles, frogs, fishes	CLGNP	RS	species presence, breeding condition of mammals; habitat associations	yes (annotated)	Kitchener *et al.* (1975)
mammals, birds, reptiles, frogs	Wilson Inlet foreshore	Off Res – Remnant vegetation	presence of species and habitat associations	yes	Regan (1997)
mammals, reptiles, frogs	TPBNR	RS	species presence	yes	Hopper (1981)
mammals, birds, reptiles, frogs	Kybulup Reserve (now part of FRNP)	RS	species presence	yes (annotated)	Chapman (1987)
birds, reptiles, frogs, fishes	Mount Manypeaks	RS	includes noisy scrub bird, western bristlebird and ground parrot	yes	Danks
mammals, birds, reptiles, frogs	Nullarbor Region, sites in NNR, and Roe Plain	RS Off RS	Species presence, species assemblages, conservation implications	yes	McKenzie and Robinson (1987)
mammals, reptiles, birds	Eyre, NNR	RS	Species presence, breeding and movements of red-capped Plovers	yes (annotated)	Martindale (1980)
mammals, birds,	Ravensthorpe	Off RS -	Species presence, abundance and	yes (annotated)	Chapman and Newbey

reptiles, frogs, fishes	Range	Corridor	distribution; seasonal abundance of mammals		(1987)
mammals, birds, reptiles, frogs	Monjingup Lake Botanical Park, ne	Off RS wetland	species presence	yes (annotated)	Harold (1996)
Mammals (including bats), birds, reptiles, frogs	DNR	RS	species presence	yes (annotated	McKenzie *et al.* (1993)
Mammals, birds, reptiles, frogs	Sandpatch, near Albany	Off RS	species presence	yes (annotated)	Halporn *et al.* (2000)
mammals	TPBNR	RS	species presence	yes	Kivell (1999)
mammals	WBNP and QNR	RS	species presence; habitat type; trapping ratios per vegetation type	yes	Regan (1998)
Mammals (including bats)	Pallinup River to Green Range	Off RS - Corridor	trapping and reported sightings; also inventory of all mammals known to occur, or suspected in the area	yes	Leighton (1996)
Mammals (including bats)	Eyre, NNR	RS	species presence	yes	RAOU (1982)
Tarsipes rostratus (Honey Possum)	Eyre, NNR	RS	extension of range more than 400km east .	n/a	Watkins (1989)
Parantechinus apicalis (Dibbler)	Various	RS	results of survey for dibbler at various sites on south coast	n/a	Baczocha, and Start (1997)
Potorous gilbertii (Gilbert's Potoroo)	TPBNR, Mt Many peaks	RS	search for animals		Coutrney *et al.* (1998)
Cercatetus concinnus (Western Pygmy Possum)	Eyre, NNR	RS	presence	n/a	Hooper and Wells (1989)
birds	Eyre, NNR	RS	bird counts	yes	RAOU (1980, 1982, 1985, 1988, 1989)
birds	all SW, 4 sites in review area	Off RS – Remnant vegetation, corridor	survey for birds on road verges and farms; diversity related to site characteristics such as patch shape area, isolation, grazing, tree and shrub species	yes	Newbey (1999)
waterbirds	Nornalup to east of Esperance	RS Off RS - wetland	results of 3 year (1988/89 - 1990/91) extension of the CALM/RAOU waterfowl counting program in sw WA; counts,	yes	Halse *et al.* (1990, 1992, 1994, 1995)

			distribution, breeding		
waterbirds	9 Sites east to Albany	RS	Species presence, habitat, threats		Jaensch (1992)
Dasyornis longirostris, Western Bristlebird	FRNP and Lake Magenta	RS	survey of location of nests and vegetation associations	n/a	McNee and Newbey, (1997)
	FRNP	RS	distribution		Chapman and Newbey (1995)
Psophodes nigrogularis nigrogularis, Western Whipbird	FRNP	RS	distribution		Chapman and Newbey (1995)
Western Whipbird and Western Bristlebird	Albany to CANP	RS Off RS – rem veg	historical records, location of sites were found in this survey	n/a	McNee (1986)
Pezoporus wallicus, Western Ground Parrot	WNP and Mt Manypeaks	RS	locations of positive records	n/a	McNee (1993)
	Walpole to Israelite Bay	RS Off RS	presence/ vegetation association; include historical records of GP	n/a	Watkins (1984)
	FRNP	RS	distribution		Chapman and Newbey (1995)
Cinclosoma alisteri (Nullarbor Quail-Thrush)	Eucla to Cocklebiddy	Off RS	all known records, habitat	n/a	Pedler and Burbidge, (1995)
Thinornis rubricollis, Hooded Plover	Nornalup to Eyre	RS Off RS - Corridor	all positive sites west of CANP; breeding times	n/a	Newbey (1996)
Leipoa ocellata, Malleefowl	Eyre, NNR	RS	search for mounds	n/a	RAOU (1982)
Reptiles	Eyre, NNR	RS	species present	yes (annotated)	RAOU (1982)
Lizards	Roe Plain	Off RS	basic natural history information on mostly agamid and scincid lizards	yes (annotated)	Greer *et al.* (1991)
Reptiles and frogs	Israelite Bay to Eucla (Great	RS Off RS	species, relative abundance and habitat preference	yes (annotated)	Storr *et al.* (1981)

	Australian Bight)				
Frogs	Albany area	Off RS	species presence (10 schools in Albany region)	yes	Leighton and Tupman (1993)
Frogs	sites east to Albany	RS	species diversity and abundance	yes	Jaensch (1993)
Invertebrates	TPBNR	RS	species presence	yes	Smith (in prep a).
Spiders	TNP	RS	presence of Mygalomorph spiders.	no	Main (1987)
Ants	CANP	RS	faunistic composition and community structure	yes	Anderson and Burbidge (1992)

Appendix 6: Additional species lists for specific areas

Land category : RS = Reserve system (CALM managed land), Non RS = Non reserve system

Species	Location	Land type	Annotated list ?	Reference
Birds	CLGNP	RS	no	National Parks Authority Western Australia
birds	FRNP	RS	no	National Parks Authority Western Australia
birds	Albany area	Off RS	yes	Garstone (1981).
birds	CANP	RS	no	Department of Conservation and Land Management.
birds, mammals	WBNP	RS	no	Department of Conservation and Land Management (1998)
reptiles, frogs	SNP	RS	no	Bush (1985)
terrestrial invertebrates	TPBNP	RS	yes	Smith (in prep a)

Appendix 7: Documents containing information on general distributions of species

Species	Area Covered	Information provided	Reference
mammals	Australia	summary of information on all mammals of Australia; ecology; past and present distribution	Strahan (1995)
birds	Eucla Division	range and status	Storr (1987)
	SW Land Division	range and status	Storr (1991)
non-passerine birds	WA	description, distribution, status, breeding of all non-passerine birds of WA	Johnstone and Storr (1998)
reptiles	Kalgoorlie-Esperance Region	annotated list of species	Bush (1981)
dragons and monitors	WA	description, distribution of all WA species	Storr *et al.* (1983)
skinks	WA	description, distribution of all WA species	Storr *et al.* (1981, 1999)
geckos and pygopods	WA	description, distribution of all WA species	Storr *et al.* (1990)
snakes	WA	description and distribution of all snakes of WA	Storr *et al.* (1986)
frogs	WA	description, distribution of all WA species	Tyler *et al.* (1994)
	Southern WA	description, range, biology	Main (1965)