1995 Mammal Conservation Course

Batalling Field Study Centre
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Department of Conservation and Land Management
Central Forest Region

Contents

1995 Mammal Conservation Course
Opening Address: Focusing Science on Wildlife

Neville Marchant

This address is based on one presented last year at this training course by Dr Jim Armstrong, the Director of the Science and Information Division. Dr Armstrong talked of the taxon approach to conservation That is, the approach which concentrates on preventing species "falling off the planet".

CALM has put an enormous amount of effort into the study of rare mammal species such as the Numbat, Woylie, Chuditch, Mardo, Dalgyte etc. This approach is not the best one to adopt because we need to attack the threatening processes rather than concentrating on a very few taxa.

Later I will expand on this theme by describing a system of classification which will indicate just how little we really know about most of the species we should be conserving.

Before I do this I want to describe the structure and role of CALM's Science and Information Division to give you a framework in which I will present some of the facts about our current state of knowledge.

Overhead I shows the structure of the Division. There are four Groups, each is divided into Sections, each Science Group has two Sections and the Science Service Group has four.

The key to understanding the functions and relationships of the Groups and Sections is presented in Overhead 2.

The inventory of Western Australia has historically concentrated on two taxonomic groups, namely vascular plants and vertebrates. In the case of plants for example, CALM's herbarium has gathered information on the taxonomy of vascular plants since the 1920''s. The herbarium is integrated within the two bio-groups, Bio-resources and Bio-conservation as a resource where information about plants is stored in a retrievable system. CALM has a sophisticated database system where all plant specimen records are recorded on computer. Information on labels, including notes on soil, landform,

vegetation type and associated species is linked to a precise geographic location. The value of this information can be understood when it is coupled with other information such as climate, geology, disease records, landforms, vertebrate records etc. GIS systems offer us an incredible tool for conservation and land management.

Bio-resources Group has only recently started to determine the state of knowledge of the so-called lower plants, the algae, fungi, lichens and bryophytes which probably total 5 times the number of taxa of the vascular plants. The problem now facing the Bio-resources Group is where to go now; how to most effectively fill the gaps in knowledge. If we have taken over 70 years to gain the knowledge we have how long will it take to fill in the gaps? What strategic information do we need for conservation? How many decades can we wait to obtain enough information about sufficient taxa to conserve ecosystems before they disappear?

In the case of Bio-conservation Group, the Division is now asking the question: How much effort should we put into taxon conservation if we know so few taxa? Wouldn't it be better to put effort into studying threatening processes? Look at the achievements of CALM with the control of the feral predator the fox; this is a fantastic success story to date. Doesn't this tell us that we may not need to study all of the characteristics of each mammal; instead we should identify and do something about the threatening processes. Just keep on removing foxes and cats.

What can we do about *Phytophthora cinnamomi*? We don't want to spend valuable time studying what the pathogen does if that doesn't tell us how to contain it. Weeds are another threat we don't do enough about; we usually wait until they reach plague proportions before we do anything.

I called this address "Focusing Science on Wildlife" ; you will by now see that I am saying we must focus on threatening processes. We can no longer "fiddle while Rome burns"; we have to be smarter in how we approach conservation.

A real problem we face is one I alluded to earlier; we concentrate on a few types of organisms and feel that this is achieving broad conservation goals. This is the concept of charismatic taxa ie. taxa we regard as attractive, the "warm and cuddlies" the "cute" and in the case of plants with showy flowers, the "pretty". We concentrate on mammals, the short-necked swamp tortoise and the banksia and grevilleas etc. In fact, in CALM we still talk about "flora" and "fauna" which is usually taken as referring to charismatic taxa or at least the taxa we can easily see. It is high time we caught up with the rest of the world and adopted a system of classification terms which are unbiased.

The Whittaker Five Kingdoms System was published in 1969. It encompasses all biota in a widely accepted taxonomic framework. Overhead 3 is a simplified version; the notes include a synopsis of the System. Overhead 4 shows the five Kingdoms and familiar examples.

This system allows us to see the gaps in our knowledge. Overhead 5 shows the estimated number of species for each of the Kingdoms, the lowest estimate of the number of species in the world is one and a quarter million, ranging to an upper estimate of twelve million species!

If we accept the conservative estimate of the number of species in the world lets look at the number of species in each of the taxa in a pie chart, Overhead 6. Animals account for 800 000 species, 64%

In the Kingdom Animalia 46 000 of the total of 800 000 are chordates (the category chordates has become synonymous with animals and fauna) which includes tunicates and other brainless chordates. The animal kingdom also includes:-

birds	9000 species
fish	25000 species
amphibia	2000 species
reptiles	5000 species
mammals	4500 species

So if we look at the number of animals which are mammals in the same pie chart with percentages marked for each of the five Kingdoms (Overhead 7), we see that mammals are only a half of one percent. This is what I mean when I say we are putting all our efforts into charismatic taxa.

Of course the figures presented here are world figures. We can give you an educated guess at the number of plants in the south west WA as approximately 3.3% of the world's plant species.

At a meeting at Dryandra on October 12 and 13, the Bio-resources Group decided to develop a training course in Biodiversity based on this Mammal Training Course. If we can obtain funding we will present a course to equip CALM staff with the skills to understand and assist to ameliorate threatening processes.

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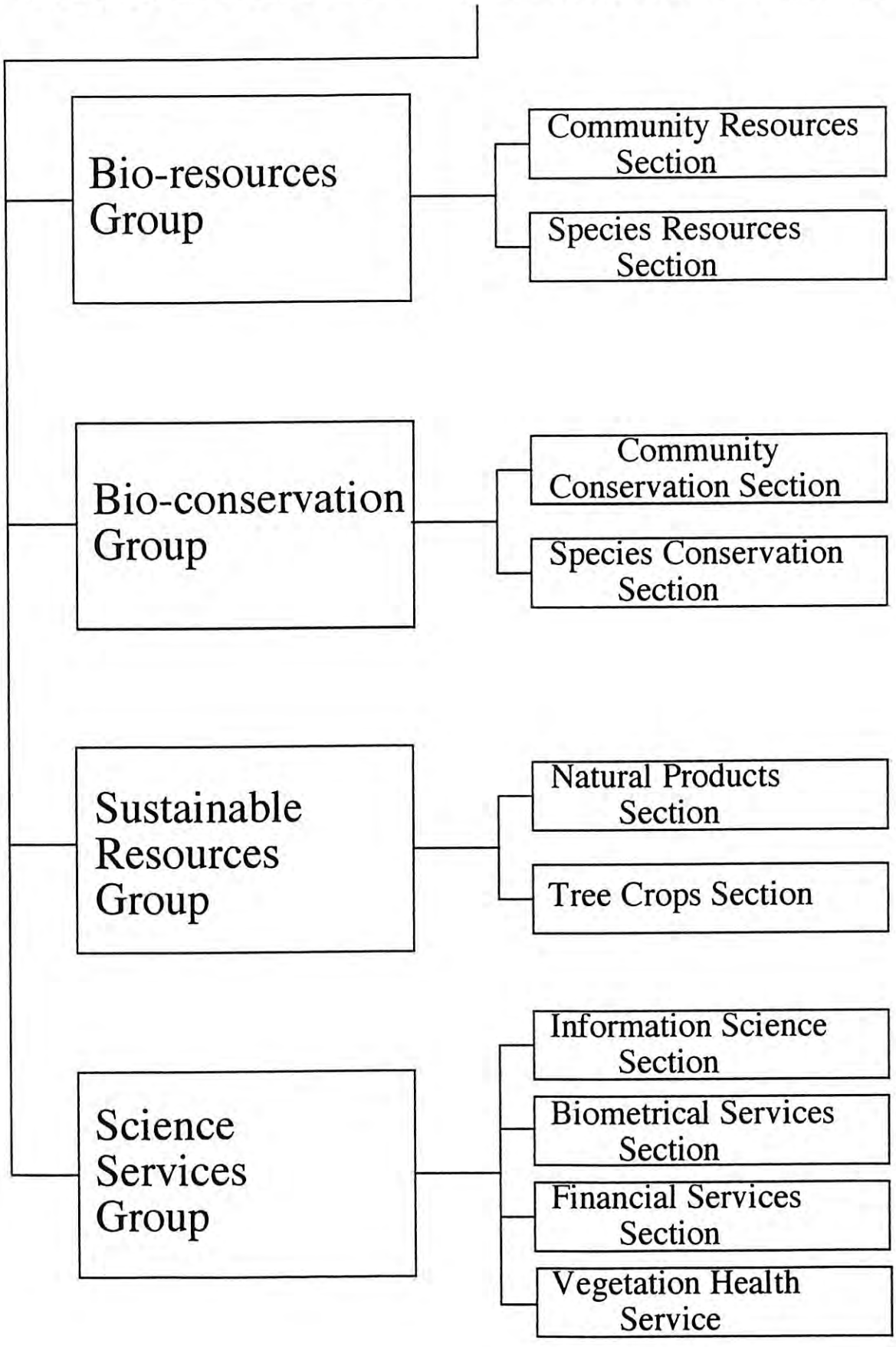
CALM
Science and Information Division



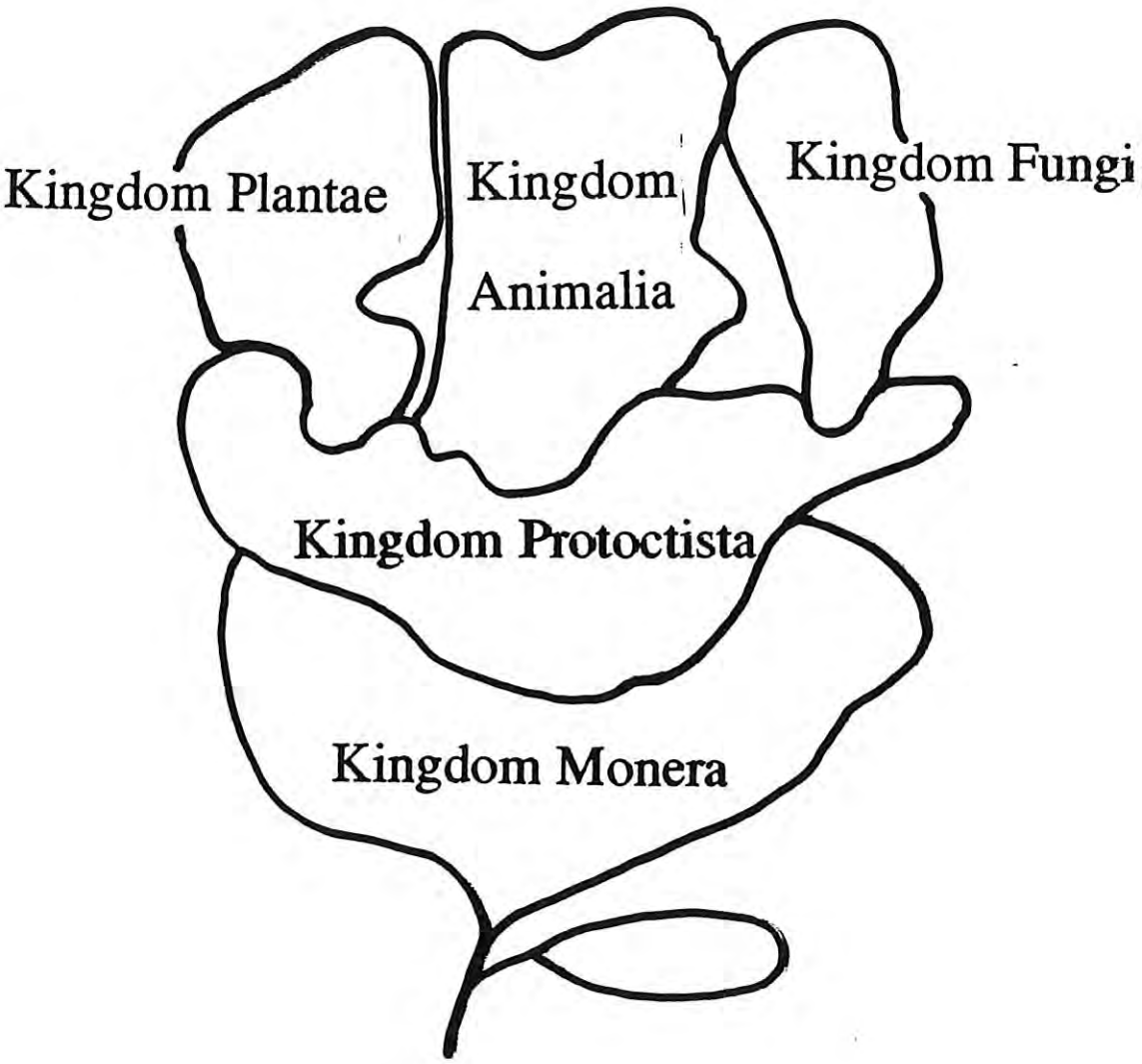
Overhead 1

CALM
Science and Information Division

Bio-resources Group	*Bio-conservation Group*	*Sustainable Resources Group*
inventory	***threatening processes***	***sustainable utilisation***
fauna	**weeds**	**forest products**
flora	**managing change**	**seeds**
landscape values	**fire**	**boronia**
	fungal pathogens	**crocodiles**
	salinity	**parrots**

Overhead 2

THE WORLD'S BIOTA
Whittakers 1969 Five Kingdom System



THE WORLD'S BIOTA

Whittakers 1969 Five Kingdom System

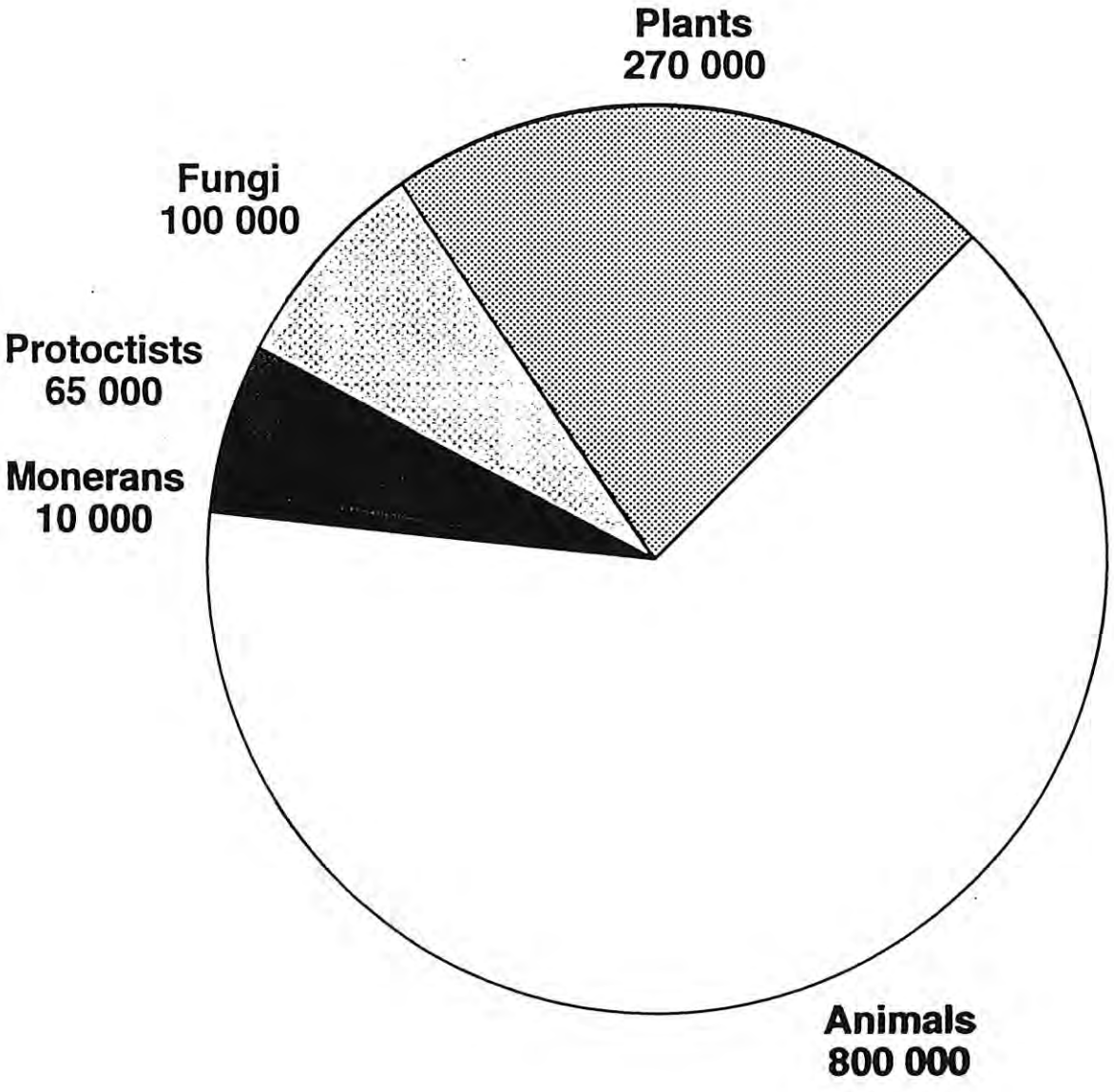
Kingdom	*examples*
Monera	*bacteria and allies; blue-green "algae"*
Protoctista	*unicellular plants and animals; algae, water moulds; Amoeba*
Fungi	*mushrooms; lichens*
Animalia	*insects, corals, chordates*
Plantae	*mosses, conifers, ferns; flowering plants*

THE WORLD'S BIOTA

Kingdom	*species*
Monera	10 000 to 100 000
Protoctista	65 000 to 200 000
Fungi	100 000 to 300 000
Animalia	800 000 to 11 000 000
Plantae	270 000 to 300 000

LOWER ESTIMATE	=	1 245 000
UPPER ESTIMATE	=	~12 000 000

The Five Kingdoms
Conservative Estimate of Numbers of Species = 1 245 000



The Five Kingdoms
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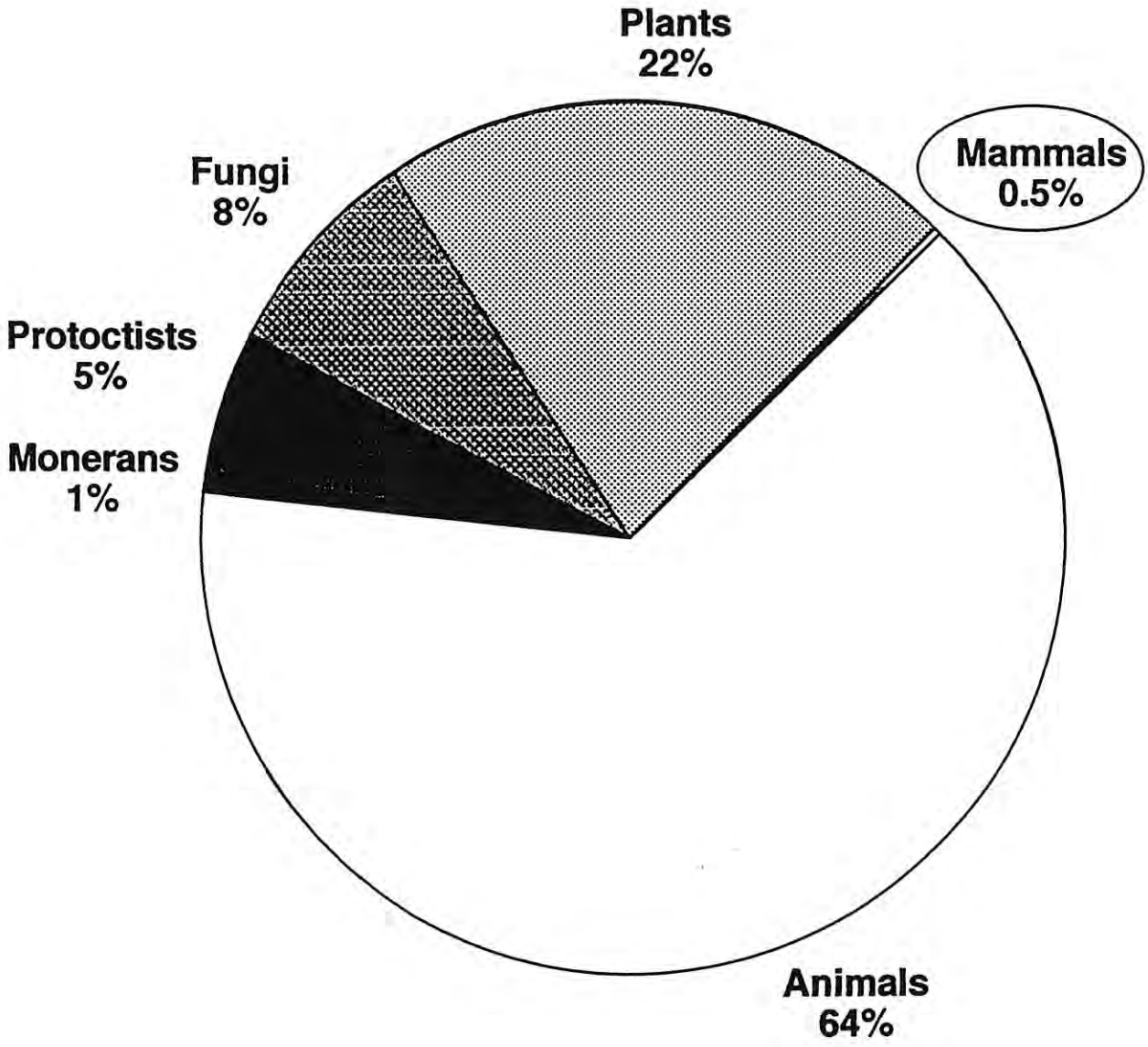

Synopsis of the Classification of organisms Based on the Whittaker five Kingdom system

References:

Margulis and Schwartz (1982) *Five Kingdoms; An Illustrated Guide to the Phyla of Life on Earth.* Freeman, San Francisco)

Margulis, L *et al.* (editors) (1989) *Handbook of the Protoctista* Jones and Bartlett, Boston

Whittaker, R H (1969) New concepts of Kingdoms of organisms *Science* **163:** 150-160

Five kingdoms are recognised. All organisms in these kingdoms are either are cells or are composed of cells. Some arguably living forms that do not fit this description are viruses, which, although they reproduce, can only do so by entering a host cell. Viruses are probably more closely related to their hosts than to each other.

Kingdom Monera

Approximately 16 phyla. Mostly bacteria and their allies; all prokaryotes (without a membrane-bounded nucleus; all other kingdoms are eukaryotic).

Examples

Phylum Actinobacteria	(Actinomycetes)
Phylum Cyanobacteria	(blue-green algae)
Phylum Pseudomonads	
Phylum Spirochaetae	

Kingdom Protoctista

Includes groups traditionally called "unicellular animals or unicellular plants' which were originally called Protista. Now regarded as including multicellular plants and animals so the term Protista is not used. The Protoctista comprise the non-plant non-animals non-fungal organisms ie defined by exclusion. 27 Phyla recognised

Examples

Phylum Bacillariophyta	(diatoms)
Phylum Chlorophyta	(green algae)
Phylum Ciliophora	(ciliates)
Phylum Foraminifera	(forams)
Phylum Myxomycota	(slime moulds)
Phylum Oomycota	(water moulds eg *Phytophthora)*
Phylum Phaeophyta	(brown algae)
Phylum Rhodophyta	(red algae)
Phylum Rhizopoda	(eg *Amoeba)*

Kingdom Fungi

Eukaryotic organisms which form spores. 5 Phyla

Examples

Phylum Ascomycota	(Ascomycetes)
Phylum Basidiomycota	(Basidiomycetes)
Phylum Mycophycophyta	(lichens)

Kingdom Animalia

Eukaryotic organisms with a multicellular embryo (blastula).32 phyla recognised.

Examples

Phylum Arthropoda	(insects)
Phylum Cnidaria	(corals, soft corals, bryozoans, previously called coelenterates)
Phylum Echinodermata	(sea urchins)
Phylum Porifera	(sponges)
Phylum Rotifera	(rotifers)

Kingdom Plantae

Eukaryotic organisms, with multicellular embryos and green chloroplasts. 9 phyla recognised.

Phylum Angiospermophyta	(flowering plants)
Phylum Bryophyta	(mosses, liverworts and hornworts)
Phylum Coniferophyta	(conifers)
Phylum Cycadophyta	(cycads)
Phylum Filicinophyta	(true ferns)
Phylum Lycopodophyta	(fern allies, previously grouped with the true ferns into the 'pteridophytes')

N Marchant

INITIAL SITE SELECTION OF FAUNA MANAGEMENT AREAS

Rob Brazell
Nature Conservation Officer
Mornington District

Why Manage Fauna?
Why Monitor Fauna?
What is a Fauna Management Area?

Some consideration to these questions is required before embarking on any survey or management programme.

WHAT ARE YOU LOOKING FOR?

1. What fauna do you intend to target in your search?
   Use information from:
   - Material from fauna siting records.
   - Mining and development environmental assessments.
   - Local knowledge. Senior gang members - neighbours etc.
   - Mammals of Australia - Former Range of individual species.

From these you can make up a list of what may be present or formerly was present in the vicinity.

2. You may target an individual specie (eg Quokka) or a range of species (ie Critical Weight Range).

   If you choose a single species your target area may become habitat selective depending on the characteristics of the species.

   On the other hand if your survey is for a broad range of species the habitat range should broaden.

PREPARATION/MAPS

3. Use API/vegetation maps to define forest vegetation structures.
   eg: Wandoo woodland versus Jarrah forest etc
   50:000 or 25:000 contour map for topograpghy

- aerial photo - additional overview of topography/vegetation and access, include the amount of bushland on adjoining private property/other crown lands.

4. With the above having been researched and an understanding of species requirements developed, it is time to consider the location of the survey in more detail.

Survey Considerations - Access
- all weather road conditions-regular maintenence etc
- disease status
- security of traps
- local knowledge

- Is the area manageable?
- Should fox control be implemented at a latter date.

- Interface with other landholders - estate users.
ie: special rural developments - recreation useage

- Ability to alter fire management regime,
- fuel reduced buffers
- adjacent high values

DESIGN AND IMPLEMENTATION OF FOREST MAMMAL SURVEYS

KD Morris AND GR Friend
CALM Wildlife Research Centre, Woodvale

Introduction

Once a forest block(s) has been selected as a potential fauna management area (FMA) and the different vegetation/habitat types have been defined, it is necessary to determine what fauna, in particular mammals, are present. Several survey techniques are available for this to be achieved. These include trapping, spotlighting, looking for animal signs, and opportunistic sightings. The searching for animal signs and opportunistic animal sightings are also useful techniques to use when initially selecting potential sites for fauna survey. Lectures will be presented on trapping and spotlighting techniques as well as animal handling techniques, data recording and analysis, and the collection of specimens for the WA Museum.

These techniques are also appropriate for use in pre and post logging fauna surveys.

A list of equipment required to undertake a fauna survey is attached. The cost of these items is approximately $5000. However most of the expensive items, such as traps and spotlights, are a once off purchase. The recurring cost for consumables such as bait, plastic vials, pens etc, would probably be $500 a year.

While it is possible to provide you with the techniques to undertake fauna surveys, the success of them rests with the people undertaking the work. Most native mammals in the forest are now rare and difficult to trap or see. Survey work can be frustrating and disappointing and should be undertaken only staff that have a genuine interest in wildlife. They should not viewed as an easy task that can be accomplished in office hours. Most mammals are nocturnal and don't knock off for weekends.

Equipment Required for Fauna Surveys

1. Map of area to be surveyed.
2. Traps: Elliott traps (Elliott Scientific Company, Upwey, Victoria).
   Cage traps (Sheffield Wire Company, Welshpool, WA).
   Pit traps and flywire (Rheem Pty Ltd, Fremantle, and Valectro Industries, Osborne Park)
3. Hessian - sufficient for each cage trap.
4. Flagging tape.
5. Marking pen(s).
6. Data sheets and clipboard folders - trap results
   - spotlighting results
7. Field note book - for recording trap numbers and locations, and opportunistic fauna sightings.
8. Bait - peanut butter (order in bulk from Sanitarium).
   - oats
   - sardines

9. Field kit - plastic tackle box or similar
   - weighing balances (100g, 1000g and 2500g, Persola or Salter
   - dial measuring callipers (Rob Cameron and Co., Riverdale).
   - ear tags and applicator (#1 Monel fingerling tags, National Band and Tag Co USA)
   - elastoplast for taping in joeys
   - forceps for picking up scats.
10. Large calico or hessian holding bags.
11. Small calico bags.
12. Plastic vials for scat samples.
13. Spotlight(s).
14. First Aid Kit for animal bites and scratches.
15. Field guides - mammals, birds and reptiles.
16. Binoculars and camera.

Trapping Techniques

The use of traps is the most effective means of determining what mammal (and reptile, frog and invertebrate) fauna is present in a potential FMA. However, because most native mammals mow occur in low numbers in the fores, it is also the most time consuming and can be very frustrating when few or no animals are caught.

Where traps are located and spaced depends to a large degree on what you want to find out. For most survey work where presence/absence data is an initial requirement traps can be set in linear transects. However for monitoring work where abundance data is required, setting traps in grids is required. I will be talking to you mainly about linear transects, while Gordon Friend will discuss applications of the grid method.

1. Trap type:

A preliminary survey should use as many types of live traps as possible so that the complete range of the fauna is sampled. Kill traps, such as Break Back traps, should not be used.

Trap types and their uses include:

a. Small Elliott trap: a small (23cm x 9cm x 8cm), aluminium, folding box trap suitable for some reptiles and small mammals up to 30g. It is not often used.

b. Medium Elliott trap: a medium sized (33cm x 10cm x 9cm), aluminium, folding box trap with a treadle release mechanism, suitable for trapping mammals up to 250g body weight. This is the most commonly used "Elliott" trap.

c. Large Elliott trap: a large (46cm x 15.5cm x 15cm), aluminium, folding box trap suitable for trapping mammals up to 1kg in body weight. These are sometimes used, however cage traps are more commonly used for mammals of this size. Mammals such as Chuditch can destroy the mechanisms of the traps if caught, and they are difficult to clean. They are also more expensive than cage traps.

d. Cage traps of various dimensions: usually 20cm x 20cm x 56cm long and constructed of galvanised steel mesh. Most have treadle release mechanism. Traps of this size are suitable for mammals up to 2.5kg (Chuditch, Possum, Woylie, Bandicoot. Larger cage traps (45cm x 45cm x 90cm) are suitable for mammals up to 4kg (Quokka).

e. Pit traps with flywire: the type of pit trap used varies considerably. In general they are either PVC tubing at least 15cm diameter and 40cm deep. Rheem buckets ("Nappy" buckets) of 30cm diameter and 40cm deep are also used. these are dug into the ground so that the lip of the trap is level with the surface. Because of the work involved in setting these traps up, they are usually put in and left for repetitive trapping. They must be capped firmly when not in use. They are most useful for small dasyurid mammals and reptiles. Predators such as Chuditch, goannas and bandicoots can learn to empty the contents! The flywire fence usually extends for 2.5m on either side of the pit trap and acts as a collector directing fauna into the pit trap. Either "soft" fibreglass or "hard" aluminium flywire can be used. Both have advantages and disadvantages.

2. Trap location and spacing

Traps need to be located so that all habitats/vegetation types are sampled. Trap locations need to be pre-determined using maps showing vegetation types and access routes. The different trap types are also set at different intervals because they target different species.

a. Small and medium Elliott trap: usually set at 20m spacings in a line of at least 10 traps (covering 200m). A line of Elliotts should be set in each habitat type.

b. Large Elliotts and cage traps: can also be set in a line of 5-10 traps at 30-50m spacings to target mammals such as Bandicoot and Possum, and along tracks at 200-250m spacings to target wider ranging species such as Chuditch and Woylie. When set in lines over short distances (150-300m), these should be set in each habitat type, perhaps at the same location as the Elliott traps. When set along tracks these traps will cross habitat boundaries.

c. Pit traps: should also be set in lines of 5-10 traps with 20m spacings in each of the habitat types.

3. Trap setting:

Reasonable care needs to be taken when setting traps. Traps should be set in level positions that are not readily visible from the track to avoid public curiosity and possible theft of traps. This applies mainly to cage traps that may be set along tracks. Natural cover for traps should be used wherever possible. This helps disguise traps and provides protection for trapped animals. Under shrubs and next to logs are good sites. Trap function should be tested before leaving the trap. There is nothing more frustrating than knowing an animal was in the trap, but the door did not shut properly!

The use of hessian bags to cover the rear of cage traps is an important part of trapping. This serves 3 purposes:

a. it protects any animals trapped from cold, rain and heat
b. it protects the bait, meaning that baits have to be replaced less frequently
c. it prevents the bait from being taken by an animal from the rear of the trap and forces them to enter through the front if they want the bait.

Traps must be marked prominently so they can be found again. The person setting the traps may not be the one that checks the traps. Flagging tape is good for this purpose. Trap points are usually marked numerically and it is sometimes useful to include the name of the track as well, eg Ernie 26. It is important to keep a record of the location of traps and how many are set. All traps must be accounted for at the end of they survey.

4. Trap numbers:

Obviously the number of traps used in a fauna survey depends on the size of area to be surveyed and the diversity of habitat. However, to have an effective FMA with mammal conservation as a primary aim, an area of at least 10 000 ha is required (1-2 forest blocks). To adequately survey this area, which may have three dominant habitat types, the following numbers of traps are required:

a. Elliott traps (usually medium Elliotts): 60 -set in 3 lines, each of 20 traps.

b. Cage traps: 100 30 set in 3 lines of 10 closely spaced traps (30-50m)

70 set along tracks at 200m intervals (sufficient for 14km of track).

c. Pit traps: 15 - set in 3 lines each of 5 pit traps with flywire collector, at 20m spacings.

5. Bait:

Elliott and cage traps need to be baited with a mixture of peanut butter, oats and sardines. This should be made up into a doughy mix, not too sloppy as it messes traps. This mixture has been shown to be effective in attracting all forest mammals. Pit traps do not require bait.

Elliott traps require an amount of bait about the size of a 20 cent coin. Ideally a forest block should surveyed twice, once in spring and again in autumn. Traps need to be checked for captures early in the morning. In warmer months, traps should also be checked in the afternoon as bobtail skinks and goannas often enter traps during the day.

6. Trap maintenance

Transporting cage traps stacked on top of each other in vehicles or trailers often means that they require some "metal bending" as they are being set to ensure that they work properly. Elliott traps are readily fouled if they catch an animal. They should be cleaned immediately as scats will prevent the release mechanism working. Cage traps are more self cleaning but may also require cleaning. The need to collect scats from traps for dietary analysis should be considered before cleaning.

7. Trapping results:

A standard mammal data sheet is filled out daily as animals are captured (see attachment). The use of this will be explained in a later lecture. Once a survey has been completed, the success of the survey can be measured using a Trap Success Rate (usually expressed as a percentage). This is the number of captures divided by the number of trap nights. A trap night is one trap set for one night. For example, if you have 50 cage traps set for 4 nights, you will have achieved 50 x 4 = 200 trapnights. If you trapped 4 Chuditch in that time, your trap success rate would 4/200 x 100 = 2.0%. Trap success rates can then be compared statistically.

It is useful to establish a data base on a computer to store trapping data and to assist in data analysis. Note books and data sheets tend to get lost. PARADOX is a user friendly database management system currently in use in several CALM offices. This will be demonstrated to you.

CHUDITCH
Dasyurus geoffroii

K.D. Morris
CALM Wildlife Research Centre, Woodvale.

Introduction

The Chuditch, sometimes known as the Western Quoll or Western Native-cat, is one of four species of native cats in Australia. Two other species occurs in New Guinea. It is a dasyurid marsupial, closely related to the smaller marsupial mice (*Pseudantechinus, Ningaui, Sminthopsis* etc.) and the larger Tasmanian Devil. It is the largest carnivorous marsupial in W.A. and is **not** a feral cat or related in any way to that group of cats!

The common name Chuditch has been adopted because it is the Nyungar Aboriginal word for this species and it now only occurs in the SW of W.A. The word reflects the explosive hiss the animal makes when it is angry. It was also known by other names to Aboriginal people in other areas and was an important totem animal, particularly to desert people.

Historically, quolls were among the first animals to be reported in Australia, when Captain Cook saw footprints and collected either a Tiger Quoll or Eastern Quoll in 1770 in Botany Bay. A specimen of a quoll, probably the Northern Quoll, was taken by his party at the Endeavour River, Queensland.

Description

The Chuditch is a medium-sized mammal, with males attaining 1.5 kg and females 1.0 kg. It is characterised by up to 60 white spots covering the flanks and back of the body, neck, and top of head. They do not occur on the tail. Much of its tail is covered with an attractive black brush. Fur colouring is brown, with paler fur on the belly. The head colour of older Chuditch tends towards grey. It has prominent, slightly rounded ears and a pointed nose.

The Chuditch was named *Dasyurus geoffroii* in 1841 by John Gould from a specimen taken from the Liverpool Plains in western NSW - this was the last one from NSW! It derives it generic name *Dasyurus* from the Greek for furry tail, and *geoffroii* after an eminent C19 British zoologist.

Two sub-species of the Chuditch have been descibed - *D. g. geoffroii* based on specimens collected in eastern Queensland, N.S.W., and South Australia, and *D. g. fortis* based on specimens taken from Shark Bay and south-western W.A. The W.A Chuditch were descibed as being a larger animal but validity of these desciptions has been queried and it is now difficult to confirm because of the lack of specimens outside the south-west of W.A.

Distribution and Status

Chuditch formerly occurred in every State and territory of mainland Australia. In the mid 1800's naturalists reported the Chuditch as being reasonably abundant and widespread throughout its range. However, the geographical range of Chuditch contracted dramatically following European settlement. Specimens were last collected in N.S.W in 1841, in Victoria in 1857, and in Queensland between 1884-1907. The species disappeared from the Nullabor Plain in the 1930's and the arid zone in the mid 1950's. In W.A., it was collected from Derby and Shark Bay in the mid to late 1800's. By 1907 it was absent from areas north of Geraldton, but still numerous in the south-west. It still occurred on the Swan Coastal Plain around Perth in the 1940's and early 1950's, but has now disappeared from this area.

Chuditch are now restricted to the south west of W.A., in an area bounded approximately by Gingin, Southern Cross and Esperance. This is approximately 5 % of their former range. The largest populations are found in the Jarrah forest, but even here they now occur at low to very low densities. They also still persist in localised areas in the central and southern wheatbelt. Chuditch have never been recorded in pure Karri forest.

It is estimated that only 4 500 Chuditch persist in the Jarrah forest and perhaps another 1 500 in the wheatbelt.

Reasons for decline probably vary in different areas, but all relate to a decline in the productivity of the environment. Being a carnivore with high energetic demands and at the top of the food chain, the Chuditch would be affected by any loss of productivity in the ecosystem, perhaps more than organisms further down the food chain. It disappeared from the Swan Coastal Plain by the 1940's probably because of habitat loss and persecution, while in the arid areas changed fire regimes and predation may have been responsible. Although it still survives in the wheatbelt one of our most disturbed habitats and in the Jarrah forest, it is probably in lower densities than it should be. Recently it has been demonstrated that Chuditch numbers will increase significantly if foxes are controlled in the forest. Foxes can affect Chuditch numbers through direct predation, particularly dispersing young, and through competition for food.

In 1983, the Chuditch was declared a threatened species in W.A.

A Management Program has now been prepared for the species. This includes all the biological knowledge for the species and provides management guidelines for operations. In addition, a Recovery Plan has been written detailing the actions and funding required over the next 10 years to ensure the conservation of the Chuditch. Fortunately this has been supported by the Commonwealth Government and Alcoa (through WWFN).

Diet

A Chuditch consumes about a quarter of its body weight in food each night. It eats a wide range of food. In the Jarrah forest, 60 % of the diet is made up of large invertebrates, such as cockroaches, beetles and centipedes. They also eat small mammals such as Mardos and Black Rats, and probably the young of bandicoots and Woylies. Birds, reptiles and freshwater crustaceans are also eaten. The red pulp surrounding Zamia seeds are eaten and captive Chuditch at the Zoo eat banana and pear.

Chuditch forage at night, primarily on the ground, but are also good climbers and will climb to obtain prey or escape from predators. Recreation sites in the forest are often visited by Chuditch seeking BBQ scraps and scavenging in rubbish bins.

Reproduction

Chuditch are seasonal breeders, with animals usually breeding in their first year. Females can enter

oestrus from late April to early July. They are promiscuous and will allow several different males to copulate with them over the 4-10 day oestrus period. A female may have another oestrus in August if she does not become pregnant earlier.

The gestation period is very short, only 15-19 days and up to 6 young are born at a very immature stage. They are 5mm long and weigh only 15mg. They grow guickly and double their size in about 12 days. Spots first appear on their body at about 44 days and eyes open at 80 days. Hair starts appearing on the body by after 50 days of age.

They remain in the pouch for 60 days, and are then deposited in a burrow or hollow log. Weaning starts in mid September with the young making some forays away from the den, initially with their mother and later by themselves. They are probably most vulnerable to predation at this stage of their life.

The young finally disperse at 170 days old, usually in December/January. They live up to 4 years in the wild, and reproductive success decreases with age.

Mortality

Chuditch can be killed in many ways, unfortunately most of these are not natural events. Natural predation by owls and snakes probably affects juvenile animals the most. Accidents such as drowning, and disease also kill Chuditch. Un-natural mortality factors include road kills, shooting, rabbit-trapping, poisoning with strychnine, and predation by foxes and feral cats. Loss of suitable habitat makes Chuditch more susceptible to un-natural mortality.

Den Requirements

The availablity of suitable dens for day time refuge and nursery sites, is important for the conservation of Chuditch. In the Jarrah forest, 65% of dens are in earth burrows under rocks or up-rooted trees, and 35% are in horizontal hollow logs. In the desert, Chuditch also denned in hollows in termitaria.

In one year, a female Chuditch will use up to 66 logs and 110 burrows in her home range. Burrows are usually excavated to make them suitable as dens, however logs and hollows must have certain dimensions to be suitable as a den site. These are:

Diameter of hollow (pipe):	8 - 23 cm.
Diameter of log at den:	31 - 110 cm (average 77 cm).
Den log d.b.h:	52 - 191 cm.
Den-entrance distance:	0.7 - 8.2 m (usually > 1.0 m)

Home Range

Both sexes are solitary and occupy large home ranges (males 1500 ha, and females 400ha). Male home ranges may overlap substantially, but female show little or no overlap. The home ranges include a smaller, central core area defined by den locations. Male core areas comprise about 400 ha, and females about 90 ha.

Chuditch Management

As mentioned earlier, a recovery plan for the Chuditch has been prepared and this is now being funded by the ANPWS and Alcoa. The objective of this plan is to downlist the Endangered status of the Chuditch to Vulnerable. That is:

1) To ensure that the Chuditch persists in its present range.
2) To increase population numbers through expansion into its former range.

Six recovery actions are necessary for this to be achieved. These will be implemented over the next 10 years and include:

a) The integration of Chuditch habitat requirements into forest management practices.
b) The development and application of fox control programs that are Chuditch-safe.
c) Monitoring representative Chuditch populations.
d) Research into distribution and habitat requirements in the semi-arid zone, and disease.
e) Captive breeding program.
f) Develpment of techniques for translocating Chuditch into areas of vacant, suitable habitat.

Integration of Habitat Requirements:

a) Response to prescibed burning:

Most of the Jarrah forest is burnt on a 5-7 year rotation to reduce litter loads. The response of Chuditch to this is not fully understood although it is known that they do survive both spring and autumn burns and continue to utilize recently burnt areas. The longer term effects of fire on breeding and recruitment are not known and will be examined in the near future.

Prescibed burning may actually benefit a wide ranging species such as Chuditch, because it establishes a mosaic of different forest vegetation ages which provides the variety of food required by Chuditch.

The most important issues for Chuditch are the retention of suitable denning logs and the quick recovery of arthropod fauna after a fire. A spring burn is more likely to achieve this than an autumn burn. Spring burns do not consume logs on the ground and leave islands of unburnt vegetation including areas along streams and rivers. Smaller burns are preferable to larger burns as there is less chance that the entire home range of a Chuditch would be burnt at the same time.

Thus to benefit Chuditch, based on existing knowledge, smaller spring burns are preferable. Riparian vegetation along creeks and rivers should be protected from fire, or burnt in a small mosaic. This would probably also benefit other species such as the Quokka.

b) Response to logging:

Very little is known about the responses of Chuditch to logging activities. The retention of suitable denning logs in these area is important and the current Jarrah silviculture prescription (2/91) now provides for this to occur. This may have to be revised following further research on this subject.

c) Response to mining:

Chuditch are known to occur in and around bauxite minesites in the Jarrah forest. Many of these areas are now being rehabilitated and artificial den sites are being created with logs and rocks. Fast growing vegetation is being used to promote early colonization by insects and other invertebrates and so provide food for Chuditch.

Chuditch-Safe Fox Control Programs

Chuditch once occurred in higher densities throughout its range and it is possible that the fox and cat have supressed Chuditch numbers, as they have done to many herbivorous marsupials, through predation and/or competition for food.

Foxes and cats can be controlled using dried meat baits containing 1080 poison. However, it is possible that chuditch also take the poison baits. Although they do have some tolerance to 1080 it was

not known if this is sufficient to prevent mortality or sub lethal sterility effects. Recently it has been demonstrated in the Jarrah forest that fox baiting does not have a detrimental effect on Chuditch, in fact it leads to a population increase. Poison baits are taken by Chuditch but they are not consumed in sufficient quantities to affect the Chuditch. It would appear therefore that fox control in Chuditch areas can be undertaken using dried meat baits containing 1080 poison.

Unfortunately, strychnine is still available to farmers and pastoralists for fox and dingo control. Chuditch are known to have been killed by this non-target specific poison. With 1080 now being more readily available, the APB will be encouraging farmers and pastoralists to use this poison rather than strychnine, particularly in areas where Chuditch are known to occur.

Monitoring Representative Chuditch Populations

Regular monitoring of representative Chuditch populations enables the effect of forest management and disease to be assessed, as well as providing information on the breeding biology, diet and population densities of Chuditch in the forest. Populations are being monitored at Perup, Batalling, Lane-Poole and will be monitored at a site to be selected in the Mundaring District. A population in a semi arid location will also be monitored in the future once a suitable population has been found.

Research into Distribution and Habitat Requirements in the Semi-arid area.

Very little is known about Chuditch in the wheatbelt and adjacent mallee areas. Surveys of large reserves (>10 000ha) will be undertaken over the next 10 years and a site for population monitoring established. To date, Frank Hann NP and Lake Magenta NR have been surveyed with positve results. Karroun Hill NR and Jaurdi Station have been surveyed with negative results.

Captive Breeding

A captive breeding program has been underway at the Perth Zoo since 1989. This has been successful with 52 young being produced for release into areas previously occupied by Chuditch. Captive bred Chuditch may also be sent to other zoos in Australia for display and education purposes.

Translocation

Twenty four captive bred Chuditch were released at Julimar Conservation Park in September and their progress is being monitored. Chuditch were last recorded in this area in 1973. If this trial is successful, Chuditch will be re-introduced to a semi-arid area, probably Karroun Hill Nature Reserve in 2-3 years time. Some apparently suitable areas of the Jarrah forest also lack Chuditch and captive bred animals could also be re-introduced to these areas.

There has also been a request by Dr John Wamsley to re-introduce Chuditch to a 1 000 ha site in the Murray mallee area of South Australia. Chuditch were last recorded in this area in the 1880's.

SOUTHERN BROWN BANDICOOT OR QUENDA *Isoodon obesulus*

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Description

The southern brown bandicoot or quenda is a member of the Peramelidae, a family of marsupials found only in Australia and Melanesia. Six species of bandicoots have been recorded in Western Australia (not counting the bilbies, which belong to the Thylacomyidae), of which two, the desert bandicoot, *Perameles eremiana*, and the pig-footed bandicoot, *Chaeropus ecaudatus*, are extinct.

A fully grown southern brown bandicoot is rather larger in size than a rabbit. The fur on the upper surface of the body is dark greyish or yellowish-brown and rather coaruse to the touch, as the guard hairs are quite stiff. On the underside the fur is softer and creamy white to pale brown. The short, sparsely-furred tail and the upper surfaces of the hind-feet are dark brown. The southern brown bandicoot has a long pointy nose, rounded ears and small teeth which are evenly spaced along the jaws (compared with the kangaroos and other marsupials that have incisors and molars separated by a distinct gap). Males grow larger than females, becoming sexually mature at about 800g and attaining weights of over 2.5kg. The scrotum in adult males is usually darkly pigmented. Females are sexually mature at about 700g and rarely exceed 1.5kg in weight. The pouch opens rearward, as in the other species of bandicoot, and contains eight nipples.

Distribution and Status

The southern brown bandicoot is found in the south-east of the continent as well as in the south-west, and on part of Cape York in far north Queensland. Figures 1 & 2 show the recorded and present distribution of the species. Three subspecies of the southern brown bandicoot have been described: Isoodon obesulus obesulus from South Australia, I.o. affinis from Tasmania, and I.o. fusciventer from Western Australia. Quenda is the Nyunga word for the species, so this name should be perhaps applied only to the south-western subspecies.

As a species, the southern brown bandicoot is not considered to be endangered or even vulnerable (ANZECC, 1991). However, it appears on the State threatened species lists in Western Australia, New Souther Wales and South Australia; in all of these states the species has undergone considerable contraction in range, especially during the last twenty years.

In Western Australia, the range of the quenda has shrunk since white settlement, especially in the northern and eastern areas that it previously occupied. In most cases, its disappearance is related to the clearing of vegetation for agriculture, especially in the wheatbelt. The populations inhabiting Tutanning Nature Reserve and Dryandra Forest became extinct in the 1970's with an increase in fox numbers. The last quenda stronghold in the wheatbelt seems to be in the area around the town of Mount Barker. There are apparently secure populations in the jarrah and karri forests, and along the south coast as far east as

Cape Riche, and the only island population of *I.o. fusciventer* is found on Daw Island in the Recherche Archipelago.

The Swan coastal plain provides good habitat for quendas, but is largely cleared for agriculture, so that, ironically, some of the best surviving populations on the Swan coastal plain are on the outer fringers of the Perth metropolitan area. Populations there are now threatened by urban expansion.

The quenda is listed on Schedule 1 of the Wildlife Conservation Act 1950 (fauna that is rare, or is likely to become extinct) because of the historic decline in its range and because it falls within the Critical Weight Range (CWR) of Burbidge and McKenzie (1989), who predict that such animals are most likely to undergo serious decline.

Habitat Requirements

Quendas prefer areas in which there is a high proportion of dense vegetation between 0 and 1 metre above ground, especially where there is foliage below 0.5m. They will, however, forage out into open areas provided there is cover nearby in which to take cover and to nest. In addition, their food requirements limit them to the more productive parts of the landscape. On the Swan coastal plain, they inhabit the dense vegetation fringing permanent and seasonal wetlands. On the Darling scarp and in other forested areas, they are mainly found along watercourses and in nearby shrublands. The extensive shrublands along the south coast also provide good habitat.

Biology

Diet

The diet of the quenda consists mainly of insect larvae and adults as well as earthworms and other soft-bodied invertebrates of similar size. Small reptiles and even small mammals are also taken. Most feeding is done by digging, and faeces contain soil as well as the hard remains of the foot items, such as insect exoskeleton and reptile scales. Small diggings, often about 5cm wide and 5cm deep are made in the soil. The animal digs first with the forepaws, then pokes its snout in to extract the food item. This often results in a quite conical hole.

Reproduction

Quendas are able to breed year round, although in some populations studies near Perth there have been no females with young between early May and July (Figure 3). Between one and six young are produced, but it is unusual for more than three young to survive to weaning, which occurs after about 60 days. Birth occurs quickly after the weaning of the previous litter, so three or even four litters may be produced in a year. Dispersal of the young bandicoots to available habitat from their mother's home range occurs soon after weaning. Longevity may exceed three years.

Home range, interactions, activity and nesting

Quendas are generally nocturnal, and most activity occurs near dusk and dawn. Animals are often seen out during the day, however, although it is unknown how much of their activity is diurnal. A wider range of food items, including diurnal reptiles and insects, is available to animals active by day as well as by night, but a greater risk of predation is also encountered.

In quenda populations of low density, there is little overlap between home ranges of animals of the same sex. Where numbers are high, however, female home ranges overlap extensively, and even some males occupy the same areas (Figure 4). Amongst the males, however, there is usually a large dominant animal that moves widely through the habitat patch, while subdominant males have small home ranges and apparently keep a low profile.

Home ranges in a heathland habitat in Victoria have been found to vary between 25ha for males

and 11ha for females (Lobert, 1990).

Nests are usually built in a slightly raised position, to avoid inundation in winter. Grass and other vegetation is collected, sometimes mixed with earth, and a well-concealed nest is constructed in a shallow scrape.

Predation

There is little quantitative evidence concerning the relative importance of the quenda's various predators. Amongst the native fauna, large reptiles such as carpet pythons could easily take young quendas, and medium-sized to large diurnal raptors (e.g. little eagles) and owls are also potential native predators. Chuditch undoubtedly take young quendas, but again, evidence is lacking.

There is more information on the role of introduced animals. House cats living near bandicoots are often reported to bring in young, and foxes have been identified as predators of quendas by several lines of evidence. Quenda bones have been found in fox dens at Perup (Christensen 1980) and at Tutanning (Friend, unpublished). The quenda populations at Tutanning and Dryandra became extinct during the 1970's, when numbers of many CWR mammals in the south-west dropped, some populations going to extinction. A rise in fox numbers was reported at this time, and where fox control was subsequently implemented, dramatic increases in the numbers of those mammals followed.

Management for Conservation

The following facts are relevant to the conservation management for quendas:

1. Quendas need dense vegetation.
2. Populations are centred on drainage lines in the forest, and on wetlands on the Swan coastal plain.
3. Fox predation can push quenda populations to extinction, especially in the drier parts of their range.
4. Reproductive rate is high, so quendas can quickly invade unoccupied habitat.
5. There are several previously occupied areas of suitable habitat in which fox control is being carried out. These may be suitable for re-introductions.

Given facts 1-3, it is clear that disturbance that removes the cover afforded by dense vegetation will reduce the viability of local bandicoot populations. Frequency of fire in the dense scrub along watercourses should be as low as possible, even if this means excluding fire from parts of a valley system at each prescribed burn, so that any one part is burnt only every three burns.

Apart from the circumstantial evidence that foxes caused the extinction of the quenda at Tutanning and Dryandra, the effect of fox control on existing quenda populations has not yet been determined. The Batalling experiment may provide this evidence, as may other trials currently being set up on CALM estate.

Re-introduction of quendas to previously occupied areas, under fox control prorams, may be considered in order to counter the attrition of populations elsewhere through urban and other development.

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ECOLOGY AND MANAGEMENT OF THE NUMBAT *Myrmecobius fasciatus*

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Description

In size, as well as in some of its actions, the number resembles a squirrel. Adults have a head and body length of 200-250mm and tail length of 150-180mm. Males attain slightly higher body weights than females (maximum 700g and 550g respectively).

The numbat's coat is distinctively coloured. The overall colour is reddish brown, the predominant colour of the head and upper back. There is distinct horizontal black stripe through the eye, however, and partway down the back, faint white bands cross the body. Towards the rump, these become stronger, and are accentuated by the progressively darker, and eventually jet-black bands between the white bands. The number of whate bands varies between four and eleven. The bands are often broken, the two halves offset along the midline. The pattern formed by these bands is unique to the particular animal, and may be used to identify individuals.

The hair on the underside of the body is off-white. The tail is covered with long brown hairs, many of which are tipped with white. The underside of the tail, near the body, is quite red in colour.

Distinctive features of the numbat's body shape include the pointed nose and elongate jaw, housing the largest number of teeth in any Australian land mammal. The tongue is exceptionally long, and can be protruded at least 5cm beyond the tip of the nose (about the length of the head). The teeth are poorly developed, and many do not protrude above the level of the animal's gums.

Distribution and Status

At the time of european settlement of Australia, the numbat was apparently found across much of southern Australia from the west coast to the semi-aris parts of western New South Wales (Figure 1). This knowledge is based on museum specimens, of which there are about 200, all collected since 1830, published accounts by reliable observers and information collected by trained interviewers from Aboriginal people who had earlier led nomadic lifestyles. There are no records of the numbat from Victoria but the species probably occurred in the north-west corner of that State. Aboriginal knowledge indicates that numbats were also found in the southern part of the Northern Territory (Friend et al. 1982). There is little information on habitat preference in the eastern part of this range, but in northwestern South Australia, Finlayson (1933) described the habitat as "mulga sand dunes", while Aboriginal informants told Firend et al. (1982) that walpurti were found in sand dune country, mulga country and spinifex country but not in rocky ridge country.

Krefft's account (1866) of mammals found near the Murray-Darling confluence in 1856-7 gives the impression that numbats were on the decline in that semi-arid country where cattle had already been

run for several decades. The most recent museum specimen from New South Wales was collected in 1900 from the border with South Australia. By that stage numbats had already disappeared from the vicinity of Adelaide, although they were to survive in the north-west of South Austrlia until well into this century, becoming extinct there between the 1930's and the 1950's (Finlayson 1961). In Western Australia the species was still quite widespread in the southern half of the State in the 1950's, although the clearing of land for agriculture was reducing its habitat rapidly. Calaby (1960) made the statement that the numbat was then probably the most abundant medium-sized mammal in the south-west of Western Australia.

Between the 1950's and the 1970's, numbats became extinct in the arid zone in Western Australia. The most recent account of the walpurti related to an animal sighted in the mid-1960's in the Gibson Desert (Friend et al. 1982). This extinction was part of the dramatic collapse of the mammal fauna of the arid zone that occurred between 1940 and 1960, and which is believed to be due to several factors. These factors include the change in fire regime following the demise of the nomadic lifestyle of the Aboriginal people, as well as the arrival of the fox. The rapid progress of land clearing greatly reduced available habitat in the last stronghold of the species in the semi-arid wheatbelt of Western Australia. Surviving populations, such as the well-known colonies at Dryandra Forest near Narrogin and the Tone-Perup area east of Manjimup, appeared health nonetheless.

In the mid-1970's, there was a dramatic decline in numbat sightings. The lowest population numbers appear to have been reached in 1975 at Tone-Perup and in 1979 at Dryandra (Christensen 1980; Friend 1990b). Both populations subsequently recovered, but others because extinct during this period. These included colonies at Boyagin Nature Reserve near Brookton, in the Pingaring area (including Dragon Rocks Nature Reserve) and soon after, at Tutanning Nature Reserve near Pingelly. Subsequent research has indicated that the decline of the numbat and simultaneous declines in other medium-sized mammals were due to increased predation by the introduced red fox Vulpes vulpes (King et al. 1981, Kinnear et al. 1988; Friend 1990b).

An experiment carried out at Dryandra in 1982-5 indicated that removal of foxes causes an increase in numbat numbers (Friend 1990b). The area of the forest subject to fox control was extended at the beginning of 1989, and the population continued to grow. The sighting rate on standard vehicle surveys has increased from 0.14 per 100km in 1979 to 7.8 per 100km in 1991 (Figure 2). Hill NR (north of Beacon) and to Tutanning NR, commencing in 1985, 1987 and 1990 respectively.

Knowledge of the present distribution of the numbat was gained through surveys during the 1980's based on recent museum speciments and reports from the public in response to appeals in the media. All reports were followed up with a search for the distinctive diggings near the sighting location. These surveys revealed that numbats were confined to Dryandra Forest and some small reserves nearby, parts of the jarrah forest between Great Eastern Highway and the Tone-Perup area, and a small area of uncleared land on the Swan coastal plain on the southern fringes of Perth near Jandakot (Connell & Friend 1985).

Since then, it appears that most or all of the northern jarrah forest populations and the Jandakot population have become extinct. Given home range size and overlap detailed below, this remnant distribution (Figure 2) represents a maximum numbat population of 2000, and probably closer to 1200 animals.

Surviving numbat populations occur mainly on land under CALM's management. This land includes State Forest, Conservation Parks and Nature Reserves. Other land tenure types on which numbats are found include water reserves and private land. More than 90% of the world population of numbats, however, exists on CALM estate.

In 1973 the eastern form of the numbat (Myrmecobius fasciatus rufus) was declared to be "fauna which is likely to become extinct, or is rare" under Section 14(2)(ba) of the Wildlife Conservation Act 1950, Western Australia. This classification was extended to the full species in 1983 after the decline in remnant numbat populations during the 1970's. The numbat is on the ANZECC List of Endangered and Vulnerable Vertebrates (1991) in the Endangered category, and is listed as Endangered in the IUCN Mammal Red Data Book (IUCN 1984).

Habitat Requirements

Known numbat populations occupy several different habitat types, but only a small porportion of the range of habitat types previously occupied by the species. The habitat types occuped recently are:

Dryandra Forest and Boyagin NR.

Woodland on valley floors and slopes, dominated by Eucalyptus wandoo and E accedens (powder-bark), with an understorey of shrubs including Gastrolobium species. Numbats also use adjacent upland vegetation types to a lesser extent, as well as mallet plantations.

Northern Jarrah forest and Tone-Perup area:

Forest dominated by E marginata and E calophylla, with open lower canopy of Banksia grandis and understorey of shrubs Bossiaea etc.

Jandakot area:

Banksia attenuata and B menziesii woodland with emergent E Marginata and E todtiana.

Karroun Hill NR:

A range of vegetation types including: Eucalyptus loxophleba and Callitris columellaris open woodland with an open understory. Tall closed shrubland of Allocasuarina acutivalvis, Melaleuca uncinata and Acacia?. Acacia ? closed shrubland. Eucalyptus salubris woodland.

Biology

Diet and feeding activity

Many of the characteristic features of the numbat are a result of its adaptation to a specialised diet of termits (Isoptera). While ants (Formicoidea) are also taken, there is little doubt that the feeding activity is essentially a hunt for termites. Numbats show no strong preference for any species of termite, taking each species roughly in proportion to its abundance (Calaby 1960).

During a feeding session, a numbat moves around an open area, nose to the ground, every now and then stopping to investigate a spot, then often digging rapidly with both forefeet, while sitting on its haunches. After making a small excavation, the numbat puts its nose into the hole, which has breached a shallow termite gallery, and extracts termites by pushing its tongue rapidly and repeatedly into the gallery. Termites within reach stick to the numbat's tongue, and are pulled into the slightly open mouth. The jaws are then closed and the insects are held in the mouth by the slightly ridged palate, as the tongue is protruded again. The extraction of termites from a gallery, from the first excavation to the end of feeding, takes about 2 seconds (Friend, unpublished observation). The excavations are distinctive in appearance, and are shallow-conical, rarely over 50mm in depth, and of a similar diameter.

Numbats appear to spend much of the day feeding, and observations of captive animals show that each individual consumes between 15,000 and 20,000 termites each day. This corresponds to approximately 10% of the body weight of an adult animal (Friend, unpublished).

A feature that sets the numbat apart from almost all other marsupials, and other Australian mammals, is its strictly diurnal nature. Although their daily activity pattern changes during the year, numbats do not emerge from their night refuges until well after dawn, and return to one of their nests before dark. In summer, numbats are active throughout the morning, but there is a period of inactivity between midday and late afternoon, followed by an active period before dusk. In winter, there is only one active period, of between 4 and 6 hours from mid-morning to mid-afternoon. This pattern of activity corresponds closely to the availability of termits in the upper soil layers, as these insects respond to the temperature of this environment (Friend, 1985).

Home range and interactions

Numbats are solitary and territorial. They occupy home ranges which are exclusive of other individuals of the same six. Once a juvenile numbat has established its home range after dispersal, that animal remains in or close to that area for the rest of its life.

The male pattern of adjacent home ranges overlaps the female pattern. Although use of habitat by each sex changes during the year (females contract their area of movement in summer, males in winter), the overall result is that there is approximately one pair of established adults per 50ha of high-quality habitat. These data were obtained by radio-tracing 15 numbats in wandoo woodland in Dryandra Forest and Boyagin Nature Reserve, but the results of tracking to numbats in the Perup Forest indicate a home range size of the same order in Jarrah forest (Christensen et al. 1984). If 50 animals is taken as a minimum viable population, and if it is assumed that 50% of a given area is suitable habitat, the minimum area which can support a population is 2500ha. Tutanning NR is near this minimum size, as is each of the two separate sections of Boyagin NR (total 5,000ha).

Reproduction and dispersal

Knowledge of the reproductive ecology of numbats is largely due to research in Dryandra Forest since 1981 (Friend, unpublished). Details are provided here in order to demonstrate the importance of various components of the habitat, and to provide a timetable for the critical events of the numbat's year.

Production of young by numbats is a highly synchronised event. At Dryandra, all young are born in January or early February, and most in the second half of January. Development of the young while attached is relatively slow compared with other marsupials. The femal deposits her young in a nest (usually in a burrow) in late July and continues to suckle them each night. In early September, the young come to the entrance of the burrow each morning after the female has emerged, often before she has left on her daily foraging trip. During the first week or so, they do not move more than a few centimetres from the burrow mouth, but as time goes on, they make longer excursions. By mid-October, the young numbats are supplementing their mother's milk with termites that they dig up for themselves, and moving up to 100 metres from the nest, still within their mother's home range. The female often moves her litter to a succession of nests in logs, trees or other burrows, particularly after the loss of any young to predators.

In November, some young start to nest away from the mother and their siblings, within the maternal home range. Later that month or in early December, all young leave their maternal home range and disperse. The dispersal movement is quite rapid, rarely taking more than a week from departure to establishment in the area where the number will spend the rest of its life.

Dispersal appears to take place as straight-line movements, while the animal is moving through bush. A numbat at Dryandra was followed over several days, during which time it moved 4 kilometres from its natal area straight to the edge of farmland. It then moved along the forest-farmland boundary for two kilometres before reaching the area in which it established its home range. Radio-tracking other dispersing numbats has shown that they rarely cross farmland, but often end up in forest

at the edge of the reserve. This evidence indicates that the farmland-forest interface is an important barrier for dispersing numbats, and suggests that corridors of native vegetation will be used by dispersing young, as they follow the edge of the bushland.

Females breed in their first year, while males do not become sexually mature until their second year. From September, established males begin to move outside their winter home ranges. At this stage, the male pre-sternal gland becomes active, exuding an oily liquid that stains the animal's ventral surface red-brown. As the height of the mating season approaches, the male's testes enlarge as they begin to produce sperm, reaching a peak in late December. The male scrotal region swells with the enlargement of the accessory glands. By January, male numbats are ranging widely and traversing the home ranges of a number of females.

Females come into oestrus during January. In captive animals, the onset of oestrus has been established by monitoring the sudden increase in epidermal cells in the urine. If mating does not occur during the next 48 hours, young are not produced. The gestation period is 14 days, after which the young are born, pink, hairless and measuring about 10mm in total length, and attach themselves to the four teats (Friend & Whitford 1985).

Refuge and nesting requirements

Numbats use hollows and burrows for a number of different purposes. These include nesting at night, resting during the day and as refuges when under threat of predation. When the young are too large to be carried by the mother on her daily foraging trips, they are left in nests in hollows or burrows during the day, and suckled there at night. In areas that lack logs, or in summer, some numbats rest during the day under shrubs and fallen foliage. They sometimes even take refuge from threat under this kind of cover, but there has been no record of numbats nesting at night in such a position.

Numbats construct their own burrows. A typical burrow consists of a single, gently sloping shaft 1-2 metres long widening out into a roughly spherical, terminal chamber. A nest fills the chamber, and consists of readily available plant material such as grass, leaves or shredded eucalypt bark (Glauert 1935; Christensen 1980; Friend and Burrows 1983; Christensen et al. 1984;). Nests of similar materials are also made in nest logs.

Predation

Causes of mortality in numbats have been established by four methods, as follows;

a) direct observation,
b) evidence provided by the condition and/or location of remains of radio-collared numbats and by marks on the radio-collars,
c) monitoring population change in areas with and without fox-baiting,
d) notes accompanying specimens forwarded by the public.

a) Direct observation

The only recorded observation of a numbat being taken by a predator concerned a collared sparrowhawk or a brown goshawk (Friend & Burrows 1983).

b) State of retrieved radio-collars

This is the most objective measure of the relative importance of different causes of death within a population. It still shows only the final cause of death, however; it is impossible to tell whether the animal was weakened by some other influence, in some way before death.

Most of the retreived collars showed that a predator was involved, and that birds and

mammals took approximately equal numbers. Of the avian predation events, two were probably Little Eagles and two were Wedge-tailed Eagles. From observation of the birds in the vicinity of numbat nursery burrows, the most important avian predators are almost certainly Collared Sparrow-hawks and Brown Goshawks, particularly of newly emerging number young. These birds are very competent at taking prey on the ground beneath the tree canopy.

Mammalian predators were all fox and cat, with the exception of one instance of predation by a dingo at Karroun Hill NR. Fox predation was prevalent at Dryandra and Boyagin, but cats are significant predators at Karroun Hill NR. Reptilian predators were all carpet pythons (Python spilotes). Calaby (1960) suggested that Gould's monitor (Varanus gouldii) was a likely predator of young numbats, but no supporting evidence was found in this study.

Only one numbat out of 10 known to be in three prescribed burns was killed by the fire.

c) Experimental manipulations

Poisoning foxes by the use of 1080 poison while monitoring the numbat population size showed that removal of foxes caused a dramatic increase in numbat numbers (Friend, 1990b). Given other evidence of fox predation, this result indicates that predation by foxes regulates numbat populations, and that a regime of fox baiting will allow numbat numbers to rise until they reach limits imposed by other factors (e.g. food supply, refuges and cover from other predators).

d) Information associated with specimens

The only causes of death revealed from data accompanying specimens were vehicle collison and "fox kill" (WA Museum Specimen MO2245). Roadkills are not considered to be a significant cause of mortality in any known numbat population.

Management for Conservation

The need for management.

The world population of numbats is at a critically low level. Even generous estimates pub maximum numbers at only 2000 animals, while if we acknowledge the patchy nature of the occurrence of the species and assume that core home ranges never overlap, the estimate is below 1500. At present, the Dryandra population is the most secure, and it numbers less than 500 animals. While recent research has defined the threats to the species and limited management has shown how these threats can be reduced, loss of populations is still proceeding.

Fox Control

The numbat population at Dryandra, and the successfully re-established population at Boyagin Nature Reserve have been protected from fox predation by monthly baiting with 1080 in meat baits, laid at a density of 15 baits per hectare. Lower baiting intensities may be effective in other areas, but this is yet to be tested.

Fire

The effect of fire on numbat habitat depends on intensity and season. Removal of understorey thickets exposes numbats to greater risk of predation by birds of prey and cats, even if fox control is in place. Studies at Dryandra have shown that a fire in spring caused a nett loss of logs, whereas fires in autumn resulted in a nett gain over the same period. Fire needs to be used at long intervals in order to ensure that thickets are regenerated. At Dryandra the interval is of the order of thirty years (Burrows and Maisey 1987).

Timber harvesting

A study of a thinning operation in mallet plantation at Dryandra showed that the main effect on the numbats was the disturbance caused by the presence of men and vehicles. Resident animals cease to use the area using the operation, but return soon after. By opening the canopy, a clear-felling operation exposes numbats to a higher risk of avian predation. The long-term (ten years or more) may be positive, in that an increased amount of wood remains on the ground for hollow logs and termite food (Christensen & Maisey 1984). Pre-logging surveys are recommended in areas where numbat populations are suspected, to establish the importance of the proposed coupe for the numbat population in the area. As a rule of thumb, no more than 10% of the local population should be put at risk.

Re-introduction

The survival of the numbat depends on protection of existing populations and the establishment of new populations in suitable previously occupied habitat. A program of re-introduction is proposed as part of the recovery plan currently being prepared for the numbat. Various areas are being considered as re-introduction sites. It is considered that the smallest area that can contain a viable population is about 2000ha.

Successful re-introduction requires the translocation of a sufficient number (15 or more) individuals of about even six ratio, each year for two or three years. Fox control and if possible cat control need to be implemented from the outset. Animals should be moved in November or December, after the young are weaned but before the mating season.

Re-introductions have to date depended on animals from the wild, although three out of four released from a captive colony survived and established home ranges.

Genetic management

The future scenario for the numbat is that its survival will depend on a number of discrete, managed populations on conservation estate, with some other small colonies in zoos or fenced areas. To prevent inbreeding and loss of genetic variability, it will be necessary to transfer individuals between colonies on a regular basis (Friend 1990). This may require the movement of only one or two animals per population every two or three years, but it will be necessary to institute a program of transfers to ensure that all populations are linked genetically.

References

Available from the author.

USE OF RE-INTRODUCTION IN FAUNA CONSERVATION

Tony Friend
Wildlife Research Centre, Woodvale

1. Definitions (IUCN, 1987).

Translocation is the movement of one or more individuals of a species from one place with free release in another.

There are three classes of translocations:

1) Introduction of an organism is the intentional or accidental dispersal by human agency of a living organism outside its historically known native range.

2) Re-introduction of an organism is the intentional movement of an organism into part of its native range from which it has disappeared or become extirpated in historic times as a result of human activities or natural catastrophe.

3) Re-stocking is the movement of numbers of plants or animals of a species with the intention of building up the number of individuals of that species in an original habitat.

These notes will deal only with re-introduction. Generally, introduction and re-stocking are not used in fauna conservation today except as a last resort, because of possible negative effects on the environment and on the evolution of the species.

2. Why Re-Introduce Species?

There are a number of reasons to carry out re-introductions. The most commonly cited reason is:

a) to increase the security of a threatened species by establishing more populations and more individuals. An additional benefit, if properly managed, is an increase in the genetic variability of the species as a whole. Examples include the re-introduction of the Lord Howe Island woodhen to Mt Gower, the noisy scrub-bird to Mt Manypeaks and the numbat to Boyagin NR.

Other reasons include:

b) for scientific knowledge: re-introduction allows much information to be gained about the species which might not be learned by studying existing populations. For instance, manipulative experiments that could not be carried out on the major surviving populations might be carried out on new populations established for the purpose. Alternatively, re-introduction can be into habitat types no longer occupied by the species in question. Examples are the re-introductions of the boodie or burrowing bettong to Heirisson Prong and to the Gibson Desert NR and the quenda to Tutanning NR.

c) for aesthetic reasons, where conservation is not really an issue. An example of this is the

continuing program to re-introduce koalas into parts of Victoria.

d) in order to achieve fauna reconstruction at a chosen site, some species might be re-introduced with little conservation benefit to that species, but where the reconstruction of a biological community may have ecological benefits as well as having inspirational and educational benefits for the human population.

e) in order to remove problem animals or animals which would otherwise be displaced by human activity (this may not be a valid reason in itself, but may provide stock for a valuable conservation action).

f) for a combination of commercial, educational and conservation benefits. An increasing number of sanctuaries are currently being set up, generally involving predator exclusion fencing, inside which threatened species are established.

Most successful re-introductions achieve several of the goals listed above, whatever the primary reason for their enactment.

3. The Re-Introduction Program

A re-introduction must be considered from the outset as a program that starts at the initial assessment of feasibility and continues until the monitoring program has shown that the exercise has been a success or a failure. The basic steps, from IUCN (1987) are outlined below.4. ROLE OF MONITORING

The main purpose of monitoring is to assess the success of the re-introduction, but in practice much more can be achieved. Most important is the process of learning in order to improve the chances of success in future re-introductions. If monitoring is not carried out adequately, little will be learnt, and a failed re-introduction will be a complete waste of animals and resources.

Monitoring can answer questions such as:
Is the habitat quality adequate (food, shelter)?
Were the translocation methods suitable (release methods, timing)?
Was habitat preparation adequate (predator control)?
How do the animals use their new habitat, compared with the source population?

REFERENCE

IUCN (1987). The IUCN position statement on translocation of living organisms. IUCN, Gland.

RE-INTRODUCTION IN FAUNA CONSERVATION

1. FEASIBILITY STUDY

Study historical ecology of species in original habitat to establish cause of extinction .
Assess changes in habitat -is cause of extinction removed?
Identify suitable source for re-introduction stock.
- genetics
- climatic tolerance
- habitat adaptation
- sufficient numbers

Determine attitude of local human population
- no hunting
- tolerance
- co-operation

Ensure adequate funding available
- for re-introduction
-for intensive monitoring
- for ongoing management

DECISION TO PROCEED OR NOT

2. PREPARATION

Release area identified.
Release area prepared.
Source of animals secured.
- wild
- captive-bred

Size and composition of release group(s)
- social organisation
- expected mortality

Logistics

3. RELEASE

Time of year
Time of day
Release method
- pens
- feeding
- neither
- proximity to others

4. POST-RELEASE MONITORING

Immediate
- dispersal
- establishment
- condition
- breeding
- numbers or recruitment/mortality rates

Long-term
- for at least five years in predictable environments

5. DEPARTMENTAL POLICY

A CALM policy on translocations is currently being drafted. Its intention is to regulate and coordinate the use of translocation of flora and fauna in Western Australia to maximise the benefits to nature conservation.

FERAL CAT CONTROL

D. ALGAR
CALM Wildlife Research Centre, Woodvale

Impact of Feral Cats on Fauna

Feral cats are widely acknowledged as a serious threat to populations of small to medium-sized vertebrates in Australia. Cats are opportunistic predators, feeding on a wide range of prey species. They are highly fecund, producing two or more litters a year and highly adaptable to a range of harsh environments. Cats are extra-ordinary colonisers and have become one of our most successful, widespread feral introductions. Cats occupy most ecological habitats across mainland Australia and many offshore islands.

Cat predation has caused the local extinction of a number of species. Predation by feral cats may also seriously affect the continued survival of many native species persisting at low population densities. Other factors such as displacement by cats of native carnivorous species (e.g.. native cats) may reduce the viability of certain species populations and biodiversity. Cats are also the primary hosts and reservoirs for a number of diseases such as the protozoan parasite causing toxoplasmosis. Marsupial species have been shown to be highly susceptible to toxoplasmosis and rarely survive its effects.

The Problem

Control methods for feral cats have not been extensively researched. When cat control has been implemented it has generally relied on using standard fox baiting procedures. These routine procedures consist of aerial baiting campaigns (5 to 10 baits/km_) using dried meat baits. The recommended baits are cut from kangaroo meat (120g wet-weight), injected with 4.5mg of 1080, and then dried to 40% of their original weight. There are however, no data on the effect of fox-baiting on cats. There is circumstantial evidence that despite susceptibility to 1080 poison, bait uptake by cats is low during existing control programmes.

This has been highlighted during recent re-introduction programmes of numbats at Karroun Hill NR and boodie and golden bandicoots at the Gibson Desert NR. Despite baiting of these reserves, cat predation has significantly affected the survival of the re-introduced species.

Control of feral cats is therefore one of the most pressing problems in the conservation of threatened vertebrates in Australia today. There is an urgent need to develop and implement effective and economic broad-scale feral cat control campaigns.

Research into Control

There are three options available for feral cat control:-

1. Poisoning with 1080 baits is the primary option. The efficacy of a baiting campaign is determined by the proportion of cats killed in the population. No baiting campaign is likely to achieve total eradication. The critical factor is whether the control measure has sufficiently reduced cat density to permit native species to maintain viable populations.

2. Following baiting in small scale areas or islands further reductions in cat numbers may be achieved using trapping and hunting. These techniques are labour intensive and can only be justified in areas of limited size or where total eradication is warranted (e.g. islands).

3. If the above conventional control techniques do not achieve the required level of cat reduction, it may be necessary to implement some form of biological control. Examination of biological control techniques is beyond the scope of this research programme however, it will be possible to assist future work by collecting data on a number of demographic parameters relevant to biocontrol strategies.

The objectives addressed by the feral cat research programme are therefore as follows:-
a) Examination of acceptability of various bait mediums and flavour enhancers to improve bait uptake.

b.) Establish the efficacy of baiting campaigns using preferred bait types and also current standard fox baits in killing cats.

c.) Research into baiting intensity and frequency to maximise baiting effectiveness.

d.) Develop a technique to census feral cat numbers.

This project addresses the most immediate methodological problems and should deliver an operational method to control feral cats in strategic areas.

RINGTAIL AND BRUSHTAIL POSSUMS

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Introduction to the species

Brushtails and Ringtails are arboreal marsupials, and so depend on trees. Both are primarily folivores, and a major dietary component is the leaves of Myrtaceous species common in the habitat. Trees also provide shelter in the form of hollows or rest sites used during daylight.

Both have the pouch well developed and carry the young to a relatively advanced stage. Large pouch young have short fine fur that facilitates them moving easily within the pouch, but within a few days of the first emergence the fur rapidly grows relatively long and fluffy and the young then becomes too large for the pouch. Unlike kangaroos the young are not permanently attached to the nipple. After emergence young may ride the mother's back for a week or two while learning how to get around the trees. There is usually only a single young, but sometimes twins are born.

Ringtails are recognised in the field by the following characters: the ears are short and rounded; the fur on the tail is short dense and lies flat along the skin; the fur on the distal part of the tail is white. Adult ringtails of both sexes weigh about 1000g. Brushtails differ by having: erect tapering ears; the fur on the tail is longer and bushy (fur sits at 90° to the long axis of the tail); the fur on the distal part of the tail may be black, white or grey. Female adult brushtails weigh about 1300g and males about 1600g. Both species have similar pink-orange eyeshine.

Both SW possums have sister groups in Eastern Australia. The (few) studies on western possums suggest that the southwest populations of both species differ from their eastern relatives in a number of important biological parameters. That both southwest taxa are unique, and distinct from the eastern populations suggests co-evolution with the forest communities of the southwest. In those forests that support them they are an integral unit of the ecosystem.

W.A. Possum Populations

Both species have suffered extensive local decline or extinction throughout much of the species original (pre-European) range. Comparison of current and original distributions suggests that within W.A. local extinction (or extensive decline) has affected roughly 70% or more of the original range. For both species the geographic pattern in decline shows that populations in the relatively drier and less densely wooded areas are much more likely to have declined than those in wetter parts of the range. Within the SW forests brushtails are still relatively common. But the decline of ringtails has been far more extensive.

Few formal studies of either species have been undertaken in the SW forests, though the biology of their eastern relatives is better understood. Studies at Tuttaning (Sampson late 60's, and more recently Kinnear) and Perup (Inions 1985) made observations of brushtails. In the early seventies Mike Ellis recorded his observations of a captive group of ringtails, and of populations at East Augusta and Two Peoples Bay. Recently the W.A. Museum completed a field study of ringtails. Further, a substantial amount of data (mostly from spotlight surveys and trapping) exists within some CALM groups.

Translocation of both species has frequently occurred, primarily using nuisance or rehabilitated animals from urban areas. Within the Busselton area a group of carers raise and rehabilitate derelict ringtails, which are released to the Leschenault Peninsula with the intent of establishing another ringtail population on coastal CALM land.

Habitat and Natural History

The abundance of possums varies considerably between sites, suggesting that better quality habitat is able to support more individuals. Thus possum abundance can be used as an indicator of habitat quality at different sites.

Several WA studies identify habitat parameters likely to influence the abundance of possums. At Tuttaning Jack Kinnear's studies showed that brushtail abundance increased dramatically in seasons following commencement of intensive fox baiting. The WAM ringtail study showed that the most abundant ringtail populations inhabit coastal forests characterised by high foliage nutrient levels in Peppermint leaves and a relatively dense, continuous canopy. In such habitat high density ringtail populations seem able to coexist with the resident fox population, even though some predation does occur. Inions work at Perup showed that brushtails tended to preferentially use those parts of their home range which had higher levels of foliage nutrients. Recent studies of possums at Ludlow have shown that, in that area, possum abundance is positively correlated with both hollow abundance and the amount or density of canopy, and that both factors have the potential to limit population size.

The distribution of ringtails in the SW shows that most extant populations occur in coastal and near-coastal areas, or associated with drainage lines or watercourses (Collie R., Warren R. catchment). On the southern tip of the Swan Coastal Plain the species is relatively abundant. All coastal populations live in vegetation containing Peppermint as a common tree. If eucalypts are present as a common vegetation component (as at Ludlow) then brushtails are present also.

In coastal forests of Peppermint there are few hollows and brushtails are extremely rare (the habitat appears unsuitable for them). In such habitats ringtails use a variety of rest sites, but most commonly build nests in trees (called **dreys**). These range from flimsy platforms for temporary use to large spherical nests woven from pliable vegetation collected and carried in the tail to the construction site.

The degree of arboreality differs between the two species. Brushtails use the ground frequently (at Perup Inions found they spent about one-third of their active period on the ground), and as a consequence are frequently caught in cage traps. If sufficient canopy connections exist ringtails are primarily canopy dwellers and consequently are rarely seen on the ground or caught in traps. Where trees are more widely spaced ringtails must descent to ground level more frequently.

Ludlow and the Perup area are the only SW forests that have both species present throughout a relatively large area. A recent survey of ten Ludlow sites showed that possum abundance varied by up

to a factor of ten between sites, and one site had more than twice as many possums as any of the other nine. Survey data for both Perup and Ludlow shows that the relative abundance of each species varies between different habitats. Sites with the highest densities of possums tend towards a one to one ratio of brushtails to ringtails. In lower density areas it is more likely that one species outnumbers the other.

Ringtail and Brushtail Possums in S.W. of W.A.

At Abba River (Ludlow) the older Tuart trees provide hollows and the Peppermint forms an extensive lower strata. Here both species use Tuart hollows (3-8 each year) as their major rest site, and both eat predominantly Peppermint leaves. Young ringtails and males sometimes rest in dreys (only near the watercourse), temporary platforms, or amongst dense vegetation or under logs. Breeding female ringtails at Abba River always use Tuart hollows. Ringtails very occasionally rest on the ground during daylight, but more frequently during relatively hot summer weather, when they rest in cool damp spots. Dreys are extremely rare in eucalypt woodlands since they don't provide adequate shelter during hot summer weather.

These patterns suggest hollow parameters influence abundance; brushtails are absent from the Peppermint forest even though its leaves form the staple diet at Abba River. Dreys are only abundant in cooler, humid areas.

Ringtails at Perup use about 2.5 ha of forest each (and 4-8 hollow trees each), at Abba River about one ha and at Locke Estate less than one ha. Home range size for brushtails rarely exceeds 5ha. Both species show home range overlap, with only small core areas used exclusively by one individual. Excursions from the home range are rare.

Reproductive patterns differ between the species. Brushtails tend to breed seasonally. At Abba River there is a single breeding season, with births concentrated May and June. Ringtails in nearby populations may have different reproductive patterns and growth rates of young. Females at Abba River had one young each year which was born during winter, but some females gave birth at other times of the year. At Locke Estate twenty percent of births were of twins and some females raised two consecutive young in a single year. At Locke Estate breeding was more evenly spread throughout the year with somewhat fewer births during late summer.

In Victoria Pahl observed in his study population of drey dwelling ringtails (*Pseudocheirus peregrinus*) extensive deaths following a period of unusually hot weather. Some years in Busselton similar observations have been made by wildlife carers who treat distressed *P.occidentalis* found under water tanks, or on lawns during daylight trying to get water from reticulation systems. In contrast with the cool, wet weather of summer 1991-92 there were several hot periods in early 1991 which were associated with numerous observations of dehydrated and thirsty animals active during daylight in urban Busselton. This information highlights the importance of adequate shelter from high daytime temperatures, and of macro- and micro-climatic factors associated with condensation during darkness. Brushtails occur in far more arid areas than ringtails, and presumably are able to more economically balance cooling costs and water availability.

Survey Techniques

Because possums eat plant tissue they produce relatively abundant faecal pellets. Defecation patterns differ to some degree, with most ringtail pellets falling from the canopy, while many brushtails deposit small clusters of pellets at ground level. While the shape of pellets is generally distinctive, the best feature of pellets for identification purposes is the general size of fragments within the pellet. The digestive system of ringtails is more specialised for browsing than brushtails', and as a consequence faecal pellets contain finer, smaller fragments than brushtails. Identification of the species using faecal pellets

requires an adequate sample of pellets because sometimes young animals produce odd pellets, and as ringtails age, their teeth become less efficient.

In more open woodland scratch-tracks result from repeated use of an ascent path on favoured trees. Both species have very sharp claws which usually mark the trees surface. They are particularly prominent on pale barked species such as Wandoo. Scratch-tracks are rare in areas with denser forest, since canopy travel is usually preferred.

Night surveys are conducted by spotlighting or headtorching, the former being more applicable in open eucalypt forest and the latter better in more dense Peppermint associations. Unfortunately spotlight results form a very soft measure of abundance, primarily because different people vary greatly in experience and ability to pick eyeshine amongst foliage. Further, comparison of results from different habitats is more likely to reflect differences in possum visibility due to patterns of penetration of light through different vegetation.

Trapping programs are ideal to determine brushtail abundance, but may fail if used to identify presence/absence in low density populations. Similarly, spotlighting may yield no sightings in low density areas.

Dry abundance and occupancy rates (percentage of dreys occupied of the total number checked) vary dramatically between sites. At Two Peoples Bay dreys are very abundant, but only about 10% were occupied, but at other sites occupancy rates are as high as 40%. In Peppermint forest each ringtail frequently uses 3-8 different rest sites each year within the home range and dreys are relatively abundant structures in Peppermint forest with a resident ringtail population.

Management of Habitat for Possums

The following habitat parameters have been implicated as having the potential to influence possum abundance:

FOX ABUNDANCE and/or CANOPY CONTINUITY
NUTRITIONAL QUALITY and abundance of food species
HOLLOW ABUNDANCE and quality
SUMMER MOISTURE (primarily ringtails)

Sites with lots of possums of both species are characterised by the positive nature of all parameters except fox abundance. Studies aimed at identifying habitat which may be occupied using maps should consider the relationship between vegetation type, drainage patterns, topography and soil and leaf nutrient levels to identify the potentially best areas within the survey area. Day searches of four to six sites can quickly determine the relevance of the selection procedure by providing a relative assessment of the abundance of faecal pellets, hollows, scratch-tracks etc.

While nutritional quality is not easily influenced, structural characters of forests are constantly influenced by land management procedures. The disturbance associated with structural changes to forest may be short term (e.g. small areas cleared for temporary use) or long term (e.g. hollow formation).

Some short-term considerations are easily implemented. At Ludlow some Tuart regeneration proceeds on plots roughly the size of the area flattened by one or two falling tuarts. Initially some of the peppermint trees in an area are knocked down and left to dry. At this stage possums may be displaced from the canopy until they establish and scent mark alternative routes. Fox baiting one week prior to and again during clearing can provide temporary gaps between fox home ranges for the temporarily exposed possums. This consideration has application to the development of recreation areas, which in coastal

peppermint forests are frequently in the best ringtail habitat.

Another short-term application of baiting is to provide temporary protection during translocation. Animals released into habitats with adequate canopy cover may still be exposed while the area is explored and until regular canopy routes are established. Ringtails may also come to ground during hot weather: fox baiting in January may have a greater impact on reducing annual predation of ringtails than winter baiting.

Hollow abundance is a long term issue in habitat management. Brushtails appear to be absent or very rare in SW forests that lack hollows. The ringtails sensitivity to dehydration and overheating implies that it survived in inland areas only where some rest sites provided adequate thermal insulation, or where water supply was adequate. A small reduction in the abundance of hollows may result in dramatic decline in availability of the highest-quality hollows necessary for ringtails to survive one or two weeks of each summer, or perhaps as little as a few days every two or three years.

Similarly, structural changes to forest they may appear minor to us might have major impact on population numbers. Thinning forest may affect nightime condensation patterns by increasing air flow (and hense inhibiting condensation). Reduced ground cover may increase summer soil surface temperatures and hence decrease the frequency of summer dews. Reduction of the understory may also increase the success fox predation. While there is little hard data to guide managers with respect to these habitat parameters a knowledge of the potential of such factors to cause local decline may assist in ensuring the persistence of possum populations. Particularly for ringtails habitat disturbance they may have little impact during winter may, if carried out during hot weather, cause decline in ringtail numbers.

WORKING WITH THE MEDIA

Community Education and use of the media topromote CALM's wildlife programs.

Ron Kawalilak
Director, Corporate Relations

Why are the Media Important?

On behalf of the people of Western Australia, CALM directly manages over 20 million hectares or 7.5% of WA: its national parks, conservation parks and marine parks, State forests and timber reserves, nature reserves, marine nature reserves, and all associated animals, plants and forest produce. CALM is also responsible for conserving native plants and animals throughout the state.

Significant success in this major job is only possible if CALM has the good will, cooperation and support of the community. That, in effect, is the reason for the public relations (ie. public information, community education, media liaison, community relations, etc) program which CALM pursues actively.

CALM must identify itself as an effective and trustworthy organisation, communicate that to key audiences, and promote wider cooperation with the department in the prevention and solution of conservation and land management problems in WA.

CALM's media relations activities are based on an understanding that the department must have public support if it is to achieve its mission, that public support cannot exist in a communication vacuum, that CALM has a right and an obligation to communicate its views and values to the wider WA community, and that CALM also has a responsibility to appreciate the views and values of this community.

It is therefore the policy of CALM:

•to initiate release of information to the media when it is likely to aid in public awareness and understanding of nature conservation and wildlife management, forest resources management, national park and recreation management in WA, and of the programs, services and policies of CALM;
and

•to respond to media requests for information fully, accurately and promptly.

Who are the Media?

The media are among the most important publics CALM has, for through the media other publics can be reached. Media personnel are in the business of gathering information and presenting that information to the public. They work in a very competitive, high-pressure industry. Tight deadlines and often the lack of time to thoroughly research a story contribute to the pressure. As a result reporters will press hard for further details and insist on answers now.

Table 1 gives you an idea of the best time to contact various media representatives.

Table 1: When to Contact the Media

Media	Reporters hrs	Best Time	Deadlines
West Aust	Mostly noon to 9pm or 2-11pm. Some reporters work 10am-6pm	Afternoon, about 2.30pm	1st ed: 6-7pm 2nd ed: 10-11 pm. Very important news can be later.
Community Papers	Mostly 9am-5pm Mon to Frid	Tues, Wed, Thur	Generally 5pm Thursday
Country Papers	Deadlines for country newspapers vary but invariably it is Thursday/Friday for those papers that publish on Tuesdays. Check with your local newspaper office. They will appreciate the interest shown.		
Radio news: ABC	Shifts: 5am to midnight. Roundsmen: 9am to 6pm	For 7.45am bulletin: 5-7am. For 7pm bulletin up to 6pm	Bulletins throughout day
Radio news: Commercial	Many have staff on shifts from 5am to midnight	Breakfast news: 5-7am. Midday 10.30-11am. Drivetime bulletins 4-6pm: 3-4pm	Bulletins throughout day
TV news	Mostly 9am to 6pm	Morning rather than afternoon, especially about 11am.	Bulletins: 5pm Film coverage: 2pm.

Meeting the Media

Although common courtesy and common sense are the best parameters when dealing with members of the media, there are certain guidelines to follow:

- If and when you do visit or telephone a reporter do so with his or her deadlines in mind. The nearer the deadline, the busier the reporter.
- Always return calls from reporters and do so as soon as possible.
- Keep all conversations with media people brief and to the point.
- Always assume everything you say is on the record. Never say anything to a reporter you are not prepared to see on the front page of a newspaper or hear as a lead story on television or radio newscast.
- Avoid opinion; state fact.
- Keep within the sphere of your own knowledge.

- When you promise to provide information keep your promise and as soon as possible. Promise nothing unless you can deliver.
- Be a reliable source of information.
- Never lie to a reporter. The public will not tolerate dishonesty and the media will never forget it.
- Try not to slant the facts or tell only half the story.
- If there are good reasons why you cannot tell the facts as they are DON'T SAY "NO COMMENT". If possible, say why it is inappropriate for you to comment.
- Don't blame a reporter for a headline, caption, or editing that detracts from a story. That's a task done by subeditors and out of the reporter's control. (HOWEVER, on smaller community or country papers, the reporter may also be the editor).
- Be prepared. Have something to say and know how to say it.

Right or Wrong?

Even with the best of intentions, sometimes the media gets it wrong. This will happen from time to time - you will be misquoted or your comments distorted.

If the story is simply technically wrong, ring the reporter or editor and let them know.

If the story is a distortion, discuss it with your manager before approaching the editor. Ring the editor and explain why it is a distortion. Don't debate the issue, rather try to encourage the paper to offer an explanation/apology either by a correction or a letter to the editor in the next edition.

If your story gets a good run, ring the reporter or editor and thank them. This will be appreciated and will give the paper confidence in approaching you for information or stories in the future.

Handling an Interview

In addition to the previous guidelines, there are some general techniques to help you handle an interview with a reporter.

- Work with Corporate Relations. They will be able to help you sort out your "story" and what the reporter will be looking for.
- Predetermine one or two major points you would like to communicate and at the earliest opportunity try to express them.
- Look to each question from the public's point of view and be positive but brief in your answers.
- Avoid jargon. Speak to the public in the language it understands.
- Emphasize key points in an interview. Reporters may not have heard or understood them the first time.
- Give credit to other agencies, where appropriate.
- Never ask to review the story but do offer to clarify any technical information with the report as stories are developed.
- Remember to always BE YOURSELF!

Television and Radio Interviews

Because of the complex nature of the electronic media it is worth noting a few wrinkles which help in dealing with radio and television reporters.

You have to think as they do .. in brief meaningful terms. As a rule of thumb keep one thought to a sentence and keep your language conversational. Avoid pronouns and, if possible, lists of figures.

Television reporters will normally go over the questions they will be asking, before the camera is switched on. But beware, they often throw in some unplanned questions and you should be ready to respond accordingly. As opposed to straight news stories, current affairs programs are often of a confrontational nature and some are deliberately provocative and sensational.

When being interviewed on television:

- Look the interviewer in the eyes; don't talk to the camera.
- Let the interviewer finish the question before you answer.
- Study your subject beforehand, but don't learn everything by rote as it will appear "unnatural" and boring.
- If at all possible, wear something (eg. uniform) that will identify you as a spokesperson from CALM.
- Remember that television is a visual medium: don't pick your nose; don't scratch your ...
- Be on time, especially for studio interviews. Television is planned down to the last second.
- Don't say 'Um' and 'Ah'! We all know this is not easy when trying to find the right words, but it should be avoided. Far better to delay your response until the correct words are formulated in your mind.

What can be said about television applies generally to radio as well. You do have the advantage of not being seen and as many radio interviews are conducted by telephone you are likely to be more at ease. Also, if you do 'Um' and 'Ah', this can often be edited out before it goes to air.

If you are being interviewed over the telephone, do not have a radio on in the background tuned to the same station - the result is a very unpleasant feedback noise.

Newspaper Interviews

Newspaper staff have three major problems to contend with when putting their publications together.

The first of these is time: when sub-editors get hold of a story, they are often racing the clock to meet a deadline and a story can become distorted through hurried editing and insufficient checking.

The second relates to competition. Newspaper staff like to be the first with the news, and in their efforts to achieve this ideal, their stories will suffer due to the urge to 'get something different' from the opposition. Headlines are designed to attract the reader's eye to a certain story and therefore encourage increased sales of the paper.

Finally, because newspapers do like to cover many topics, space is at a premium. Sub-editors look at a long story and start to cut extraneous matter until a manageable article results.

And because advertisements are the mainstay of newspaper finances, they are planned some time before the editorial pages are allocated their space. Your story will often appear as a very short item, or may not appear at all.

When do you Approach the Media?

You should have a feel for when a news item would be of interest locally, statewide or even nationally. You should be familiar with the media in your area, their editorial personnel, their interests and their audiences.

Reporters are interested in what is new, unusual, important or exciting, but it doesn't hurt to point

out such things as solid performance and long term activities if a news angle can be identified.

Local media are interested in activities and individuals within their circulation areas. News items must possess interest or significance to other living in the area.

Community and country papers like to run people's names. Do don't overlook the new value in events or activities involving local employees.

CALM is a gold mine of feature ideas - the secret is to recognize them. Do not hesitate to pass along feature ideas to Corporate Relations people. They will be delighted to receive them, and will help you develop your ideas and select an appropriate medium for them.

Who has Media Responsibilities?
Everyone in CALM has a responsibility and a role to play concerning the media.

It is the responsibility of the Director, Corporate Relations (or designate);
- to establish and maintain the format and procedure for developing, approving and distributing CALM media releases;
- to respond to significant instances of inaccurate or misleading media reports by recommending appropriate action to the Executive or to Branch, Region and District Managers;
- to provide advice and assistant to all CALM personnel in responding to requests for information from the media; and
- where appropriate, to be the primary CALM contact with the media.

It is the responsibility of each Director or Branch, Region and District Manager:

- to be the primary spokesperson for their Division, Branch, Region or District:
- to designate staff to act as spokespersons for specified issues or subjects: and
- to approve, in consultation with the Director of Corporate Relations or designate where feasible, staff appearances on live radio or television programming, except:
    - -where the subjects to be discussed are of a non-controversial or non-policy nature or
    - -where prior approval is not possible, such as on site during emergencies.

It is the responsibility of all CALM staff:
- to respond fully, accurately and promptly to requests for information from the media providing (a) they are technically competent to do so, and (b) another staff member has not been designated as the spokesperson for such enquiries;
- to refer requests for information beyond their area of competence or designated authority to an appropriate source for reply;
- to refer requests to appear on live radio or television to their Manager for approval;
- to refer any issue that is controversial to their Manager or to the appropriate member of the Corporate Executive (often the Executive Director or Regional Services Director); and
- not withstanding the above, if questioned by the media about a sensitive or potentially contentious issue, to promptly advise their Manager and the Director of Corporate Relations (or designate).

Contact Numbers:

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IDENTIFICATION AND COLLECTION OF VERTEBRATE FAUNA SPECIMENS

Ken Aplin
Dept Terrestrial Vertebrates, WA Museum

Introduction

A sound knowledge of the present and former range of native animals, and of the extent of genetic variability across this range, are essential tools for effective fauna management. This session will deal with some of the basic steps towards acquiring this knowledge, viz. the collection and identification of specimens; the assessment of observational records; the role of taxonomic research; and the potential uses of museum specimens for the documentation of various aspects of species ecology. It will also provide some guidelines as to when voucher specimens should be taken for identification.

A name and a place

For a fauna record to be of any use, it must contain at least the following two, vital pieces of information,

1) a reliable taxonomic identification, ie. what species the record pertains to; and

2) accurate locational details, ie. data on the site of capture/observation.

Should either be lacking in adequate detail, then the entire record will most likely be worthless, irrespective of what else is recorded.

Locational data

As a general rule of thumb, locational details as provided with fauna record should be sufficient to allow for someone else to return to within a short distance of the original capture site, and thereby have the best chance of locating additional animals. At the same time however, it is useful if the location can be expressed in sufficiently general terms that the record is meaningful at a glance (eg. "4.2km NNE Meekatharra" rather than "SE corner of Lot 432, Shire of..) An ideal compromise is to provide a general locality which relates to a named locality as listed in the State Gazetteer, followed by a more specific reference that has meaning in the local context (eg. small wetland, western side of Brand Highway, 3.6km N of Shell Roadhouse, Gingin").

Precise coordinates derived from a Satellite Navigation System are of course a invaluable addition, but should always be backed up by a written statement of locality.

Notes on habitat, environmental conditions, time of day, and collecting method also assist with the relocation of collecting sites, as well as providing useful clues to the ecology of the animal in question.

Taxonomic Identification

The critical issues in relation to fauna identification are **reliability** and **verifiability**. Is a particular record valid, or does it represent a simple misidentification of something else? And is there any means of checking the record of a particular species at a given locality?

The **reliability** of a fauna identification is determined by a variety of factors, not all of which are under an individual fieldworker's control. Questions which need to be asked either when assessing a fauna record, or when designing a fauna survey, are: 1) how good is the taxonomy of the group of animals; 2) how easily distinguished are the different members of the group; 3) what is the basis of the record (eg. observation, scats, skeletal, voucher specimen); and 4) how experienced is the observer and/or the identifier. The same factors also need to be considered when deciding whether or not to retain voucher specimens of a given taxon. This topic is taken up again later.

How good is the taxonomy?

When a non-specialist sets out to identify an animal specimen, they are generally working from the premise that the animal is well-known to science and that it has a scientific name. The extent to which this is true varies markedly between different groups of animals. Birds are probably the best known of all animal groups, with the discovery of a new species being an event of international significance. At the other extreme, many groups of invertebrates are so poorly documented that the proportion which bear a formal scientific name may be as low as 1-2%. Clearly, there is little chance of getting a reliable identification on a specimen of one of these poorly known groups.

A good indication of how well-known a given group is can be obtained by plotting the cumulative description of new species of a given group. Figure 1 shows these statistics for each of the major groups of Australian vertebrates except birds (the last full species being described in 1948; less than one subspecies per year since then). Clearly, from this figure, it is only among the birds that we can claim to have a complete inventory of the vertebrate fauna. In the case of reptiles, for example, the last ten years in WA have seen an average of 7 new species being described every year, with no sign of any decrease in rate over this period. Our knowledge of mammals, with an average of 1.8 new species/year, is probably more complete, however it bears remembering that many of these have suffered serious range reductions, and so are much less freely available for study.

Delving below the level of species, studies of genetic and morphological variability are currently underway for a small number of species of birds, mammals and lizards. Surprisingly, birds are perhaps the least studied in this regard, despite the presence of numerous problems that require a population genetic approach.

Although the rate of description of new species of vertebrates has changed little over the last 10-20 years, the nature of the new taxa being described has changed markedly. Twenty years ago, collections from remote areas would often contain many new species that were radically different from anything previously known. Today, discoveries of this kind are rare (although not unknown, fide 1981 description of *Morelia carinata*, from the Kimberley). More often, new species are discovered through the recognition of two or more closely related forms from within what was previously understood to be a single species. These groups of closely related species are often referred to as "sibling species complexes".

Genetic studies have played a major role in the resolution of many sibling species complexes (eg. Baverstock et al. 1984). The discovery of so-called "fixed genetic differences" between two groups of organisms in sympatry, represents prima facie evidence for reproductive isolation between the groups,

ie. for the presence of two species. Such evidence cannot be ignored, even where there are no other differences in morphology, ecology or behaviour.

Exactly how common this phenomenon really is remains unknown, however the last ten years experience in Australia with various groups of mammals, lizards and frogs suggests that it may be true of many (possibly even the majority of) "widespread" species.

How easily distinguished are the different species?

While some species are very distinctive and can be identified at a glance (eg. bustard, numbat, mountain devil), the great majority are only subtly distinguished, one from the other. In such cases, identification can be difficult, requiring access to a microscope and reference materials, and in the case of mammals, requiring access to characters of the skull and teeth for positive identification.

The task of identification can be particularly difficult among members of the sibling species complexes mentioned above. Many biologists have in the past assumed that closely related species will only coexist in nature if they show significant morphological divergence (thereby reducing competition). We now know this to be a fallacy. Morphologically very similar species can and do coexist, and studies based on field identifications alone may be invalidated in the event of the subsequent recognition of sibling species. As an example, much of the literature on *Antechinus stuartii* in southeastern Australia is now virtually uninterpretable, since it was recognised that "stuartii" actually encompasses two species which occur ion sympatry in many of the most intensively studied sites (Dickman et al. 1988).

The potential impact of unrecognised sibling species on reintroduction may be even more serious - possibly resulting in hybridization with reduced fertility and fitness.

What constitutes an adequate fauna record?

Fauna records can be based on a wide variety of different kinds of evidence. Here they are discussed under three headings, 1) observational and incidental, 2) capture/release, and 3) specimen-backed.

1) Observational/incidental records

Under this heading I include the following kinds of records: 1) direct sightings; 2) observation of tracks or traces (eg. scratchings, nest, scats); 3) identification of calls or song.

Sighting and call-based records are particularly important for birds, and many surveys are conducted solely on this basis. Overall, observational records form the great bulk of all bird distributional records.

Most frog species also possess distinctive mating calls, and with experience, these can be used as the basis for identification. The calls of Western Australian frogs (where known) are described in Tyler et al. (198.), however calls vary with weather conditions and considerable field experience (and a good ear) is essential for reliable identification.

For mammals, sighting records are normally both fewer in number and less reliable, however spot-lighting can be a useful method for census of arboreal species. More important for mammals is the identification of tracks and traces, however such evidence may not allow for determination to species level. An introduction to the topic is provided by Morrison (1981). Once again, local field experience is essential.

The main limitation with all observational records is that they cannot be verified other than by repeated observation in the field. Indeed the only grounds on which they can be judged are 1) the competence of the observer, and 2) the existence of other evidence for the particular species. The latter criterion unfortunately lends itself to circularity, since people tend to see what they already believe to be

present.

2) Capture/release records

Identification of animals in the hand will usually result in a more reliable record. Specimens may be checked against keys and descriptions, where available, and appropriate measurements can be taken to further substantiate the identification. In theory the use of keys should require no more than a basic familiarity with the morphological terms for each group (most field-guides will provide some assistance here), however in practice it usually requires some experience to distinguish among the various alternate character states (eg. lizard subdigital lamellae keeled vs mucronate).

Standard measurements for each major group are illustrated in Fig. 2. These should be taken either with a ruler or with callipers; an accuracy of + 2-5mm is realistic for body and tail measurements, and of + 0.2mm for measurements of the foot and ear (taken with calliper). Weight should be taken on an appropriate range scale. Notes should be taken on reproductive maturity in mammals and birds, and on reproductive condition (eg. gravid, in breeding colours) in all groups of animals, since these factors may be important in assessing the measurement data. Photographs are sometimes useful, particularly if they show features of anatomical significance (eg. soles of feet, teeth in mammals).

For WA mammals, there is no comprehensive key yet available. The Australia wide key provided by Jones and Baynes (1989) can be used as is, or modified to serve a more restricted fauna. Books such as that edited by Stahan (1988) are also useful although they lack keys.

For reptiles and frogs, the WA Museum handbook series includes keys to all groups except turtles and crocodiles (in preparation). A key to southwestern tadpoles can be found in Main (1959). This is currently being revised and extended by Museum staff. Cogger's Reptiles of Australia (1988) contains keys to all groups of reptiles and frogs, including all WA species.

Keys are generally not produced for birds, presumably because it is easier to work from illustrations and distributions are well enough known that these can be used to limit possibilities. Bird nests and eggs are often identifiable to species; to date there is no key however Beruldsen (1980) contains a classification of nest and egg types and many useful illustrations. Bird chicks are also potentially identifiable, although reference material is lacking for many taxa.

Using currently available tools, it should be possible for most groups of animals to come up with an identification which is accurate **within the limits of current taxonomy.** Exceptions include tadpoles and downy chicks, as noted above, as well as a small number of especially difficult taxa within each major group. Most notable of these are the small carnivorous marsupials (eg. Nigaui, Sminthopsis ssp) which are usually distinguished on the basis of features of the skull and teeth, and various groups of frogs which are distinguished primarily by call structure (eg. Crinia species) or by chromosomal features (eg. some Neobatrachus species which are distinguished primarily by their ploidy [number of sets of chromosomes]).

Until recently, identifications of animals held and then released have been subject to the same limitations as observational records. In neither case could the record be verified other than by additional fieldwork, and in neither case could the record be reassessed in the context of taxonomic changes. In recent years, however this situation has changed somewhat through the development of new techniques of identification.

One such technique with application specifically for mammals is the taxonomic identification of hair samples. Using works such as Brunner and Coman's (1974) manual and the regional treatment of Valente and Wooley (1982), it should be possible to identify mammalian hair samples at least to generic and in

many cases to species level. This technique is used most frequently for identification of hair in scats, but could also be employed as a routine check on field identifications, particularly among the more difficult groups such as bats, rodents and dasyurids. Some comparative work would be required to complete the coverage for WA, taking into account recent revisions in various groups.

Feathers can often be identified on the basis of size, shape and pattern, and can be useful in cases where an unusual record is involved.

Identification through biomolecular means is another possibility open to the contemporary fieldworker. Small samples (eg. tail segments) can be compared with samples of known identity using isozyme electrophoresis, but this process is wasteful of tissues and materials because each comparison requires a separate analysis. Recent advances in DNA technology provide more elegant methods whereby small samples of blood or other tissue (eg. toe or ear clipping) can be amplified, analysed and comparison with libraries of DNA "signatures" of known species. The initial work involved in producing such libraries would be considerable, particularly if it were undertaken for groups other than mammals. Again, sibling species complexes would represent the greatest challenge, although analysis of rapidly evolving portions of DNA should allow for fine discrimination of this kind.

3) Specimen-backed records

A voucher specimen with good locality details represents the most reliable evidence of a species presence in an area. All aspects of the species morphology can be examined, both externally and internally, and direct comparisons can be made with other reference materials. Importantly, the material can be examined and individually assessed by any worker who would doubt the identification.

The WA Museum is the State's official repository for all fauna specimens. The terrestrial vertebrate collections currently number around 175,000 specimens, of which more than half are reptiles and frogs.

One major feature of a specimen-backed record is that it can be continually reassessed, such that the identification is kept up to date with changes in taxonomy. Moreover, since all voucher specimens automatically become part of the Museum's reference materials, they also contribute to the growing body of knowledge regarding that particular group, thereby improving the prospects for an accurate, fully resolved taxonomy and a good knowledge of distributions.

Voucher specimens can also be informative in other ways. Dissection of preserved specimens can result in detailed knowledge of reproductive patterns, dietary preferences and parasite loads (eg. Kitchener and Halse 1978, How et al. 1987), while investigation of bone and tissue chemistry may provide information on changes in heavy metal concentrations.

In the case of the more difficult sibling species complexes, voucher specimens alone may not be sufficient to resolve the taxonomic problems. In such cases, the most rapid and efficient way to proceed is to undertake a limited genetic study, followed by some preliminary morphological analysis, this in turn followed by a second phase of electrophoresis and a final taxonomic study. This process of working back and forth between techniques allows for the relatively speedy resolution of even the most difficult taxa. Its success, however hinges very much on the availability of frozen tissue samples from across a range of localities.

In recent years, frozen tissue samples have been taken routinely from all animals sacrificed at the WA Museum, and from many animals taken in the field. Indeed, other than in exceptional cases, we are reluctant to undertake any collecting of voucher specimens unless frozen tissue samples can also be obtained. Our express foal is to achieve good geographic coverage of all widespread, common vertebrate

species, such that systematic investigations of sibling species complexes and of geographic variation can be undertaken. For taxonomic studies, samples of 4-6 individuals per locality are generally adequate for the differentiation of sibling species and for the identification of major geographic trends.

For mammals, isolated skeletal material is potentially diagnostic. As a general rule, isolated skulls and teeth are usually identifiable to species, with postcranial material often permitting a coarser identification only. Fragmentary material such as may be recovered from fox or cat scats is more difficult to work with but may still produce useful results. Regurgitated owl pellets are an excellent source of information on small vertebrate distributions. Merrilees and Porter (1979) provide a guide to identification of bones and teeth of southwestern mammals, however it is often necessary to make direct comparisons with reference material. For identification of members of various groups of small mammals (eg. Eptesicus, Sminthopsis), a pair of calipers and a familiarity with the workings of Discriminant Function Analysis are necessary (c.f. Kitchener et al. 1987).

When should voucher specimens be taken?

In deciding whether or not to take voucher specimens, the following issues should be considered:

1) **the level of reliability required.** As indicated above, the highest level of reliability in identification is possible only with a voucher specimen and associated tissue samples. This level of confidence may be necessary if legal issues are involved or in the event of major land management decisions contingent on accurate identifications.

2) **the state of taxonomy of the group.** As noted earlier, only specimen-backed records can be reassessed in the event that the taxonomy of a group is modified. For some taxa (eg. blindsnakes, genus Ramphotypholps) the current taxonomy is so poor that a sight or capture record will almost certainly be meaningless in the context of future taxonomies. Another consideration is that the collection of additional voucher material (particularly with associated tissues) will almost certainly contribute to an improved taxonomy, thereby reducing this problem in the future.

3) **the abundance and distribution of natural populations.** The main argument against the taking of voucher specimens is that it may deleteriously affect the natural population. In certain circumstances (eg. rock wallabies on a small, isolated rockpile) this is undoubtedly true, however in the majority of cases the taking of a small number of voucher specimens will have no impact on species survival. The situation should be judged on a case by case basis, weighing up such factors as the estimated population size, breeding frequency and fecundity. A general rule of thumb for the smaller, more cryptic taxa, is that if specimens can be found without too much effort then they are probably not too uncommon.

Fixation, labelling and transport of specimens

The WA Museum is identified under its Act as the sole repository of fauna specimens in WA. This does not rule out the establishment of small reference collections in regional centres (which can be on loan from the WAM), but does imply that any such collections should be established under the banner of and as part of the Museum's wider collections. For this reason, all voucher specimens should be cycled through the Museum system, so as to validate identifications and to guarantee inclusion in the State's primary fauna database.

. Methods for the preservation of vertebrate specimens are described in many standard references. Very briefly, specimens should be fixed by injection with and immersion in a solution of 10% formalin (injection into body cavities, major muscle masses and region of salivary glands on throat; immersion in approx. 5 x volume of specimen. Small specimens (especially frogs) fix very rapidly (2 days), while larger

animals may take up to 10 days. Buffering of the solution is not necessary over this period, but does become important if the specimens are left in formalin for long term storage (for which 4% neutral buffered formalin is preferred). Most specimens at the Museum are transferred to 70% Ethanol for long term storage. Tadpoles should be left in 4% formalin because they tend to shrivel badly in ethanol.

Bird specimens should be kept frozen wherever possible and should only be fixed as a last resort. Formalin affects the feather pigments in most birds, and most specimens are stored as dry, study or "puppet" skins. Preparation of good quality study skins is a specialist job, and specimens are best delivered frozen, for preparation by Museum staff. Very few mammal specimens are now prepared as study skins, most being fixed whole so as to preserve their complete anatomy.

The preparation of skulls and skeletons is also a specialist job, the final process of cleaning being undertaken by dermestid beetle larvae and slaters in the Museum's "Dermestarium". The process of removing and cleaning a skull for identification purposes can take 2-4 hours of staff time and several weeks in the colony, hence there is often a delay of 2 weeks to a month before a confirmed identification can be supplied.

Tissue samples can be removed and preserved under field conditions, however special materials are required. For electrophoretic analysis, tissue samples must be snap frozen and stored at low temperatures (preferably -80oC). Generally, this requires access to a field dewar containing liquid nitrogen, however dry ice can be used for short term storage. Material kept in a household freezer will deteriorate fairly rapidly, and may be of little use for genetic studies.

DNA can be preserved by fixation of tissue samples in 80-85% ethanol. Samples should be minced up in approx. 5-10 times their volume of ethanol, and can be stored in this solution for long periods. Samples prepared this way are of no use for electrophoretic analysis, but can be used in DNA-DNA hybridization and sequencing studies.

Wherever possible, voucher specimens should be delivered to the Museum as "live" animals. In the case of lizards and frogs, animals stored in a freezer bag (the standard variety, which allows gas transfer but not moisture) last well for several weeks to a month. Larger animals will need to be placed directly inside a cloth bag, so as to avoid having them tear the bag apart. Mammals and birds are much less resilient and many will not survive even one day without food and/or water.

Labelling of specimens has been covered in an earlier section. An important point is that the label should include whatever field code is used by the fieldworker. This code represents the link between the Museum's and the fieldworker's databases, and without it we may be unable to relate our information to the donors.

Uses of Museum's fauna database

The Museum's specimen database is run under the relational database system called INGRES, on a SUN Sparcstation. The mammal and reptile/frog collections are fully computerized, allowing for retrieval of data by taxonomic grouping, by locality or geographic search area, or by any other attributes or keywords. Neither the bird voucher collection not the vast body of observational bird data compiled by Storr and his colleagues are computerized.

Requests for information are channelled through the Assistant Director, Museum Operations (formerly Division of Natural Science) and will generally be processed in under a week. The new database system recently installed allows for output of records in ASCII format, thereby paving the way for data transfer in magnetic or electronic form.

The full potential of the Museum's fauna databases will not be explored until the data can be accessed in a spatial context, i.e., within a GIS environment. Establishment of a system of this kind represents a high priority for the Museum, and should be a goal shared by all groups involved in fauna conservation and management.

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YELLOW-FOOTED ANTECHINUS (or MARDO), *Antechinus flavipes*

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Description

- Small, nocturnal and partly arboreal marsupial belonging to the family Dasyuridae.
- Distinguished from others in the group by distinct change in colour from the slate-grey head to the rufous rump, feet, belly and sides. Prominent white eye-ring and black tip to tail.
- Colour various greatly around Australia;, the most striking rufous individuals occurring in northern Queensland.

Distribution, habitat and habits

- Wide distribution including south-west WA and most of the eastern seaboard.
- Occurs in a broad spectrum of habitats from tropical vine thickets, swamps and dry woodlands to dense moist forest.
- South-west animals belong to the subspecies Antechinus flavipes leucogaster.
- Nervous and cheeky disposition, making very rapid movements as is scampers around hunting prey.
- Active carnivore, consuming insects, small birds and House mice may also include flowers and nectar in is diet.

Features of life history and biology

- Like most other antechinuses, breeding occurs over a short period in late winter, after which all adult males die. Thus during late winter and spring the population comprises only pregnant or nursing females and dependent young.
- Gestation lasts about a month, and the new-born young (as many as 12) are carried in the pouch for up to 5 weeks and weaned after about 3 months.

Conservation

- This species is generally abundant throughout its range and is considered to be under no threat.
- Some data from the karri forests suggest that abundance is greatest in denser vegetation characterizing longer unburnt stands.
- Foxes, feral cats, chuditch and owls probably prey on the species to a significant degree, particularly in the summer months when young animals are dispersing.
- In view of the species' breeding strategy and habitat requirements research needs to be directed at evaluating the impact of fire, feral predators and logging, particularly in the jarrah forest where little work has been carried out.

BRUSH-TAILED PHASCOGALE, *Phascogale tapoatafa*

Susan Rhind
School of Biological And Environmental Sciences
Murdoch University

The Brush-tailed Phascogale (*Phascogale tapoatafa tapoatafa*) is a member of the family Dasyuridae. Although related taxonomically to the Red-tailed Phascogale *(P.calura*) it is not simply a large version of this species, and shows many differences.

Description

Silver grey in colour with a distinctive black bottle-brush tail, P. tapoatafa most closely resembles a small squirrel in appearance. The adults are about 40cm in total length and show sexual dimorphism, with the males being up to twice the size of the females. The animals vary considerably in size (mainly weight) between localities. For example, in central Victoria males weight an average of 274g and females 191g, whereas near Manjimup in Western Australia average weights are 160g and 125g respectively. Such variation is also observed between different areas of eastern Australia and may be due to rainfall and its effect on food abundance.

Distribution and Status

The Brush-tailed Phascogale occurs throughout Australian coastal forests and woodlands. In northern Australia, a separate subspecies (*P.t.pirata*) is recognised and is distinguished by its smaller form and dental differences. In southern Australia, the distribution of P.tapoatafa has contracted since European occupation and the species' abundance has declined by about 40% in Victoria and New South Wales. It is most likely extinct in South Australia. In Western Australia P. tapoatafa formerly extended into the wheatbelt with records of animals as far east as Merredin, and recent fossils at Balladonia and Dongara. It is now confined to the jarrah and mixed karri forests of the south-west.

P.tapoatafa is given the official status of "rare" in the Eastern States, and is regarded as "common" and "stable" in Western Australia. The general Australia-wide decline in distribution and abundance clearly demonstrates the phascogales cannot withstand land clearing. Their resilience to the effects of fire and logging is unknown.

Life History and Habitat Requirements

Brush-tailed Phascogales are solitary, completely arboreal and dependent on trees for both nesting sites and food. They nest in tree hollows, and show preference for secescent and dead trees. The animals use each hollow for 3-6 days before swapping to another, and they therefore require many trees with hollows within their range. They also depend on trees as a food source. Previous literature makes much of the blood-thirsty habits of phascogales, but current research shows that they are almost exclusively insectivorous, obtaining the insects by gleaning the bark of trees. Ground foraging appears to be uncommon.

P.tapoatafa individuals occupy large territories for a small animal, and in Western Australia females appear to occupy exclusive (1 female only) areas of 25-60 hectares. Males can cover at least 100 hectares during the mating season. The necessity for such large territories seems to relate to food requirements. As such, the density of P. tapoatafa in any given area is usually very low and animals are rarely encountered.

The life history strategy of P.tapoatafa is similar to the Antechinus species, with all males dying in July following the annual breeding season. Females carry up to 8 young for 7 weeks before depositing them in a tree hollow. Young become independent at about 100 days of age and begin to disperse around christmas each year. The toll of raising a large litter is massive, and in Victoria about 50% of females do not survive to successfully wean their litters. Some females breed in a second year, but none are known to survive beyond two years in the wild.

Conservation

Conservation of P.tapoatafa is dependent on the persistence of its habitat and the control of feral animals. Cats appear to be a serious problem, and both feral and domestic cats frequently kill phascogales. From a management point of view, there is urgent need to identify the impact of fire and logging on this species, as they are obligate tree-dwellers and are not completely restricted to forest regions of Western Australia that are predominantly of commercial timber value. Their solitary nature and requirement of large territories means that populations are unlikely to persist in reserves that are less than several thousand hectares.

RED-TAILED PHASCOGALE
Phascogale calura

Gordon Friend and Tony Friend
CALM Wildlife Research Centre, Woodvale

Description

Phascogale calura is a tree-dwelling squirrel-like marsupial, distinguished from closely-related Antechinus species by the presence of a striking brush of long black hairs on the distal half of the tail, and from it congner, *P. tapoatafa*, by the rusty red colouration at the base of the tail. (The species name calura means "beautiful tail"). Adult males are significantly larger than adult females, averaging about 60g and 40g respectively, and current research suggsts that sizes of individuals may differ greatly between isolated populations.

Distribution, habitat and habits

At the time of European colonisation of Australia, P calura had a wide but patchy distribution throughout arid and semi-arid areas of the Northern Territory, South Australia, Victoria and Western Australia. Now, however, the species is confined to remnant patches of vegetation in the central and southern wheatbelt region of Western Australia. Available information suggests that within this region *P. calura* inhabits long-unburnt tall and dense vegetation of the Eucalyptus wandoo/Eucalyptus accedens and Allocasurina huegeliana alliances, with populations being most dense in the latter type. In these habitats box poison plants (toxic to introduced herbivores and predators) are very common and burning is infrequent, and these two factors may have contributed to the persistence of populations in the south-west.

P calura nests communally in hollow limbs and trunks of eucalypt trees and old casuarinas, and within the dense "skirts" Allocasuarina habitat by jumping from tree to tree, but also spend considerable time on the ground. Diet consists of a wide range of invertebrates, particularly cockroaches and beetles, small birds and small mammals (especially the introduced house mouse), suggesting that *P. calura* is an opportunistic predator.

Features of life history and biology

Breeding occurs synchronously throughout populations during a three-week period in July each year, after which all adult males die. Females produce one litter of six to eight young per year, but some females may breed in a second or third season. P calura shares this unusual 'semelparous' life history strategy with *P. tapoatafa* and several species of Antechinus. Research has shown that male death results from acute haemorrhage of gastrointestinal ulcers which are a manifestation of physiological changes caused by persistently high stress levels in the males leading up to and including the breeding season. Such a reproductive strategy offers no insurance against reproductive failure, and, not surprisingly, is characteristic of species like *P. calura* which inhabit areas where the climate is both seasonal and predictable.

Conservation

Apart from some work on breeding, diet, habitat preferences and physiology there is very little information available on the ecology of *P. calura* to ensure its effective long-term conservation. CALM, however, has recently completed a three-year program of research on the species' distribution, habitat usage and response to fire. This work resulted in the discovery of several new populations of *P calura* and a considerable widening of the species known range. Its apparent disappearance from nature reserves where it was recorded in the 1970's, however, indicates that not all populations are secure.

An experimental low intensity fire conducted during this research caused significant mortality amongst the tagged *P calura* population, but did not lead to long-term changes in population dynamics or decline in the condition of animals. This result was probably attributable to the close proximity of intact populations in the surrounding unburnt areas, which allowed rapid recolonisation of the 100ha burnt block. The work showed that fire prescriptions for land containing *P calura* populations should ensure that significant adjacent areas of suitable habitat are left unburnt.

There was also a change in nest site selection following the fire, with old *E. wandoo* trees (which survived the fire) being favoured. Animals then travelled greater distances to their feeding areas in the Allocasuarina, thus potentially increasing their exposure to predation by foxes, cats and owls. Further research is currently examining the response of *P. calura* populations to predator control programs.

LITTLE LONG-TAILED DUNNART
Sminthopsis dolichura

G R Friend and D J Pearson
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Description

This dunnart was described as recently as 1984, having previously been considered part of the Common Dunnart, S murina complex. The external similarity of S dolichura to other species of Sminthopsis make field identification difficult, particularly when dealing with sub-adults. Indeed, there is a need for further research on the taxonomy of the complex in order to clearly define the various species and their distibutions.

Distribution, habitat and habits

The Little Long-tailed Dunnart occurs in a variety of different habitats in semi-arid and arid country in south-western Western Australia and South Australia, and has been recorded in numerous conservation reserves and national parks. Preferred habitats include eucalypt woodlands, woodlands dominated by Acacia and Casuarina species, shrublands, heaths of myrtaceous and proteaceous species and hummock grasslands with an overstorey of low trees or mallees.

It is an active nocturnal hunter, subduing its prey of beetles, crickets, spiders and geckoes with an onslaught of rapid bites. Animals captured in pitfall traps with House Mice will readily kill tham and devour the head and/or hindquarters. It is not known whether such predation occurs amongst non-restricted animals in the wild. During the day these Dunnarts shelter in a nest of dry grass and leaves constructed within a hollow log, a grass tussock or grasstree (Xanthorrhoea spp) In hummock grasslands, individuals may shelter in the abandoned burrows of hopping mice.

Features of life history and biology

Throughout its range, the Little Long-tailed Dunnart is often common in areas on early stages of regeneration following fire. It becomes particularly abundant 3-4 years after fire and may temporarily displace other species of dunnarts in such area. The breeding season spans from August to March, with most females giving birth to one litter of up to eight young. There is limited evidence that some females may rear two litters in a season, but this is yet to be confirmed in the field. No laboratory studies of breeding have yet been carried out, but it is likely that oestrous cycle, gestation length and developmental rates are similar to those for S murina.

The young become independant of the mother when they are about 5g in weigt and disperse widely, often into less preferred habitat. Females may commence breeding when 8-9 months old andlive for up to two years. Males are capable of breeding when 4-5 months old, but the longest time between captures for a male in the field is only 14 months.

Conservation

Foxes and feral cats probably prey on the species to a significant degree, particularly during spring and autumn when large numbers of juvenile animals are dispersing. Despite this, the Little Long-tailed Dunnart appears to be secure and under no immediate threat, although populations may fluctuate greatly in response to different seasonal conditions.

Size

Head and body length = 74mm

Tail length = 95mm (males), 90mm (females)

Weight = 11-20 (14.8)g (males), 10-21 (12.4)g (females)

Identification

Dorsal fur pale to dark grey; head pale grey with a thin black eye ring. Face, cheeks and patches behind the ears brownish. Ventral surfaces white. Ears long and bare. Tail is long and thin, the dorsal surface light grey and the ventral white. Differs from *S. hirtipes* and *S. granulipes* in lacking granular ternimal pads or hair on the interdigital pads of the hind toes. The lack of a prominent dark head stripe or patch and a non-incrassated tail distinguishes it from *S. crassicaudata* and *S. macroura*. Adults differ from *S. ooldea* by their larger size and lack of an incrassated tail. Differs from *S murina* by its longer tail and the dorsal fur being grey rather than brownish. Distinguish from *S. gilberti* by its longer tail and shorter ears and feet. Differs from *S. griseoventer* by its longer tail and white rather than grey ventral fur.

Recent Synonyms

Sminthopsis murina fuliginosa (south western Western Australia), part of *Sminthopsis murina murina* (South Australia)

Other Common Names

None

Status

Common in suitable habitat

Subspecies

None

References

Kitchener, DJ, Stoddart, J and Henry, J (1984). A Taxonomic Revision of the Sminthopsis murina complex (Marsupialia, Dasyuridae) in Australia, including descriptions of four new species. Rec. West. Aust. Mus. 11(3), 201-248.

(Extracted from the forthcoming 2nd Edition of Strahan, R (Ed.) The Australian Museum Complete Book of Australian Mammals. Angus and Robertson, Publishers.

FOREST BATS

N.L. McKenzie
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Biology and evolution

Flying is a great way to forage. In energy terms, flying beats walking or swimming every time — by an order of magnitude. Insects seized this opportunity with great success early in the evolution of life, although problems such as gas exchange rates to body volume set physical limits to their size.

It is hardly surprising that the aerial niches were the last to be colonised by vertebrates. Agile flight requires a number of anatomical specialisations of organisms as bit as vertebrates. A light but strong skeleton is essential, especially for the long bones that form the wing spars. For prolonged flight it is also important to have a way to minimise moisture loss in conditions of fast air-flow.

Birds dominated the flying niches soon after the time of Dinosaurs. But birds basically rely on their eyesight. This is not much use when there isn't much light, so the equivalent night-time foraging niches were open to the rapidly evolving mammal groups. A role that bats have filled.

Bat wings are thin membranes of skin that are deployed by the bones of the hands, arms and legs. The hand bones are grotesquely elongated to provide propulsion and most of the control surfaces (the flaps and things).

Bats are thought to have evolved from small gliding insectivores that foraged in forest canopies. Later, the group diverged into megabats and microbats, whose anatomical differences relate to their different diets.

Megabats

The megabats comprise the flying foxes and blossom bats of the Old World tropics (Asia, Africa, India & Australia). Flying foxes include the largest bats in the world, with wing-spans of up to a metre.

Megabats eat fruit or nectar, found using their sharp eyesight and sense of smell. In this case, advantages accrue to both the eater and the eaten, so evolution has assisted from both directions. Biologists call this co-evolution. Megabats are pollination and seed dispersal agents for many tropical trees and shrubs. The position of the flowers and fruits at the ends of branches, or hanging off the bare trunk, the pungent odours and nocturnal flowering are clues to the interdependence of megabats and tropical plants such as figs, bananas, coconut palms and boababs. If you have every heard a large flying fox crash-landing in a fruit tree at night you will understand why they need an exceedingly tough hide.

Microbats

But the microbats had even tougher problems to overcome. They had to catch small, elusive animals

in the dark, and without any assistance from co-evolution because the prey had every reason to evolve in the other direction.

Echolocation involves bouncing sounds of things to determine their range and shape. It has evolved in animals several times, independently. It is known from whales, shrews, rodents, birds, bats and blind people.

But the microbats stand out among echolocators because their calls are not just broad-band clicks, they are structured in time. This development may have been crucial to the success of bats, in permitting them to hunt successfully in the face of competition from other aerial insectivores, and eventually to gain an almost exclusive franchise on the night.

Microbats are the "small bats" that are so common world-wide. Most are about the size of your hand and eat insects, either by chasing and catching flying moths, beetles etc., or by gleaning insects from the ground, from bark or foliage. But microbats have also expanded into a variety of other food niches. Ghost bats, are relatively large and prey on small nocturnal mammals and lizards. Other species have evolved large hind feet armed with sharp claws to fish the surface of pools. In the New World (the Americas) where there are no megabats, a group of microbats eats fruit and nectar, carrying out the seed and pollen transmission roles.

The blood-eating "vampire" bats of South America are parasites. Fortunately, the "Temple of Doom" is not infested with Vampire Bats, they don't occur anywhere in the Old World. Indiana Jones misrepresented a colony of Indian flying foxes.

The specialisations for nocturnal flight are so demanding that they pervade a bat's whole life-style. Their anatomy, ecology and patterns of behaviour reflect their use of flight and, for most microbats, their use of structured echolocation.

The disadvantages of echolocation over vision are its short range and that it can be detected by the target so it exposes the predator's presence. These limitations explain why there are no bat-equivalents of falcons, hawks and eagles. Another disadvantage is the complex transmission, reception and information processing equipment required. The ears of most bats are large, with a confusing array of curved surfaces, lumps and pointy bits.

Well, try hanging a TV antenna and a radar dish on your face and see how good you look!

Around the nostrils and mouths of some are additional fleshy antennae to focus the transmitted sounds, and re-shape the wave-form of the returning signal.

Conservation

Birds and mammals maintain a constant body temperature. Thus, unless they can hibernate, they burn a lot of energy every day. Flying homeotherms such as birds and bats forage more cheaply, which offsets the problem and may explain why so few of even the largest bats have become rare or extinct compared with their ground-dwelling relatives.

Even so, as with birds, the population densities of many species have declined. These trends are a worry, because bats have assumed such important ecological roles, and the trends imply that they are vulnerable.

1. As human populations increase throughout Asia, the all-important pollination and seed dispersal roles of megabats in tropical forests are being threatened. Most megabat species live in colonies

of dozens to ten of thousands of individuals that cooperate in the search for food. Unfortunately, colonial populations are accessible to hunters, and are not being systematically slaughtered to be sold as meat in markets throughout protein-hungry Asia.

2. Few countries have bothered to examine the role of microbats in Agricultural areas. An informative case study comes from Texas where the population of just one bat species (*Tadarida braziliensis*) consumes more than 6600 tons of nocturnal insects per year; many of its prey are agricultural pests. It has been recognised for more than 50 years that bats are the only predator capable of controlling the nocturnal insect populations over the grain-growing regions of southern USA.

T.braziliensis is also known as the Guano Bat. Breeding colonies of literally millions of individuals congregate annually in caves in Central and Southern America. It is ironic that many of these caves have been destroyed by miners accessing the huge deposits of bat faeces on the cave floors, one of the richest sources of superphosphate, an agricultural fertilizer. this problem is not limited to America.

In Britain, Poland and other industrialised areas of Europe, a variety of microbats are now endangered. Today, several species are known from just a few colonies in old barns, others have not been seen for more than a decade. Suggested reasons include the widespread destruction of suitable foraging habitat, the gradual accumulation of agricultural insecticide in bat tissues, and the destruction of roosting sites. The last has a disproportionate effect on colonial species; tree hollows are rarer in regrowth forests, caves are mined for cement and superphosphate or illuminated for tourism, and the roofs of buildings are fumigated as "pest-control" .

Forest Bats of the South-West

Nine species live in our temperate forests. All are microbats and all feed on insects. The flying fox (*Pteropus alecto*) has occasionally been reported, but Shark Bay is normally the southern limit of this species' range so the forest records are treated as vagrants.

The different ecological roles of the forest microbats are determined by where they hunt. Well documented observations are scarce, but I have attempted to synthesize the available data below. The way our bats partition forest habitat is determined by, their wing shapes and sonar characteristic. A Boeing 747 cannot turn as tightly as a Tiger Moth.

White-striped Mastiff Bat (*Tadarida australis*).

Common and often heard. Large, black bat with prominent strip of white fur under the base of its wings. Roosts in small colonies of up to 10, mainly in tree hollows and spouts. Females are pregnant in spring and solitary young are born in early to mid summer. It is the only South-western species with audible sonar. Very docile to handle. Fast flying, but not very manoeuvrable, it forages the open air high above the vegetation canopy, and is thought to detect its prey at a range of 3 or 4 metres.

South-western Mastiff Bat *(Mormopterus planiceps)*

Common but rarely seen. Medium sized brown bat with prominent hairy feet. Lives in small colonies of about 10 individuals, usually in small tree hollows with entrances less then 2cm in diameter. Usually quiet and gentle to handle, but aggressive to other species in captivity. Thought to breed in spring and early summer. Fast, agile, but no manoeuvrable, it forages the open airspaces above the forest canopy,

along roads and through large clearings, well clear of the vegetation.

Western Falsistrelle *(Falsistrellus mckenziei)*

Common in suitable habitat. Small colonies of 2 - 30 individuals have been found in tree hollows. It forages in mature forest, where there are cathedral like spaces under the canopy between the massive tree-trunks. Its flight is fast and straight, with wide turns.

Gould's Wattled Bat *(Chalinolobus gouldii)*

Commonly seen at dusk. Lives in tree hollows and roofs in groups of 10 - 100 individuals. A medium-speed bat, its flight pattern is irregular, with frequent changes in direction, as it hunts flying insects around tree canopies and along the sides of gaps and clearings in the forest.

Chocolate Bat *(Chalinolobus morio)*

Roosts in caves and tree hollows. Usually in large colonies of 30 - 100's of individuals. Most often seen in headlights, flitting across tracks in dense shrublands as it chases insects between and just above the shrubs.

Little Forest Bat *(Eptesicus regulus).*

Roots in small colonies in tree hollows. A small bat, it is commonly seen at late dusk foraging close against the foliage or between the branches, of trees. Flight is slow and irregular, with frequent changes in direction.

Long-eared Bats *(Nyctophilus).*

Roost under bark or in dense foliage in small groups of 1 to 6. These are most manoeuvrable of our forest bats. They forage in cluttered airspace. Their slow, fluttering flight allows them to glean the surfaces of leaves, bark and the ground. They rely on their acute hearing to detect insect movements at distance. Their sonar is of low intensity, only useful at close-range (a metre or less), but very good for distinguishing prey from back-ground clutter. Myctophilus major will intercept flying insects from a perch, like the flycatching birds do. While N.major is normally a woodland and forest bat, N.gouldi may favour shrublands. The smallest of the three species, Nyctophilus geoffroyi is usually caught close to the ground, and prefers to forage the forest floor.

Key to adult bats of the South-western Forests

1. Tail extending beyond tail membrane for:
   at least 10mm (Fig. 1) 2
   less than 5mm 3

2. Forearm (Fig. 2)
   more than 50mm ***Tadarida australis***
   less then 40mm ***Mormopterus planiceps***

3. Forearm
   more than 50mm ***Falsistrellus mckenziei***
   less than 48mm
4. Ear length from ear-hole to tip, fully extended
   less than 40mm (Fig. 3) 5
   more than 15mm (Fig. 4) 7

5. Ear
   much higher than wide, easily meet
   across top of head if pushed flat
   Forearm less than 33mm ***Eptesicus regulus***
   fleshy, almost as wide as high 6

6. Forearm
   less than 39mm, brown fur ***Chalinolobus morio***
   more than 40mm, fur on head and
   shoulders darker than body ***Chalinolobus gouldii***

7. Nyctophilus (Fig. 4)
   Y-nose leaf behind nostrils, forearm
   less than 39mm ***N.geoffroyi***
   forearm more than 39mm

8. Width across upper canine teeth
   more than 5.5mm. Forearm at least 44mm ***N.major***
   less than 5.5mm. Forearm 39 - 44mm ***N.gouldi***

How to catch South-western bats

1. Active Methods

Searching in tree hollows and caves can be rewarding, but seldom yields the same range of species as passive methods. A hand-held net is essential gear. Some colonial bats are quite rowdy in their roosts, twittering and bickering amount themselves. Listen!

During flight, bats secrete oils over their wings, and other areas of bare skin, to conserve moisture and warmth during flight. In consequence, you will often see faint blackish staining around the entrances to occupied hollows and spouts.

Seeing what they are, or getting one our for identification is often a problem. Throw a rock in. A small amount of smoke or insect repellent will often yield results in otherwise hopelessly inaccessible sites, but leave an obvious escape hole or you risk suffocating the whole colony. The back of your watch is a good reflector for examining the darkest crevices at the back of even deep hollows.

In searching a cave, look for small piles of faeces and wet spots from urine on the floor as bats often more ahead of you into inaccessible crevices or escape through back entrances. Search very slowly from the entrance inwards, checking the walls, roof and even piles of rock on the floor. Shine a light into all cracks if they are wider than your little finger. Watch out for the ubiquitous snake. If you have a net, set it across the tunnel behind you, partially mask it with a branch, then make lots of noise at the back of the cave.

But be very careful during late spring and early summer, the time when most south-western bats breed. Don't disturb breeding colonies.

2. Passive Methods

Mist nets and harp traps.
Can use trip wires at pools, and catch them as they swim ashore.
For ecological survey purposes, Mastiff bats are sometimes collected using shotguns.

The best nights are the warm, still, moonless nights, from dusk until about 20:00 hours.
Nets should be set:
Across forest tracks at various heights (a few inches above the ground to canopy height), preferable just past bends or where foliage partially masks sections of the net.
Over permanent pools, in the shadows under bridges, at the edge of clearings.
Move the nets every night; these animals learn quickly.
Attend the nets; check them quickly every 5 minutes but otherwise keep the torch off.

How to handle, feed and take care of bats

Small temperate bats usually become torpid during the day, and for much of the winter. This means that they allow their body temperature to draft down to the temperature of the air around them, just retaining enough warmth to maintain essential biochemical processes.

If roused repeatedly, they burn up the special 'black fat' reserves around their heart that fuel the process of arousal; a high-energy fat, it is essential in raising they deep body temperature. Once the black fat reserves are used, bats cannot achieve the active temperatures required to eat and metabolize the food, so they inevitably die.

Most bats you will encounter have been taken from their roosts. They will probably have roused at least once, but may have gone back into torpor in the bag or box used for transportation. To keep them alive it is best to feed them with live mealworms, moths or other small insects as soon as possible. To avoid dehydration problems it is also wise to get some sterile water into them.

The first rule is not to squeeze the bat. Broken ribs or wing bones are probably fatal.

To successfully feed and water a bat for the first time requires a little patience, it can take 5 to 10 minutes for a bat to rouse fully, a process is best done by cupping the bat between you hands. It may take another 5 minutes of pushing the mealworm against its lips before some small bats will begin eating. (Pet shops charge about $8 for a tub of 1000 mealworms). Water can be offered by pushing the tip of a plastic

syringe (without the needle) between the bat's lips. Subsequent feeding sessions usually only marred by the bat's impatience.

Bats are mostly territorial. The best care you can offer is to leave the bats in a quiet dark place, and release them where they were captured as soon as possible. If the roost has been destroyed, they may need a refuge until nightfall. Goannas, pythons, cats, Chuditches and even certain ethnics are among their predators.

Minor injuries such as torn wing membranes heal exceedingly quickly, but the bat may need to be fed, given a drink then left along for a few days. Unless the bat is obviously healthy, and is handled with a lot of conservation, the "show and tell" opportunity at the local primary school is not recommended.

Contemporary Bat Survey Method

Each species has a distinct echolocation signature.

To document these signature, we are collecting a dictionary of bat calls for the South-west. Once we have a better idea of the variation between and within species' signatures, you will be able to identify the species of bats in a Study or Monitoring Area without having to spend weeks trying to catch them all.

The system we are using was developed in Queensland and costs about $1000. It comprises:
ultrasonic detector
cassette tape recorder
a sound digitising processor
software for analysing the calls

Ecology and Management of Woylie, Tammar and Quokka.

Tony Start
CALM Woodvale

1. DESCRIPTION.

I have attached copies of the accounts of these species from the Australian Museum's Complete Book Of Australian Mammals. You will find descriptions, basic ecological and biological information and distribution maps there.

These are all medium sized marsupials. The smallest (Woylie) is about the same weight as a rabbit and the largest (Tammar) is about the weight of a fox. Table 1 shows their mean weights and includes some other species for comparison.

TABLE 1

Common name	Scientific name	Family	Weight*
Rabbit	Oryctolagus cuniculus	Leporidae	1,580g
Red Fox	Vulpes wlpes	Canidae	5,500g
Woylie (Brush-tailed Bettong)	Bettongia penicillata	Potoroidae	1300g
Quokka	Stonix brachyurus	Macropodidae	3,250g
Tammar wallaby	Macropus eugenii	Macropodidae	4,200g
Brush Wallaby	Macropus irma	Macropodidae	8,000g
Western Grey Kangaroo	Macropus fuliginosus	Macropodidae	38,500g

* mean weights taken from Burbidge and McKenzie 1989

WOYLIES are rat-kangaroos (family Potoroidae). This is a small family related to the true wallabies and kangaroos. Like kangaroos woylies hop but they hold their bodies horizontally, in fact they often appear to be hunched over. This contrasts with the much more upright posture of kangaroos. They have short faces, small ears and long tails that are tufted. You will see these features if you catch one in a spotlight because they move slowly when dazzled by the light.

If you flush one during the day it will probably "explode" from a bush right under your feet. You may see a small brown body hurtle through the bush, zig-zaging now and then before it disappears. You may well see the long, tufted tail (longer than the head and body: bandicoots have much shorter rat-like tails) but you will be lucky to see much more detail.

QUOKKAS should be familiar to most West Australians who have visited Rottnest. On the mainland you are unlikely to see one because they live in extremely dense swampy places. However, get on your hands and knees in a well used quokka swamp and you will find their tunnels are clear open

"roadways" under a mat of rushes etc. The tunnels are almost big enough for you to force your way along; those of bandicoots are much smaller. If in doubt you should not have to look far for their characteristically square droppings

TAMMARS are typical small wallabies. They have distinctive face patterns that should make it easy to distinguish them from young Kangaroos and Brush Wallabies. They often favour thickets, but can be seen in fairly open country at night.

2. STATUS AND DISTRIBUTION

WOYLIES are declared threatened under Section 14(2) (ba) of the Wildlife Conservation Act. A recovery Plan funded by ANCA is in its second year of implementation. The plan covers Western Australia and South Australia. The plan was initially written for ten years but encouraging news about their response to fox control in the Batalling Forest as well as indications that they are much more wide spread in the Southern Forest Region than previously known has caused the Recovery team to revise the plan to cover two more years and then be reviewed.

Their distribution indicated on the attached map under represents the extent of their former distribution in the arid zone; Andrew Burbidge and Phil Fuller discovered from Aboriginal people that they existed through the Great Sandy Desert and adjacent parts of the Northern Territory.

Today they occur in WA at:
Dryandra
Tutanning
Boyagin (translocated there last year)
Batalling (probably progeny of animals translocated by Per Christensen)
Perup (it also course at Kingston and in the lake Muir area - are these
separate populations or has the Perup population expanded?)
? Fitzgerald River (there are unconfirmed reports).

In SA there are populations on some offshore islands and in Yookamurra Sanctuary. However all these populations are derived from WA stock.

We plan to introduce woylies to Julimar (in WA) and Venus Bay Nature Reserve on the SA mainland. If operation foxglove is a success we may also introduce them to other areas of the northern jarrah forest.

QUOKKAS are on the reserve list. They have always been confined to the south west of WA from about Mundaring south along the high rainfall edge of the Darling Scarp and through swampy areas and probably heath lands south of Bunbury. They occur along the south coast to Mt. Many Peaks and they are in moist gullies in the Stirling Range. There are two important island populations, on Rottnest and on Bald Island.

Toady they still occur through much of this range, at least south from Jarrahdale. However it seems that they have disappeared from some creeks along the Scarp and they are much less abundant than they used to be in many others. Because of the very thick habitat, Quokkas could easily disappear without being noticed so it is important to locate populations and monitor them periodically.

TAMMARS are declared threatened under Section 14(2) (ba) of the Wildlife Conservation Act. A recovery Plan was written for the species in 1991 but we were unsuccessful in securing funding to implement it. However the species is secure on the Wallabi Islands, Garden Island and on two islands in

the Archipelago of the Recherche off the south coast of WA. The SA inland subspecies is probably extinct but the WA subspecies is present at Dryandra, Boyagin Tutanning and Perup. There was a population in Kalbarri NP until recently and there may be populations elsewhere in the Wheatbelt and South Coast Regions (eg. Fitzgerald River.)

3. MANAGEMENT.

POTENTIAL AND REALISED RANGE.

An animal's niche is that combination of environmental parameters that provide conditions within which the animal can live. Its potential range is the area in which its niche requirements are met but its realised range may be smaller than its potential range if some factor(s) excludes it from parts of its potential range.

The disappearance of the Woylie, for eg, from most of its former range implies that some factor(s) have made much of its potential range unsuitable. If we are to prevent the decline continuing, perhaps to extinction, or better still, reverse the decline, we need to identify the factor(s) and through management, alter them to a regime that is tolerated by the woylies.

Where the landscape has been fragmented by clearing or where we may want to achieve a major extension of range in a short time, we may have to translocate animals after we have identified and modified the factors that eliminated them from their previously realised range. Occasionally we may need to introduc them to areas that they did not previously occupy (such as islands).

There have already been several translocations of Woylies and it may be expedient to translocate the other species in the future, particularly if proposals to reconstruct faunas in selected areas come to fruition. However this is beyond the scope of this course unit.

PREDATION AND FIRE

There are two particularly important factors that affect the availability of potential habitat for these species on the south west mainland. Often they are inextricably interrelated. The most important is predation by foxes. In the case of woylies and tammars there has been a dramatic increase in population density wherever foxes have been baited. Indeed the places where the last few animals have held on have been in Dryandra, Tutanning and Perup, all places with abundant thickets of poison bush (Gastrolobium). It seems likely that fox numbers were lower there because of secondary poisoning effects.

The other factor has been cover. The density of cover is, of course related to fire. Fire removes dense vegetation, but with time it recovers and then, in many cases decreases as short lived shrubs degenerate. This scenario is true of poison thickets in Perup where the use of fire to maintain habitat, particularly for tammars has been advocated and certainly it provides good habitat.

However, let us consider quokkas. It seems from the accounts of old-timers that quokka hunting was a popular pass-time in pre-1930s. Today one would have little hope of getting any because they are confined to such dense vegetation that they usually have to tunnel through it. It is likely that quokkas used to have a much wider realised niche than they do now. Today they are confined to sites that are so dense that they can avoid foxes. Fox baiting may well see quokkas again occupy heathlands on the south coast and perhaps other more open sites - look at their habitat on Rottnest!

There is one very important point about quokka habitat and fire. As indicated above quokkas seem to have become scarce or have vanished &from some of the creeks along the scarp. This may well reflect susceptibility to predation" after fire has burnt their swampy thickets. Per Christensen found that if part of a swamp was burnt, quokkas moved to the unburnt part but visited the other area to feed until it was

again thick enough for them to live in.. If possible quokka swamps should not be burnt, but if they are, fox control is vital in the area until the swamp is again very thick.

CONCLUSION

Islands provide relatively secure habitat for quokkas and tammars in WA. There are no island populations of woylies except in SA (introduced and? highly inbred WA stock)

All three species are CWR mammals and all are susceptible to fox predation.

All three have declined, but to varying degrees. They have persisted where there is either very thick cover (especially quokkas) or an abundance of poison bush or both.

It is not clear how important thick vegetation is as a primary component of their niche requirements. In the absence of fox predation they may be able to live in more open sites than they generally do today. Never the less fire management of habitat is important and protection from foxes is probably most vital when fire has reduced the availability of thick vegetation.

DISTRICT FAUNA MANAGEMENT PROGRAMS as Interim Management Guidelines.

Gordon Wyre
Wildlife Branch

1. Introduction

1.1 Background/Responsibility for the Preparation of Management Programs

Unlike area management plans for which there is a statutory requirement under the CALM Act, there is no statutory requirement for wildlife management programs, nor is there even any mention of such programs in the CALM or Wildlife Conservation Acts.

CALM does, however, have a legislative responsibility to manage wildlife on CALM managed lands under the CALM Act and to manage fauna for conservation statewide under the Wildlife Conservation Act. The CALM strategic plan includes the major strategy:

"Prepare and implement wildlife management programs for wildlife throughout the state".

To further develop this strategy, CALM has adopted Policy Statement No. 44 "Wildlife Management Programs", which commits CALM to preparing and implementing written management programs for threatened, specially protected or harvested taxa, other taxa in need of intensive management and also threatened ecological communities.

1.2 Why Prepare Wildlife Management Programs?

A wildlife management program provides an ordered means of planning and conducting operations with wildlife for the purpose of meeting specific goals/objectives. It is therefore a logical way of addressing a wildlife *problem*.

In CALM's case the overall objective for fauna management is the conservation of the species involved. Whether we want to increase the population of a rare species (such as the Chuditch), control populations of a harvested species (such as Red Kangaroos) or protect from undue disruption an exploited species (such as Whale Sharks), the prime objective is the same : to ensure that the species involved are conserved and not threatened due to human impacts. If you like, the *problem* in these cases is how to achieve the conservation goal.

Policy Statement No. 44 lists the situations for which management programs can be prepared and provides guidelines for the preparation of programs under the following categories:

(i) "a *recovery plan* for a threatened taxon".
(ii) "a *recovery plan* for all threatened plant or animal taxa in a region or district".
(iii) "a *recovery plan* for a threatened ecological community".
(iv) "a *wildlife management program* for a specially protected taxon, a harvested taxon, a group of harvested taxa or other exploited taxa".

(v) "*interim wildlife management guidelines* for a threatened, exploited or any other taxon".

(NB: each of the above is considered to be a form of management program.)

1.3 District Fauna Management Guidelines/Programs

District fauna management guidelines/programs are not specifically provided for under Policy 44. Such programs can, however, be considered initially as Interim Wildlife Management Guidelines, as they involve a developmental management need and also relate to the 'interim guidelines for operations' concept.

District guidelines need not involve large scale resources and would also generally be trial programs prepared specifically to conserve rare, threatened, specially protected, or otherwise significant fauna. They need not be confined to CALM managed lands (or waters), but would probably be simpler to operate if they are.

In most cases District guidelines would be developmental, in that operations would be trialed and monitored until an acceptably successful and efficient program is developed. In this regard, they could be modified significantly throughout their life. The life of interim management guidelines should be no more than 3 to 5 years. At the end of this period, sufficient information should have been collected to prepare a full management program as a District Fauna Management Program or, where threatened species are involved, a 'recovery plan'.

2.0 The Planning Process as it applies to Wildlife Management Programs

2.1 Do we need a management program?

The answer is yes if a *problem* is identified with wildlife that requires management intervention over a considerable period of time, i.e.

-is the taxon/taxa harvested for commercial/non-commercial purposes?
-is the taxon/taxa exploited in a manner that could pose a threat to the species or the public which will be ongoing?
-are there significant species (rare, threatened or with a high public profile) inhabiting areas managed by CALM, for which special attention may be required in organising ongoing management actions such as fire, fire break contraction, public access, weed control etc?
-are there rare or other threatened taxa or habitats which can be managed to increase the chances of survival of those taxa?

Once you have decided that a management program is required you will also have a good idea what form of program should be prepared:- recovery plan/management program or interim management guidelines. Essentially if there is considerable information available on which to develop a management program then a full recovery/management program should be considered; If there is insufficient information available for the writing of a full program or insufficient resources, interim wildlife management guidelines should be prepared.

If a management program (or interim guidelines) are to be prepared, it is necessary for their preparation to be approved by the Corporate Executive.

2.2 What information do we include when writing a Fauna Management Program?

2.2.1 Introduction: the thought process

Before we begin to write a program, it helps to take time to think about what it is we want to achieve by writing and conducting a program, so that we can ensure that all appropriate matters are addressed. Perhaps the best way to achieve this is to follow an approach which involves the consideration of four basic questions.

-Where are we?
-Where do we want to be?
-How will we get there?
-How far did we get?

These questions can be considered to form a cycle, which provides for ongoing review and refinement of objectives and operations, as follows.

1. Where are we?
(i.e.what is the situation for the fauna to be managed.)
(Review of success of past management)

2. Where do we want to be?
(i.e. what is it that we want to achieve through management.)

3. How will we get there?
(i.e. identify the specific aims and strategies to be followed to achieve the overall objective.)

4. How far did we get?
(i.e. monitoring of the extent to which the aims and objectives have been met.)

Considering the questions as a cycle helps to show that there is an inbuilt process of review and that programs can be reviewed and modified, as experience dictates, throughout their operational life. This review of operations and re-analysis of the management situation is really catered for through the process of considering questions 3 and 4 (How far did we get? and Where are we?) at the end of each management cycle.

2.2.2 Policy statement 44 format

The policy suggests that interim management guidelines should include the following sections.

1. Introduction
   - taxonomy and status of species to be managed.
   - what is known of - habitat, biology, ecology, limiting factors, populations.
   - reasons for management.

2. Management Guidelines
   - Aims/Objectives.
   - Strategies to fulfil the aims/objectives.

3. Research Requirements
   - what other information is needed for a full management program to be developed.

4. Management/Recovery Team

Also, if applicable

Acknowledgments
References
Glossary
Appendices

2.3 Preparing District Fauna Management Guidelines, using an example from the Collie District

If we apply the process of 2.2.1 to the framework provided in policy statement 44 (section 2.2.2), we see how District Fauna Management Guidelines can be prepared. The sample program at attachment 1 "Conservation of Significant and Threatened Critical Weight Range Mammals in the Collie District" shows how the theory can be put into practice and will be used to exemplify the preparation of management guidelines. To simplify matters, where extracts are taken from the proposed Collie plan, these are shown in *italics*.

A. Where Are We?

1. Introduction.

Summary of the current management situation.. State why the program is being prepared. Discuss the actions that have been undertaken in the past. Describe the areas involved in management, aspects such as tenure, past and current use etc.

e.g. Small mammals in the South-West of Western Australia in the Critical Weight Range (CWR) 35g to 5,500g have shown the greatest loss from their original richness of any fauna group (Friend, 1987).

A major cause of this decline of small mammals in the forest has been the introduction of the fox and cat.

Detailed studies of the Numbat, Tammar Wallaby and Woylie have shown that predator control is the single most important management action in maintaining and increasing forest mammal populations (Kinnear, 1989).

In the Collie CALM District there are a number of threatened species within the CWR:

Threatened species still present

* Chuditch/Western Quoll (Dasyurus geoffroii)
* Woylie (Bettongia penicillata)
* Southern Brown Bandicoot (Isoodon obesulus)
* Ringtail Possum (Pseudocheirus occidentalis)

Threatened species no longer present

* Tammar (Macropus eugenii)
* Numbat/Walpurti (Myrmecobius fasciatus)

Priority II CWR species present

* Quokka etc.

2. Background on the species to be managed.

A summary of what ecological information is available. Should give details of what is known of populations and population change, habitats, factors contributing to population change etc.

e.g. Chuditch

Background

Chuditch occur throughout the Collie District and are regularly sighted by the public on roads through the forest. Keith Morris from CALM Woodvale Research has been conducting a trial on the effect of 1080 on Chuditch in the Hillman/Batalling Block area since February 1990. This will continue until February 1993.

Monitoring of the population has been done by trapping at 3 monthly intervals and tracking radio collared individuals. To date no individuals have died due to the 1080 baiting and the population has increased 5 - 10 fold in the last two years.

A significant Chuditch population is also present in the Lower Collie Valley adjacent to the River and recreation sites. Chuditch have also been trapped in Collie itself recently.

Limiting Factors

Predation by foxes is probably the major factor controlling Chuditch numbers within the District. Removal of this predation in Batalling Block has resulted in a 5 - 10 fold increase in Chuditch in 2 years.

Management Requirements

Chuditch are likely to continue to exist at low levels throughout the District without any special management assistance. Any areas that are made fox free within the District will be very favourable for the Chuditch.

The areas proposed to be made fox free within the Collie District over the next 3 - 5 years are considered more than adequate for the conservation of this species within the District.

All 1080 baits used within the District will meet the criteria below to ensure Chuditch are not effected.

Weight	-	200g wet
1080 dose/bait	-	2.5mg
Bait spacing	-	200m apart or > 6 bait/100ha

etc

B. Where Do We Want To Be?

3. Overall objective of management.

The objective should be as measurable as possible. Wherever populations are being manipulated you should aim to set particular population targets. It is, however, unlikely that you will have sufficiently detailed information of current populations when initially preparing a set of guidelines to be able to set a precise target. In these terms you should at least define in your objective whether you want the population to increase, decrease or stay about the same.

e.g. "To increase both the overall abundance and number of populations of significant and threatened Critical Weight Range (CWR) mammal species within the District."

The above objective can be refined to give target population sizes once more information comes to hand on current populations.

C. How Will We Get There?

4. Subsidiary aims and strategies for achieving them.

The subsidiary aims and strategies establish the steps that will be taken to achieve the main objective. Again, wherever possible, the aims should be measurable/quantifiable. The strategies should be in plain English and describe the actions to be undertaken to meet the aims.

e.g. "Aim

To re-establish populations of threatened fauna species that have disappeared from areas within the District in the last 30 years.

Strategies

(i) Compile a list of fauna that currently exist and previously existed in each forest block (currently being done).

(ii) Train staff in the management practices necessary for the re-establishment and monitoring of populations of threatened species.

- 4 people will be accredited to handle and lay 1080 baits, one of these will be an officer.
- minimum of 4 people in the District will be familiar with tagging, survey and handling of CWR fauna. One will be an officer who will have attended and passed the Mammal Conservation Course.

(iii) Re-establish habitats that are suitable for the future translocation of priority threatened species.

Numbats have a minimum area of 20,000ha fox free in the Eastern Jarrah Forest by 1994.

Tammars locate and identify on the master burning plan Melaleuca thickets that require regeneration in the next 5 years. Prioritise and program these regeneration burns in conjunction with the Districts burning program.

Quokkas Review the master burning plans that may adversely impact on the swamp/creek systems these animals inhabit. Implement changes after liaison with the Region and Fire Protection Branch.

(iv) Expand the fox control zone in the Eastern Area to 20,000ha in conjunction with Science and Information Division (K Morris).
(An area of 20,000ha is considered a viable size for re-introduction of a Numbat population).

(v) Investigate the possibility of reintroducing a Ringtail Possum population to the Eastern Area in conjunction with Paul De Tores (1993).

(vi) Reintroduce the Numbat and Tammar Wallaby to the Eastern Area by 1994 with involvement from Scientific and Information Division (SID)."

5. What research do we need to undertake?

Identify the research needed. This may be easier to do once the guidelines have been in operation for some time. In the example the main research requirement has been to assess the impacts of 1080 baiting on the species to be conserved. This has been undertaken prior to the writing of the program and no obvious research need has been identified at the time of drafting.

Research needs which could be considered in the Collie guidelines include:

- design of the most cost effective frequency, density and strength of fox baiting that will be effective in reducing foxes from an area of forest.
- Identification of viable population and habitat size or each managed species in the forest blocks.

D. How Far Did We Get?

6. Monitoring programs to establish what impacts the management has had.

This section can also identify knowledge/information shortfalls.

e.g. "Species and population monitoring, using a range of cage traps, will be carried out in the four fauna management areas.

The minimum standards will be:
- Trapping will be conducted on permanent transects.
- Transects will be a minimum of 10km long.
- Traps will be located at predetermined 200m intervals.
- Trapping will occur twice/year in Autumn and Spring for a week.
- Data will be collected a minimum of 4 times during the week.
- Further data collection for the North and South Areas will be reviewed after two years of data collection."

Results of monitoring should be made available for verification. It is helpful if programs can specify what data will be used and how:

e.g. "Trends in populations on each transect, represented by capture rates will be monitored to assess the impacts of management".

E. Who Will Have Responsibility For Ensuring That The Guidelines Are Implemented?
This is a fifth question which can be added to the standard four.

7. Management Team

The management team is required to oversee the development and operations of the program/ guidelines.

The team is required to Report to the District Manager, Regional Manager and Director of Nature Conservation.

e.g. A management team will be established involving:-
- 2 District Representatives
- 1 Regional Representative
- 1 Fire Protection Branch Representative
- 1 Representative from Operation Foxglove or WA Threatened Species and Communities Unit.

2.4 Preparing District Fauna Recovery Plans

Interested readers should refer to policy statement 44 for information on the preparation of these programs. Such programs should be prepared on a priority basis involving consideration by the Director of Nature Conservation and the Threatened Species and Communities Unit.

3.0 Program Implementation, Review and Evaluation

3.1 Introduction: Role of the Management Team.

Implementation, review and evaluation of programs are all roles which are undertaken, or at least overseen, by the management team.

The Management Team should meet at least once a year to:

-schedule management operations for the next year including identification of staffing and budgetary requirements; any short-falls to be brought to the attention of the District Manager, Regional Manager and Director of Nature Conservation for possible rectification.
-assess monitoring results on the success of operations and, technical or resource.
-consider reports on the operation of the program including any problems, successes, need for assistance/offers of assistance etc.
-prepare a report to be passed to the Director of Nature Conservation prior to the end of the calendar year on the operation of the program. (This is a major requirement of the team; to ensure adequate communication of program operations/achievements to Program Directors/senior staff)
-recommend/draft any amendments to the program which can be identified during its operation t through monitoring and practical management experience.

In most instances meetings will also be held during the year to 'fine-tune', schedule and, ensure resources/budgets are available for actual, management operations.

The Management Team is vital to the success of the operation, because it becomes a team of stakeholders, all with vested interests in ensuring that the program is a success. If the program is not a success, it reflects badly on the team. The team should be coordinated by a Chairman, with responsibilities for organising team meetings and supervising management of the program.

3.2 Program Evaluation

This is conducted initially by the Management Team and is further considered by the District Manager, Regional Manager & Director of Nature Conservation, based on the annual report prepared by the Management Team.

Programs are evaluated in two main areas.

(a) success in terms of achieving the aims/objectives.
(b) cost effectiveness/efficiency.

3.2.1 Success in Meeting Objectives

This is the most important form of evaluation. At the operations level it is conducted by the management team. At the Department level is based on the annual report on operations prepared by this team.

The secret of simplifying program evaluation is in the care taken to make the aims of the program measurable. Too often programs have ridiculously broad aims such as:-

-"conservation of species x in the y reserve".

If you stop and ask yourself what does the above objective mean you find that the fact that species x was present when you started the management and still there when you finished means that it has been conserved. It doesn't matter whether the population has increased, decreased or whether the species has increased or decreased its range in the reserve or become locally extinct from some areas.

A much better objective would have been:-
-conserve species x in the y reserve be retaining existing populations at least at their current levels, increasing the total population in the reserve to in excess of 2,000 and adding three new populations at localities a, b and c.

When you come to evaluate this program you need to be able to show that:-
-all existing populations are retained at least at their pre-management levels, ;
-the total population has increased above 2,000 and;
-three new populations have been established.

With such objectives you can not only measure/evaluate whether management has been successful or not, but interpret the level of success (i.e. if only two of the three objectives have been met, how close you went to achieving the 2,000 population and how many new populations were established.

Once you have measurable aims/objectives in a program it is simply a matter of comparing the result against the planned outcomes to be able to evaluate the success of the management program operations.

In the example program the objective is not stated in discrete measurable quantities, but the direction of desired population change is identified. The subsidiary aims are similarly not as precise as they could be in future. An objective of the management team should be to amend the overall objective and aims of the guidelines, in the light of data gathered during the initial years of management, to make them more precise and measurable.

3.2.2 Efficiency/Cost Effectiveness

It is up to the management team, and in particular the Chairman, to prepare costings and budgets

for programs and to assess the cost effectiveness of operations. Aspects such as staffing, equipment, frequency of monitoring actions etc should all be considered in terms of cost effectiveness. In preparing its annual report on operations the team should pay particular attention to any cost/resource shortfalls and also areas where savings can possibly be made in future operations. This is an integral part of the review process to be considered under the questions "How far did we get?"/"Where are we?".

LEGISLATION AND POLICY IN WILDLIFE CONSERVATION

Gordon Wyre
Wildlife Branch

A. INTRODUCTION

Legislation, Government Policies, CALM Strategies, Policies and Administrative Instructions : How do these relate to each other and affect our activities?

Legislation, comprising Acts of Parliament and Regulations, establishes the legal constraints on human activities. Legislation is an expression of the will of the Parliament and particularly of the Government, which has a majority in Parliament.

Legislation can also establish Government departments (statutory departments) such as CALM, and positions of authority (statutory positions), the Executive Director and the Director of Nature Conservation for example. Legislation can also establish the functions and roles of Departments and the statutory positions.

Government policy establishes a set of guidelines or guidance for interpreting how legislated responsibilities are to be undertaken. Government policies can be written down in policy statements or determined by Ministers and Cabinet. In our system of Government a Minister is responsible for the performance of the Department's which make up his/her portfolio and therefore has a strong vested interest in ensuring that Department's carry out their functions in accordance with statutory (or legal) responsibilities and Government policy. Departmental strategies and policies then interpret the detail of Departmental responsibilities and Administrative Instructions further detail what departmental staff are to do/consider in particular circumstances.

B. LEGISLATION

The two pieces of legislation defining CALM's role in wildlife conservation are:-

- the *Conservation and Land Management Act 1984* (CALM Act) and
- the *Wildlife Conservation Act 1950* (Wildlife Conservation Act).

It is the Government's intention to repeal the current Wildlife Conservation Act and replace it with a totally new piece of legislation. It is planned that the new Act will, among other initiatives, strengthen the protection of threatened fauna species and marine mammals, and provide for better management of the wildflower industry.

1. CALM ACT

The long title of this Act is:-

"An Act to make better provision for the use, protection and management of certain public lands and waters and the flora and fauna thereof, to establish authorities to be responsible therefore, and for or incidental or connected purposes".

1.1 Background/Functions

This act establishes the Department of CALM, the National Parks and Nature Conservation Authority, the Lands and Forests Commission and the Forest Products Council. The Department of CALM is established as a management authority, charged with the management of lands, waters and wildlife under policies and directions set by the Minister and the above advisory bodies.

The functions of CALM are established in Section 32(1) of the CALM Act and include:-

- to manage land (and waters) and the associated forest produce, fauna and flora;
- "to be responsible for the conservation and protection of flora and fauna throughout the State and in particular to be the instrument by which the administration of the Wildlife Conservation Act 1950 is carried out .....".

The lands (and waters) to be managed by CALM include national parks, nature reserves, timber reserves, state forest, conservation parks, marine parks, marine nature reserves, and other lands identified in specific instances.

1.2 Management plans/programs

Section 33(3) of the CALM Act provides for land to be managed according to management plans, approved by the Minister.

If no management plan exists management is to be undertaken:-

- as "necessary operations" in the case of a nature reserve or marine nature reserve (i.e. operations to preserve or protect persons, property, land, flora or fauna or to assist the preparation of a management plan).

- as "compatible operations" in the case of national parks, conservation parks and marine parks (i.e. operations for necessary operations but also include other operations approved by the Minister).

- in accordance with the purpose for which the land was vested in other cases.

1.3 Licences

The CALM act provides that the Minister, the Executive Director and their delegated officers may issue licences controlling activities in lands and waters managed by the Department (e.g. Section 101(1) "The Executive Director may grant a licence in writing to any person to enter and use any land to which this Division applies (i.e. State forest, timber reserves, wilderness area and unvested Crown lands).

2. THE WILDLIFE CONSERVATION ACT

The long title is:-

"An Act to provide for the Conservation and Protection of Wildlife".

2.1 Background/Functions in Relation to Fauna

This Act establishes that all native fauna in its wild state is the property of the Crown/Government.

The Act also establishes that all native fauna is protected from being taken from the wild (Section 14) except in situations where licences are issued to allow taking or where the fauna has been declared to be other than protected over the whole of the State by the Minister, by notice in the Government Gazette.

While all fauna is generally protected unless otherwise declared, some species may be specially protected if the Minister decides that additional protection is required. Under Section 14(2)(ba) the Minister may declare fauna to be "Likely to become extinct or rare, or otherwise in need of special protection". The net effect of such declarations is to increase the penalty for illegally taking such fauna from $4,000 (for protected fauna) to $10,000 for specially protected fauna).

2.2 Application to Lands and Waters

The Wildlife Conservation Act applies to the whole of the State, including State waters and to fauna whether in a wild state or held in captivity. Fauna is defined as including any animal indigenous to Australia and includes other animals which the Minister may declare to be fauna.

2.3 Wildlife Conservation Regulations

The Regulations are made under the Act to provide the detail for the licences to be required before a person can take fauna from the wild, study or research fauna, keep fauna in confinement, mark, sell or transport fauna, import fauna or other animals, export fauna or release fauna or other animals.

The regulations also describe the situations under which licences may be issued and the consideration to be taken into account when licence issue is to be considered.

3. SUMMARY OF LEGISLATION

Essentially the Wildlife Conservation Act and Regulations provide for the Government to be responsible for native fauna protection and management and to manage that fauna for the purpose of conservation. Because any taking, keeping or release of fauna can impact on the conservation of fauna, the Act and Regulations establish controls on these activities which apply state-wide. Further, because the import and release of fauna or other animal species may also impact on fauna conservation, the Act and Regulations provide controls to be exercised on those activities.

The CALM Act designates that the Department of CALM is to be responsible for the management of lands and waters entrusted to it (and the flora and fauna contained therein) and also for the administration of the Wildlife Conservation Act (see CALM Act, Section 33(1)(d)). While in managing lands and waters entrusted to it the principal considerations to be addressed by CALM must relate to the purposes of vesting of those areas, CALM is also required to address the conservation and protection of fauna in both these managed areas and elsewhere throughout the State through administration of the Wildlife Conservation Act. This then is the crux of the Department's legislated responsibilities for fauna conservation.

C. CALM STRATEGIES, POLICIES AND ADMINISTRATIVE INSTRUCTIONS

1. CALM STRATEGIC PLAN 1989 - 1993

The strategic plan establishes the Department's mission, primary objectives and strategies within the requirements of the enabling legislation and overall government policy.

1.1 Mission

"To conserve Western Australia's wildlife and manage lands and waters entrusted to the Department for the benefit of present and future generations."

The conservation objective is written as "to conserve the indigenous plant and animal species and environmental processes throughout the State".

1.2 Primary Objectives

Of the Department's 5 primary objectives three relate directly to fauna conservation and management viz:-

Management: To protect, restore and enhance the value of resources entrusted to the Department so as to meet, as far as possible, the diverse expectations of the community.

Conservation: To conserve the indigenous plant and animal species and environmental processes in natural habitats throughout the State.

Knowledge: To seek a better understanding of the natural environment and to promote awareness and appreciation of its values.

1.3 Strategies

The key strategies relating to CALM's fauna conservation objectives are as follows:-

- "Establish and maintain a system of secure reserves which protect viable representative samples of all the State's natural ecosystems and species ....."
- "Prepare and implement management plans for lands and waters entrusted to the Department." (Includes the fauna contained therein).
- "Ensure that conservation and land management is carried out according to sound, well researched, scientific principles."
- "Prepare and implement wildlife management programs for wildlife throughout the State". This will involve:-
  - — providing special protection for threatened flora by regulating use of their habitat.
  - — managing threatened animal populations to ensure their survival.
  - — managing the commercial exploitations of species to maintain sustainable populations and ensure their long-term conservation.
  - — conserving and managing threatened ecological communities and taxa in need of intensive management.

- "Provide an effective administrative framework for the conservation of wildlife throughout the State and the management of lands, waters and natural resources entrusted to the Department (includes the issue of licences under the Wildlife Conservation Act)."

1.4 Summary

CALM has recognised that it has a legislated responsibility for the conservation of fauna both generally throughout the State and within lands and waters under Departmental management.

The conservation and management responsibilities are to be met through the application of licensing procedures, reservation of lands for fauna conservation, and the development and operation of management plans and programs relating to Departmental operations.

2. CALM POLICY STATEMENTS

CALM has produced a range of policy statements relating to its management and administrative activities. Policy statements provide a discussion of the activities that are their subject and explain the approach to be taken in dealing with those activities in normal Departmental operations.

In relation to fauna conservation operations, the following 12 policy statements are directly relevant:

(i) No. 1: Planning
(ii) No. 11: Fire Management
(iii) No. 20: A Marine & Estuarine Reserves System in Western Australia
(iv) No. 22: Taking, Keeping & Display of Live Reptiles
(v) No. 23: Conservation & Management of Emus
(vi) No. 24: Conservation & Management of Saltwater Crocodiles (draft)
(vii) No. 27: CALM's Role in Management of Native Vegetation in Rural Areas
(viii) No. 28: Reporting, Monitoring & Re-evaluation of Ecosystems & Ecosystem Management
(ix) No. 29: Captive Breeding & Cultivation of Threatened Species & their Re-establishment or Translocation in the Wild.
(x) No. 31: Management of Reserves for the Conservation of Native
(xi) No. 33: Conservation of Threatened & Specially Protected Fauna in the Wild
(xii) No. 44: Wildlife Management Programs

The principal policies for general fauna conservation issues are discussed below.

2.1 Planning (1):

This policy provides that there will be a hierarchy of plans involving a State-wide Plan, Regional management plans and Area management plans.

These plans contain statements on their purpose and background, the resource information available, management problems and prescriptions. Area management plans may be given a priority for development if threatened fauna are involved, although the special needs of these species may best be addressed through the development of particular management programs under Policy 44.

2.2 A Marine and Estuarine reserves system in WA (20):

This policy provides for the establishment and management of marine areas for the conservation of marine fauna and flora and ecosystems, public recreation and commercial use.

Marine Nature Reserves are conservation areas as defined under the CALM Act, while Marine Parks are zoned to provide for commercial and recreational use as well as sanctuary areas.

2.3 Captive breeding and cultivation of threatened species and their re-establishment or translocation in the wild (29):

This policy commits CALM to a program involving the taking of remedial action where species have become threatened with extinction.

One of the reasons for establishing the policy is given as "apart from the statutory responsibilities of the Department to carry out research and management to prevent the extinction of native species, such activities have a very high profile (i.e. Numbat, Noisy Scrub-bird) and could clearly, with public interest and involvement aid the overall conservation of the State's flora and fauna".

The operational objective is:-

- "where such measures are warranted, to prevent extinction of animals and plants in the wild by re-establishing or translocating captive bred or cultivated populations".

The key policies are that the Department will:-

- prepare a priority list for species needing to be re-established
- undertake and foster research into the captive breeding of these species
- ensure that captive breeding/translocation programs are undertaken under approved management programs while allowing initial experimental translocations to proceed.
- translate research into ongoing monitoring and management

Research and development of fauna breeding is to be undertaken mainly within CALM, but can also involve the Perth Zoo and other organisations and individuals.

2.4 Management of reserves for the conservation of nature (31)

The objective of this program is for CALM to:-

"Select and manage conservation reserves and take other steps necessary to ensure the long-term maintenance of species and genetic diversity and the persistence of those habitats, indigenous species and ecological processes that comprise Western Australian ecosystems.

The key management policies and strategies relating to fauna conservation programs are:

Policies

- manage reserves to maintain existing species.
- where possible promote opportunity to enhance biotic diversity and reduce or eliminate exotic predation and other processes that reduce diversity.
- maintain the most favourable possible habitat for threatened species.
- monitor change in selected species abundance.
- undertake ecological research.

Strategies

- Include in the management data set information on presence of rare species/threatened species/species sensitive to disturbance.
- undertake rehabilitation programs to restore natural values including re-introductions of species.
- control native and exotic species which impact on the primary conservation values of the reserves.
- undertake research and monitoring of progress to improve knowledge of the factors to be taken into account in managing reserves. (i.e. Find out what significant species/ecosystems are in a reserve or have been there in the past and manage the reserve to maximise their conservation.)

2.5 Conservation of threatened and specially protected fauna in the wild (33)

This policy establishes the Threatened Fauna Scientific Advisory Committee to oversee the review of the lists of threatened and specially protected fauna and also commits CALM to a range of policies and strategies designed to meet the operational objective.

The operational objective is:-

- "To conserve threatened and specially protected fauna in the wild in Western Australia".

The Policy describes threatened fauna as native fauna which is:-

- presumed to be extinct.
- in imminent danger of or threatened with extinction (including where detrimental environmental changes such as foxes etc. are still impacting or where populations are critically low).
- dependent on/restricted to vulnerable habitats.
- very uncommon, even if widespread.

The Policy also identifies a "reserve species list" which covers species recently removed from the threatened list and those which do not meet the criteria for listing as threatened, but which are worthy of close consideration.

The Policy describes specially protected fauna as that which, because of its high commercial value or damage impacts, may be subject to taking to the extent that the species may become threatened. (This includes species for which a high penalty for illegal taking is required since the maximum penalty for taking protected fauna is $4,000 and for threatened or special protected fauna $10,000.)

The key policies are that the Department will:-

- Identify, locate and seek to conserve threatened and specially protected fauna.
- Implement management practices to conserve endangered and specially protected fauna and their habitats.
- Seek to reserve land that provides habitat for threatened fauna.
- Undertake/promote research into the ecology and management of threatened and specially protected fauna.
- Maintain a database for threatened and specially protected fauna.

The Policy also includes strategies to meet the policies and objectives, including:-

- Training staff to conserve and manage threatened and specially protected fauna,
- Nomination of regional/district threatened fauna officers to provide training liaison and advice.
- Establish the presence of threatened or specially protected fauna prior to actions on CALM land that might significantly impact on the species.

2.6 Wildlife Management Programs (44)

A major strategy of CALM's Strategic Plan is "to prepare and implement wildlife management programs for wildlife throughout the State". This policy describes the situation in which programs should be prepared and provides guidelines for the preparation of those programs.

The operational objective is:-

"To conserve and manage threatened specially protected or harvested taxa of flora and fauna and their habitats, threatened ecological communities and other taxa in need of intensive management by the preparation and implementation of written wildlife management programs".

Key policies are:-

- preparation of recovery plans for threatened taxa or communities
- preparation of wildlife management programs for harvested taxa (e.g. kangaroos) or taxa subject to significant human exploitation or interference (e.g. whales/dolphins/whale sharks).
- preparation of interim wildlife management guidelines in situations where there is insufficient

data available to prepare full programs.
- undertaking research to provide information required to develop programs. The policy also provides guidelines for the preparation of the various types of programs.

3. ADMINISTRATIVE INSTRUCTIONS

The key administrative instruction which give direct interpretations of how CALM staff are to hand general fauna conservation responsibilities are:

-Interim Guidelines for Operations (No. 23).
-Implementation of CALM Policy statement No. 22: 'Taking, Keeping and Display of Reptiles' (No. 40)
-Protection of Threatened and Specially Protected Fauna in Departmental Operations (No. 44).

3.1 Interim guidelines for operations (23) and; Necessary operations - A guide for managers (39)

These instructions provide the framework for the development of interim management guidelines as described in the Policy Statement on Departmental Planning. The guidelines are "stop gap" measures to be undertaken in managing areas prior to the completion of management plans. They are to be developed to ensure that the values and purpose for which the area was reserved are not lost or irreparably damaged due to management neglect.

The checklist for aspects which should be considered in the preparation of the guidelines include:-
- Fire protection, dieback protection, control of weeds and feral animals, protection of rare or endangered species, recreation management, access, soil erosion/water quality, landscape rehabilitation, mining and exploration and protection of archaeological sites.

Guidelines are to be prepared by district and regional staff and forwarded to regional managers. The instructions also advise that it would be desirable to monitor the impacts of management on flora, fauna and other values within the reserve (and within resources).

3.2 Protection of threatened and specially protected fauna in Departmental operations (44)

This instruction provides detailed procedures for Districts and Regions to follow to prevent accidental destruction of threatened and specially protected fauna.

The instruction calls for the maintenance in Regions and Districts of threatened animal registers, providing data on known location of threatened fauna. The purpose of the register is to assist with consideration of the potential for management actions (or disasters such as wildfires) to impact on threatened species.

D. DRAFT NATURE CONSERVATION STRATEGY

1. Why have a Strategy?

(i) To establish a vision for nature conservation in Western Australia, in which ecologically sustainable management across all lands and waters can ensure that the State's biological diversity is maintained.
(ii) To review the conservation objectives of the Department of Conservation and Land Management (CALM), to ensure that strategies for the maintenance of the State's biological

diversity are in place.

(iii) To review the major issues involved in nature conservation in Western Australia, the scientific and social bases upon which it is managed and the constraints within which it is conducted.

(iv) To act as a resource document for:-

- staff members of CALM who are responsible for implementing actions designed to protect the State's biological diversity;
- staff of other government agencies with whom CALM interacts in pursuing the goals of nature conservation;
- the interested public who wish to understand the basis for nature conservation management in Western Australia, and perhaps influence or be involved in that management.

2. What is the strategy?

The proposed Nature Conservation Strategy is a strategy by which CALM can discuss, give the background to, and focus, its nature conservation activities to meet the requirements imposed on the Department.

In essence the nature conservation strategy can be seen as bringing together all the existing CALM policies and strategies on nature conservation into the one document and identifying the areas where further policies and actions are required.

The Nature Conservation Strategy is all about "conserving" nature. Under the State Conservation Strategy the following objectives of conservation were stated:

-to maintain essential ecological processes and life support systems
-to preserve genetic diversity
-to ensure the sustainable use of species and ecosystems
-to maintain and enhance environmental qualities
-to optimise the 'quality of life' for Western Australians

A major thrust of the strategy is to conserve biological diversity. Why is this important?

The Earth is only suitable for human habitation because it has been conditioned by other organisms over millennia. It remains suitable because the present biota and ecosystems provide resources and ecological functions upon which we depend. Loss of biological diversity may result in loss of ecological functions and decreased opportunities for future generations.

Another major principle in the strategy is the prevention of further human induced species extinctions. The principle is stated as:-

"Extinction is a natural process, but its rate has increased greatly in Australia since European settlement. With increasing knowledge and better techniques for managing wildlife, the opportunity exists to prevent any further extinctions resulting from human interference or neglect."

In order to combat this decline the strategy has specifically identified research into the conservation of threatened species and control of endangering processes as priority areas for CALM. Actions proposed for directly reversing the decline of threatened species are listed in section 4.3.

The major endangering processes identified in the strategy are:-
-habitat destruction, including clearing, drainage or filling of wetlands, and the construction of roads, dams or buildings.
-habitat modification, including changes to structure, species diversity, nutrient levels etc.
-introduced predators/competitors/diseases.

The actions identified to be undertaken to reduce the impact of endangering processes are listed in section 4.4.

3. Conservation Objective of the Strategy

"To conserve in perpetuity the widest possible diversity of indigenous landscapes, ecosystems and species (including their genetic variability), in natural habitats in Western Australia."

Within this overall objective, CALM's vision for nature conservation in Western Australia encompasses the following goals:-

. There will be strong and continuing community support for nature conservation.
- Western Australia will maintain, in perpetuity, viable and significant examples of the whole spectrum of its natural areas and biological assets.
- Nature conservation and management will be integrated with all development, industrial and natural resource management activities in the State.
- There will be a constructive and mutually beneficial partnership between CALM and the farming and pastoral industries, so that the nature conservation values of private and leasehold land are fully realised.
- The resources available to CALM, combined with resources from the wider community (including the Aboriginal community), will enable the proper management of lands and waters for nature conservation throughout the State.
- There will be sufficient scientific research conducted to provide the knowledge to properly manage species, lands and waters for nature conservation.

4. Key Aims and Actions relating to fauna management

To achieve the above goals, as they relate to fauna management, the following key aims and actions have been identified.

4.1 Aim:- Complete the conservation reserve system by selecting, reserving and managing viable protected areas broadly representative of the natural ecosystems and species of Western Australia and including areas with special landscape, cultural and educational values.

This will be achieved by the following actions:-
- continuing to support the implementation of the EPA Red Book and other existing recommendations for additional conservation reserves.
- undertaking detailed ecological surveys of those parts of the State that are poorly known at present, e.g. the Austin and Ashburton Botanical Districts and marine areas, and recommending the implementing new conservation reserves where needed, and
- identifying and protecting the most threatened habitats by reservation of public land or, in the case of private land, by land purchase, or by negotiation with landholders as necessary.

4.2 Aim:- Promote, encourage and assist nature conservation on private and other lands and waters outside the conservation estate.

This will be achieved by the following actions:-

- helping landowners and managers to protect and manage remnant vegetation as components of regional conservation systems,
- promoting the management of rangelands in pastoral areas which are compatible with nature conservation by sustainable grazing of native plant species, and the protection of ungrazed reference areas,
- encouraging local government authorities to provide for nature conservation through their town Planning Schemes.

4.3 Aim:- Protect, conserve and manage threatened species, ecosystems and communities by conducting and applying research and protecting and managing key areas and critically threatened species.

This will be achieved by the following actions:-

- continuing to review the lists of threatened species of plants and animals and to develop priorities for research and management through the application of ranking systems,
- reserving or otherwise protecting key habitats of threatened species and managing these areas as needed, and
- conducting research to elucidate the reasons for the decline of particular threatened species and developing ways of preventing further declines through the preparation, implementation and monitoring of Recovery Plans.

4.4 Aim:- Control processes that are threatening large areas of habitat and/or many species.

This will be achieved by the following actions:-

- continuing to develop and apply techniques to protect native ecosystems from plant diseases, especially dieback disease caused by *Phytophthora* species,
- expanding and applying research into the control of exotic animals, especially foxes, rabbits and feral cats,
- developing procedures for the control of important bushland weeds and the prevention of introduction of plants from other countries that have the potential to threaten native plant communities, and
- developing and applying fire regimes that are appropriate to the conservation of the biological diversity of different parts of the State.

5. Integration of Nature Conservation Values in the Management of Lands and Waters for which CALM has management responsibility.

The strategy recognises that isolating areas into conservation reserves must inevitably restrict the range of fauna and flora species that can be conserved. Factors such as reserve size, edge effects from neighbouring properties and established human use patterns can all affect the conservation viability of reserves.

Clearly also, financial and human resources available to CALM, as well as limited knowledge of natural processes within reserves restrict CALM's ability to manage reserves and other areas for fauna conservation.

5.1 Management Decisions in CALM Managed Areas

Two guiding principles can be applied:-
-Restrict intervention to situations where there are obvious unwanted changes that need to be rectified or for specific strategic regions.
-the focus for management should be the retention of critical species processes and functions.

5.1.1 Terrestrial Conservation Reserves

Objective
To manage conservation reserves to maintain biological diversity and ecological processes within each reserve, or where that is not possible at a State and regional level.

Key Actions
-To manage conservation reserves to maintain the existing suite of native species; where appropriate to re-establish species which have been lost from the area; and in special cases, provide appropriate habitat for particular species or communities.
-Determine and maintain those ecological processes that are essential for the persistence of natural communities and ecosystems; promote opportunities for enhancing current biological diversity where appropriate; and eliminate or reduce those processes, such as loss of habitat and predation, that result in a reduction of biological diversity.
-Maintain the most favourable possible habitat and ecological conditions for species of indigenous plants and animals in danger of extinction.
-Protect conservation reserves against natural or human-induced changes detrimental to the maintenance of conservation values in the long term....
-Rehabilitate conservation reserves which have suffered detrimental changes in the past.
-Prepare management plans for conservation reserves or groups of reserves with clearly defined objectives for maintenance and where necessary, restoration of identified conservation values, with special emphasis as appropriate on:

- maintenance of species richness and continuance of natural ecological processes;
- protection of rare or threatened species including, where appropriate, reintroduction to areas from which species have been lost;
- protection for unique or unusual habitats or communities;
- maintenance of habitat for migratory species;
- control or prevention of endangering processes such as salination and its causes, introduction and spread of dieback (*Phytophthora* species), habitat alteration, hydrological changes, predation and overgrazing.

5.1.2 Marine Parks and Reserves

Principle
Management should be based upon retaining critical species, processes and functions, but will be affected by the more open and interconnected nature of marine ecosystems.

Although the objectives of marine nature conservation programs are the same as those for land, the marine environment and the laws of the sea are different in significant ways. Conservation strategies differ accordingly.

Objective
To establish and manage a system of marine and estuarine reserves for the conservation of flora and

fauna, ecosystems and habitats, environmental research and reference, and such public recreational and commercial uses as may be consistent with maintenance of the natural environment.

Key Actions

- Select, establish and manage viable representative sections of the Western Australian coastal and estuarine waters as marine protected areas for the purposes of nature conservation and public recreation in which ecologically sustainable commercial uses may occur consistent with conservation objectives.
- Undertake, encourage, support and publish scientific, economic and social research relevant to marine and estuarine management and ensure efficient transmission of research findings into operational practice.

5.1.3 State Forest

Principle

State Forests are managed to ensure the protection in perpetuity of the many uses and values derived from forest ecosystems. For nature conservation this includes setting aside a representative system of conservation reserves and managing other parts of the forest in a manner consistent with the protection of biological diversity and other nature conservation values across the whole forest ecosystem.

An integrated approach at strategic and local levels is required for successful wildlife conservation in forest ecosystems that are subject to disturbance.

At the strategic level two concepts are important:-

. The need for a system of conservation reserves that represent the pattern of biota and allows for future changes in this pattern throughout the forest regions.
. The need for management of the forests to achieve a forest structure which will sustain the full range of habitats. That is, all the recognised developmental stages of a forest must be represented.

Fauna conservation is but one of the multiple uses for which forest areas are to be managed. Identification of habitats and populations of threatened or otherwise significant species, and the subsequent management of these for conservation, is an important aspect of overall forest conservation management.

5.2 Summary

The draft nature conservation strategy is an attempt to bring together, in the one document, all of the responsibilities, principles and actions required of CALM in relation to nature conservation. In doing so it also provides a resource document for CALM managers, in terms of nature conservation requirements and also a data set of significant information on the conservation resources of the State.

FIRE AND IMPACTS ON VERTEBRATE FAUNA

MAMMALS OF WESTERN AUSTRALIA AND THEIR CONSERVATION STATUS

by Andrew Burbidge
Director - WATSCU

THE MAMMALS OF WESTERN AUSTRALIA

There are three major groups of marnmals in Western Australia: monotremes, marsupials and eutherians.

Monotremes: Monotremes are primitive mammals that lay soft-shelled eggs, hatch their young in a temporary abdominal pouch and suckle their young from pores in the skin over the mammary gland. There are three living species, of which one, the Echidna Tachyglossus aculeatus, occurs in Western Australia.

Marsupials: Marsupials bear embryonic young that undertake their initial growth attached to abdominal teats, often, but not always, protected by a pouch. Twelve families of marsupials occur in Western Australia:

Dasyuridae. A large family of carnivorous and insectivorous marsupials that are primarily terrestrial and nocturnal. Includes *Dasyurus geoffroii* (Chuditch), *Antechinus flavipes* (Mardo) and *Sminthopsis* (Dunnarts).

Myrmecobiidae. A monotypic family (only one species) - the Numbat *Myrmecobius fasciatus.* Diurnal and a specialist feeder, eating only termites.

Peramelidae. The bandicoot family. Small to medium-sized nocturnal terrestrial omnivorous marsupials. Includes *Isoodon obesulus* (Quenda) and *Macrotis lagotis* (Dalgyte).

Notoryctidae. The marsupial rnoles. Until recently thought to be a monotypic family; now known to include two species, *Notoryctes typhlops* from southern deserts and *N. caurinus*, from northern deserts. Marsupial Moles occur in sand plains and dunes in the central deserts and live underground most of the time.

Vombatidae. The Wombats. Large grazing nocturnal marsupials that live in burrows. Only one species occurs in WA, *Lasiorhinus latifrons*, the Southern Hairy-nosed Wombat of the Nullarbor Plain.

Phalangeridae. The Brushtail Possum family. Most species occur in tropical

rainforests and only three species are found in WA. One, the Common Brushtail Possum *Trichosurus vulpecula*, occurs in the south west. Predominantly nocturnal and arboreal with prehensile tails and granulated foot pads, they feed mainly on leaves.

Potoroidae. Potoroos and Bettongs. Small hopping nocturnal marsupials that are mainly terrestrial omnivores with some species feeding extensively on underground fungi. Two species of potoroos and two of bettongs once occurred in WA. Both potoroos are extinct and the Boodie now occurs only on islands. The woylie *Bettongia penicillata* is the only species now occurring in the south-west.

Macropodidae. Kangaroos and wallabies. A large family with 54 species in 11 genera in Australasia, ranging in size from small rock-wallabies and hare-wallabies at about 1 kg to the large red and grey kangaroos which weigh as much as 80 kg. Bipedal, herbivorous and mostly nocturnal, they occupy a wide range of habitats.

Burramyidae. Pygmy-possums. Very small nocturnal arboreal marsupials with only a single species, the Western Pygmy-possum *Cercartetus concinnus*, in WA.

Pseudocheiridae. Ringtail Possums. Mainly occur in tropical rainforests; two species occur in WA with only one, the Western Ringtail *Pseudocheirus occidentalis*, in the south-west.

Petauridae. The Gliders and Striped Possums. The Sugar Glider *Petaurus breviceps* is the only WA species. No species in the south-west.

Tarsipedidae. A monotypic farnily, confined to south-west WA and including the Honey-possum *Tarsipes rostratus*. A specialised feeder on nectar and pollen with a long brush-tipped tongue.

Eutherians. Mammals that bear advanced young, which develop in a uterus (womb) and are attached to the mother by a placenta. Six groups occur in Western Australia:

Rodents (Order Rodentia). All Australian rodents occur in one family the Muridae (rats and mice). About 30 species have been recorded from WA, with most occurring in the Kimberley and arid zone. In the south west forests only the Southern Bush Rat *Rattus fuscipes* is common. Three species of introduced rodents occur in the south-west - the Black Rat, Brown Rat and House Mouse.

Bats (Order Chiroptera). Two, possibly only distantly related, groups of bats occur in Australia - the Megachiroptera (flying foxes) and Microchiroptera (insectivorous bats). Only the latter occur in the south-west of WA, and there are nine species in the forests.

Whales and dolphins (Order Cetacea). Thirty five species have been reported from Australian waters.

Dugongs (Order Sirenia, family **Dugongidae**). A single species in WA, the Dugong, which does not occur south of Shark Bay.

The Dingo (Order Carnivora, **Canidae**). The Dingo, Canis familiaris dingo, a subspecies of the domestic dog, is generally considered not to be part of the native fauna, having been introduced to Australia only about 4 000 years ago.

Seals (Order Pinnepedia, family **Otariidae**). Two species occur in the south-west, The Australian Sea-lion *Neophoca cinerea* and the New Zealand Fur-seal *Arctocephalus forsteri*.

THE CONSERVATION STATUS OF WESTERN AUSTRALIAN MAMMALS

Australia has the worst record of any country for mammal extinctions. Twenty species, about one-third of all mammal species that have become extinct world-wide since 1600, occurred only in Australia or its island territories. An additional nine species of marsupials and one rodent species that are extinct on the Australian mainland still occur on continental islands.

An analysis of mammal extinctions and declines by Burbidge and McKenzie (1989)* showed that almost all the extinct and threatened species were "mediurn-sized" mammals. More accurately, they fall within the "Critical Weight Range" (CWR): non-flying mammals with a mean adult body weight between 35 g and 5 500 g.

Because most of these extinctions and declines happened many decades ago, it is difficult to be precise about their causes. However, most scientists support hypotheses that the major causes were the introduction of exotic carnivores, especially the European Red Fox and the Feral Cat, the introduction of exotic herbivores, especially the Rabbit, and changed fire regimes. There is little support for hypotheses that suggest that extinctions and declines on a continental basis have been caused by disease, overkill, clearing for agriculture and urban development or by timber harvesting. However, clearing has been responsible for the local decline and disappearance of rnany mammal species, eg, in the WA wheatbelt.

THREATENED WESTERN AUSTRALIAN MAMMALS

There has been considerable research into the conservation of Australian mammals over the past two decades. The status of Australian marsupials and rnonotremes has been assessed in the recently published Action Plan for Australasian Marsupials and Monotremes and rodents and bats are being currently assessed in draft Action Plans. ANZECC has a Threatened Fauna Network, which reviews Australia-wide lists of threatened vertebrates and CALM has a Threatened Fauna Scientific Committee that recommends species for listing under the WA Wildlife Conservation Act. WA produces three lists: a Declared Threatened Animals list, a Specially Protected Animals List (both published in the Government Gazette) and a Reserve List (see CALM Policy 33).

Tables showing threatened, specially protected and reserve list mammals occurring in CALM regions, and a full list of mammals occuring in Western Australia, are attached.

REFERENCE.

Burbidge, Andrew A. and McKenzie, N.L. (1989). Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. Biological Conservation 50, 143-198.

+ 8 pages of tables

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

DECLARED THREATENED MAMMALS - OCCURRENCE IN CALM REGIONS

	KIMBERLEY	PILBARA	GOLDFIELDS	MIDWEST	WHEATBELT	SOUTH COAST	SWAN	CENTRAL FOREST	SOUTH FOREST
Dasyurus geoffroii, Chuditch or Western Quoll	-	-	?	-	X	X	X	X	X
Dasycercus cristicauda, Mulgara or Minyi-minyi	X	X	X	-	-	-	-	-	-
Parantechinus apicalis, Dibbler	-	-	-	X	-	X	-	-	-
Phascogale calura, Red-tailed Phascogale	-	-	-	-	X	-	-	-	-
Sminthopsis psammophila, Sandhill Dunnart	-	-	X	-	-	-	-	-	-
Myrmecobius fasciatus, Numbat or Walpurti	-	-	-	-	X	-	-	X	X
Isoodon auratus, Golden Bandicoot or Wintarru	X	X	-	-	-	-	-	-	-
Isoodon obesulus, Quenda or Southern Brown Bandicoot	-	-	-	-	X	X	X	X	X
Perameles bougainville, Western Barred Bandicoot	-	-	-	X	-	-	-	-	-
Perameles eremiana, Walilya or Desert Bandicoot					Extinct				
Chaeropus ecaudatus, Kantjilpa or Pig-footed Bandicoot					Extinct				
Macrotis lagotis, Bilby or Dalgyte or Ninu	X	X	X	-	-	-	-	-	-
Macrotis leucura, Tjunpi or Lesser Bilby					Extinct				
Pseudocheirus occidentalis, Western Ringtail Possum	-	-	-	-	?	X	-	X	X
Potorous tridactylus gilberti, Gilbert's Potoroo					Extinct				
Potorous platyops, Broad-faced Potoroo					Extinct				
Bettongia lesueur, Boodie or Burrowing Bettong	-	X	-	X	-	-	-	-	-
Bettongia penicillata, Woylie or Brush-tailed Bettong	-	-	-	-	X	?	-	X	X
Lagorchestes conspicillatus, Wampana or Spectacled Hare-wallaby	X	X	-	-	-	-	-	-	-
Lagorchestes hirsutus, Mala or Rufous Hare-wallaby	-	-	-	X	-	-	-	-	-
Lagorchestes asomatus, Kuluwarri or Central Hare-wallaby					Extinct				
Lagostrophus fasciatus, Muning or Banded Hare-wallaby	-	-	-	X	-	-	-	-	-
Onychogalea lunata, Tjawalpa or Crescent Nailtail Wallaby					Extinct				
Petrogale lateralis, Warru or Black-footed Rock-wallaby	X	X	X	?	X	X	-	-	-
Macropus eugenii, Tammar Wallaby	-	-	-	X	X	?	-	-	X
Macropus robustus isabellinus, Barrow Island Euro	-	X	-	-	-	-	-	-	-
Rhinonycteris aurantius, Orange Horseshoe Bat	X								
Mesembriomys gouldii, Djintamoonga or Black-footed Tree-rat	X	-	-	-	-	-	-	-	-
Pseudomys australis, Palyoora or Plains Rat	-	-	-	-	Extinct in WA				
Pseudomys chapmani, Ngadji or Pilbara Pebble-mound Mouse	-	X	-	-	-	-	-	-	-
Pseudomys fieldi, Atakwere or Shark Bay Mouse	-	X	-	X	-	-	-	-	-
Pseudomys gouldii, Koontin or Gould's Mouse					Extinct				
Pseudomys occidentalis, Walyadji or Western Mouse	-	-	-	-	X	X	-	-	-
Pseudomys shortridgei, Poo-ooti or Heath Rat	-	-	-	-	X	X	-	-	-
Leporillus apicalis, Djooyalpi or Lesser Stick-nest Rat					Extinct				
Leporillus conditor, Wopilkara or Greater Stick-nest Rat	-	-	-	X	-	-	-	-	-
Notomys fuscus, Wilkinti or Dusky Hopping-mouse					Extinct in W.A.				
Notomys macrotis, Noompa or Big-eared Hopping-mouse					Extinct				
Notomys longicaudatus, Koolawa or Long-tailed Hopping-mouse					Extinct				
Balaenoptera musculus, Blue Whale					Oceanic				
Megaptera novaeangliae, Humpback Whale	X	X	-	X	-	X	X	X	X
Eubalaena australis, Southern Right Whale	-	-	-	X	-	X	X	X	X

SPECIALLY PROTECTED MAMMALS - OCCURRENCE IN CALM REGIONS

	KIMBERLEY	PILBARA	GOLDFIELS	MIDWEST	WHEATBELT	SOUTH COAST	SWAN	CENTRAL FOREST	STHN FORESTS
Arctocephalus forsteri, New Zealand Fur-seal	-	-	-	X	-	X	X	X	X
Neophoca cinerea, Australian Sealion	-	-	-	X	-	X	X	X	X
Dugong dugon, Dugong	X	X	-	X	-	-	-	-	-

RESERVE SPECIES LIST OF MAMMALS - OCCURRENCE IN CALM REGIONS

Phascogale tapoatafa, Brush-tailed Phascogale	X	-	-	-	-	?	X	X	X
Sminthopsis butleri, Carpentarian Dunnart	X	-	-	-	-	-	-	-	-
Sminthopsis longicaudata, Long-tailed Dunnart	-	X	X	-	-	-	-	-	-
Pseudocheirus dahli, Rock Ringtail	X	-	-	-	-	-	-	-	-
Wyulda squamicaudata, Scaly-tailed Possum or Ilungalya	X	-	-	-	-	-	-	-	-
Macropus irma, Western Brush Wallaby or Black-gloved Wallaby	-	-	X	X	X	X	X	X	X
Petrogale burbidgei, Monjon	X	-	-	-	-	-	-	-	-
Hydromys chrysogaster, Water Rat	X	X	-	X	X	X	X	X	X
Mesembriomys macrurus, Golden-backed Tree-rat	X	-	-	-	-	-	-	-	-

INDIGENOUS AND WILD EXOTIC MAMMALS OF WESTERN AUSTRALIA

TACHYGLOSSIDAE — 1 species

Tachyglossus aculeatus (Shaw, 1792) **Echidna**

DASYURIDAE — 30 species

Antechinomys laniger (Gould, 1856) **Kultarr**
Antechinus flavipes (Waterhouse, 1838) **Mardo**
t *Dasycercus cristicauda* (Krefft, 1867) **Mulgara**
* *Dasykaluta rosamondae* (Ride, 1964) **Little Red Antechinus**
# t *Dasyurus geoffroii* Gould, 1841 **Chuditch**
Dasyurus hallucatus Gould, 1842 **Northern Quoll**
Ningaui ridei Archer, 1975 **Wongai Ningaui**
* *Ningaui timealeyi* Archer, 1975 **Pilbara Ningaui**
Ningaui yvonneae Kitchener, Stoddart and Henry, 1983 **Kitchener's Ningaui**
* t *Parantechinus apicalis* (Gray, 1842) **Dibbler**
Pseudantechinus macdonnellensis (Spencer, 1895) **Fat-tailed Antechinus**
* *Pseudantechinus ningbing* Kitchener, 1988 **Ningbing Antechinus**
* *Pseudantechinus woolleyae* Kitchener and Caputi, 1988 **Woolley's Antechinus**
# t *Phascogale calura* Gould, 1844 **Red-tailed Phascogale**
r *Phascogale tapoatafa* (Meyer, 1793) **Brush-tailed Phascogale**
Planigale ingrami (Thomas, 1906) **Long-tailed Planigale**
Planigale maculata (Gould, 1851) **Common Planigale**
r *Sminthopsis butleri* Archer, 1979 **Carpentarian Dunnart**
Sminthopsis crassicaudata (Gould, 1844) **Fat-tailed Dunnart**
Sminthopsis dolichura Kitchener, Stoddart and Henry, 1984
* *Sminthopsis fuliginosa* (Gould, 1852)
Sminthopsis gilberti Kitchener, Stoddart and Henry, 1984 **Gilbert's Dunnart**
* *Sminthopsis granulipes* Troughton, 1932 **White-tailed Dunnart**
Sminthopsis griseoventer Kitchener, Stoddart and Henry, 1984 **Grey-bellied Dunnart**
Sminthopsis hirtipes Thomas, 1898 **Hairy-footed Dunnart**
r *Sminthopsis longicaudata* Spencer, 1909 **Long-tailed Dunnart**
Sminthopsis macroura (Gould, 1845) **Stripe-faced Dunnart**
Sminthopsis ooldea Troughton, 1965 **Ooldea Dunnart**
t *Sminthopsis psammophila* Spencer, 1896 **Sandhill Dunnart**
Sminthopsis youngsoni McKenzie and Archer, 1982 **Lesser Hairy-footed Dunnart**

MYRMECOBIIDAE — 1 species

t *Myrmecobius fasciatus* Waterhouse, 1836 **Numbat, Walpurti**

PERAMELIDAE — 6 species

e *Chaeropus ecaudatus* (Ogilby, 1838) **Kantjilpa, Pig-footed Bandicoot**
t *Isoodon auratus* (Ramsay, 1887) **Wintaru, Golden Bandicoot**
Isoodon macrourus (Gould, 1842) **Garimbu, Northern Brown Bandicoot**
t *Isoodon obesulus* (Shaw, 1797) **Quenda, Southern Brown Bandicoot**
t *Perameles bougainville* Quoy and Gaimard, 1824 **Western Barred Bandicoot**
e *Perameles eremiana* Spencer, 1897 **Walilya, Desert Bandicoot**

THYLACOMYIDAE — 2 species

t *Macrotis lagotis* (Reid, 1837) **Dalgyte, Greater Bilby**
e *Macrotis leucura* (Thomas, 1887) **Tjunpi, Lesser Bilby**

NOTORYCTIDAE — 2 species

* *Notoryctes caurinus* Thomas, 1920 **Kakarratul, Northern Marsupial Mole**
Notoryctes typhlops (Stirling, 1889) **Itarrutju, Southern Marsupial Mole**

VOMBATIDAE — 1 species

Lasiorhinus latifrons (Owen, 1845) **Southern Hairy-nosed Wombat**

POTOROIDAE 4 species

\# t *Bettongia lesueur* (Quoy and Gaimard, 1824) **Boodie, Burrowing Bettong**
t *Bettongia penicillata* Gray, 1937 **Woylie, Brush-tailed Bettong**
* e *Potorous platyops* (Gould, 1844) **Broad-faced Potoroo**
* e *Potorous tridactylus gilbertii* Gould, 1841 **Gilbert's Potoroo**

MACROPODIDAE 19 species

t *Lagorchestes conspicillatus* Gould, 1842 **Spectacled Hare-wallaby**
t *Lagorchestes hirsutus* Gould, 1844 **Mala, Rufous Hare-wallaby**
e *Lagorchestes asomatus* Finlayson, 1943 **Kuluwarri, Central Hare-wallaby**
* t *Lagostrophus fasciatus* (Peron and Lesueur, 1807) **Banded Hare-wallaby**
Macropus agilis (Gould, 1842) **Agile Wallaby**
Macropus antelopinus (Gould, 1842) **Antelopine Wallaroo**
t *Macropus eugenii* (Desmarest, 1817) **Tammar Wallaby**
Macropus fuliginosus (Desmarest, 1817) **Western Grey Kangaroo**
* *Macropus irma* (Jourdan, 1937) **Western Brush Wallaby**
Macropus robustus erubescens (Sclater, 1870) **Euro**
* t *Macropus robustus isabellinus* Gould, 1842 **Barrow Island Euro**
Macropus rufus (Desmarest, 1822) **Marlu, Red Kangaroo**
e *Onychogalea lunata* (Gould, 1841) **Tjawalpa, Crescent Nailtail Wallaby**
Onychogalea unguifera (Gould, 1841) **Wutu-wutu, Northern Nailtail Wallaby**

Petrogale brachyotis (Gould, 1841) **Bagi, Short-eared Rock-wallaby**
* r *Petrogale burbidgei* Kitchener and Sanson, 1978 **Monjon**
Petrogale concinna Gould, 1842 **Narbarlek**
t *Petrogale lateralis* Gould, 1842 **Warru, Black-footed Rock-wallaby**
* *Petrogale rothschildi* Thomas, 1904 **Rothschild's Rock-wallaby**
r *Setonix brachyurus* (Quoy and Gaimard, 1830) **Quokka**

PHALANGERIDAE 3 species

Trichosurus arnhemensis Collett, 1897 **Jugurruba, Northern Brushtail Possum**
Trichosurus vulpecula (Kerr, 1792) **Wayurta, Common Brushtail Possum**
* r *Wyulda squamicaudata* Alexander, 1919 **Ilangnalya, Scaly-tailed Possum**

PETAURIDAE 3 species

Petaurus breviceps Waterhouse, 1839 **Gumunda, Sugar Glider**
r *Petropseudes dahli* (Collett, 1895) **Wogoit, Rock Ringtail Possum**
* t *Pseudocheirus occidentalis* Thomas, 1888 **Western Ringtail Possum**

BURRAMYIDAE 1 species

Cercartetus concinnus Gould, 1845 **Western Pygmy-possum**

TARSIPEDIDAE 1 species

* *Tarsipes rostratus* Gervais and Verreaux, 1842 **Honey-possum**

PTEROPODIDAE 3 species

Macroglossus minimus (Geoffroy, 1810) **Northern Blossom-bat**
Pteropus alecto Temminck, 1837 **Black Flying-fox**
Pteropus scapulatus Peters, 1862 **Little Red Flying-fox**

EMBALLONURIDAE 3 species

Saccolaimus flaviventris (Peters, 1867) **Yellow-bellied Sheathtail-bat**
Taphozous georgianus Thomas, 1915 **Common Sheathtail-bat**
Taphozous hilli Kitchener, 1980 **Hill's Sheathtail-bat**

MEGADERMATIDAE 1 species

Macroderma gigas (Dobson, 1880) **Ghost Bat**

HIPPOSIDERIDAE 3 species

Hipposideros gilberti Johnson 1959
Hipposideros stenotis Thomas, 1913 **Lesser Wart-nosed Horseshoe-bat**
Rhinonicteris aurantius Gray, 1845 **Orange Horseshoe-bat**

VESPERTILIONIDAE 24 species

Chalinolobus gouldii (Gray, 1841) **Gould's Wattled Bat**
* *Chalinolobus* affin. *gouldii* (Broome mangroves)
Chalinolobus morio (Gray, 1841) **Chocolate Wattled Bat**
Chalinolobus nigrogriseus (Gould, 1856) **Hoary Wattled Bat**
Eptesicus baverstocki Kitchener, Jones and Caputi, 1987 **Inland Forest Bat**
* *Eptesicus douglasorum* Kitchener, 1976 **Yellow-lipped Eptesicus**
Eptesicus caurinus Thomas, 1914 **Western Cave Bat**
Eptesicus finlaysoni Kitchener, Jones and Caputi, 1987 **Finlayson's Eptesicus**
Eptesicus regulus (Thomas, 1906) **King River Eptesicus**
* *Falsistrellus mackenziei* Kitchener, Caputi and Jones, 1986 **McKenzie's Bat**
Miniopterus schreibersii (Kuhl, 1817) **Common Bent-wing Bat**
Myotis adversus (Horsfield, 1824) **Large-footed Mouse-eared Bat**
* *Myotis* sp. (*selysius* group, Pilbara) **Pilbara Mouse-eared Bat**
Nyctophilus arnhemensis Johnson, 1959 **Arnhem Land Long-eared Bat**
Nyctophilus geoffroyi Leach, 1821 **Lesser Long-eared Bat**
Nyctophilus gouldi Tomes, 1858 **Gould's Long-eared Bat**
Nyctophilus major Gray, 1844 **Western Long-eared Bat**
Nyctophilus walkeri Thomas, 1892 **Pygmy Long-eared Bat**
Pipistrellus westralis Koopman, 1984 **Mangrove Pipistrelle**
Scotorepens balstoni (Thomas, 1906) **Western Broad-nosed Bat**
Scotorepens greyii (Gray, 1843) **Little Broad-nosed Bat**
Scotorepens sanborni (Troughton, 1937) **Northern Broad-nosed Bat**

MOLLOSSIDAE 6 species

Chaerephon jobensis (Miller, 1902) **Northern Mastiff-bat**
Mormopterus beccarii Peters, 1881 **Beccari's Mastiff-bat**
Mormopterus loriae Thomas, 1897 **Little Northern Mastiff-bat**
Mormopterus planiceps (Peters, 1866) **Southern Mastiff-bat**
* *Mormopterus* sp. affin. *planiceps* **South-western Mastiff-bat**
Nyctinomus (Tadarida) australis (Gray, 1838) **White-striped Mastiff-bat**

LEPORIDAE 1 species (1 exotic)

i *Oryctolagus cuniculus* (Linnaeus, 1758) **Rabbit**

MURIDAE — 37 species (4 exotic)

Conilurus penicillatus (Lichtenstein, 1829) **Brush-tailed Rabbit-rat**
r *Hydromys chrysogaster* Geoffroy, 1804 **Water-rat**
Leggadina lakedownensis Watts, 1976 **Lakeland Downs Mouse**
* *Leggadina* aff. *lakedownensis* **Thevenard Island Mouse**
e *Leporillus apicalis* (Gould, 1853) **Lesser Stick-nest Rat**
t *Leporillus conditor* (Sturt, 1848) **Greater Stick-nest Rat**

Melomys burtoni (Ramsay,1887) **Grassland Melomys**
t *Mesembriomys gouldii* (Gray, 1843) **Black-footed Tree-rat**
r *Mesembriomys macrurus* (Peters, 1876) **Golden-backed Tree-rat**
i *Mus musculus* Linnaeus, 1758 **House Mouse**
Notomys alexis Thomas, 1922 **Spinifex Hopping-mouse**
t *Notomys fuscus* (Jones, 1925) **Dusky Hopping Mouse**
e *Notomys longicaudatus* (Gould, 1844) **Long-tailed Hopping-mouse**
e *Notomys macrotis* Thomas, 1921 **Large-eared Hopping-mouse**
Notomys mitchellii (Ogilbyi, 1838) **Mitchell's Hopping-mouse**
* *Pseudomys albocinereus* (Gould, 1845) **Ash-grey Mouse**
t *Pseudomys australis* Gray, 1832 **Plains Rat**
Pseudomys bolami Troughton, 1932 **Troughton's Mouse**
* t *Pseudomys chapmani* Kitchener, 1980 **Western Pebble-mound Mouse**
Pseudomys delicatulus (Gould, 1842) **Delicate Mouse**
Pseudomys desertor Troughton, 1932 **Desert Mouse**
\# t *Pseudomys fieldi* (Waite, 1896) **Shark Bay Mouse**
e *Pseudomys gouldii* (Waterhouse, 1839) **Gould's Mouse**
Pseudomys hermannsburgensis (Waite, 1896) **Sandy Inland Mouse**
Pseudomys laborifex Kitchener and Humphreys, 1986
Pseudomys nanus (Gould, 1858) **Western Chestnut Mouse**
* t *Pseudomys occidentalis* Tate, 1951 **Western Mouse**
t *Pseudomys shortridgei* (Thomas, 1907) **Heath Rat**
i *Rattus exulans* (Peale, 1848) **Polynesian Rat**
Rattus fuscipes (Waterhouse, 1839) **Southern Bush Rat**
i *Rattus norvegicus* (Berkenhout, 1769) **Brown Rat**
i *Rattus rattus* (Linnaeus, 1758) **Black Rat, Ship Rat**
Rattus tunneyi (Thomas, 1904) **Pale Field-rat**
Rattus villosissimus (Waite, 1898) **Long-haired Rat**
Zyzomys argurus (Thomas, 1889) **Common Rock-rat**
* *Zyzomys woodwardi* (Thomas, 1909) **Kimberley Rock-rat**

ZIPHIIDAE — 8 species

Berardius arnuxii Duvernoy, 1851 **Arnoux's Beaked Whale** ?
Hyperoodon planifrons Flower, 1882 **Southern Bottle-nosed Whale**
Mesoplodon bowdoini Andrews, 1908 **Andrew's Beaked Whale** ?
Mesoplodon densirostris (Blainville, 1817) **Blainville's Beaked Whale** ?
Mesoplodon grayi Von Haast, 1876 **Gray's Beaked Whale** ?
Mesoplodon layardii (Gray, 1865) **Strap-toothed Beaked Whale** ✓
Mesoplodon mirus True, 1913 **True's Beaked Whale** ?
Ziphius cavirostris Cuvier, 1823 **Cuvier's Beaked Whale** ✓

PHYSETERIDAE — 3 species

Kogia breviceps (Blainville, 1838) **Pygmy Sperm Whale** ✓
Kogia simus (Owen, 1866) **Dwarf Sperm Whale**
Physeter catodon Linnaeus, 1758 **Sperm Whale** ✓

DELPHINIDAE — 16 species

Delphinus delphis Linnaeus, 1758 **Common Dolphin**
Feresa attenuata Gray, 1875 **Pygmy Killer Whale**
Globicephala macrorhynchus Gray, 1846 **Short-finned Pilot Whale**
Globicephala melas (Traill, 1809) **Long-finned Pilot Whale**
Grampus griseus (G. Cuvier, 1812) **Risso's Dolphin**
Lissodelphis peronii (Lacepede, 1804) **Southern Right Whale Dolphin**
Orcaella brevirostris (Gray, 1866) **Irrawaddy Dolphin**
Orcinus orca (Linnaeus, 1758) **Killer Whale**
Peponocephala electra (Gray, 1846) **Melon-headed Whale**
Pseudorca crassidens (Owen, 1846) **False Killer Whale**
Sousa chinensis (Osbeck, 1765) **Indo-Pacific Humpbacked Dolphin**
Stenella attenuata (Gray, 1846) **Spotted Dolphin**
Stenella caeruleoalba (Meyen, 1833) **Striped Dolphin**
Stenella longirostris (Gray, 1828) **Long-snouted Spinner Dolphin**
Steno bredanensis (Lesson, 1828) **Rough-toothed Dolphin**
Tursiops truncatus (Montagu, 1821) **Bottlenose Dolphin**

BALAENOPTERIDAE — 6 species

Balaenoptera acutorostrata Lacepede, 1804 **Minke Whale**
Balaenoptera borealis Lesson, 1828 **Sei Whale**
Balaenoptera edeni Anderson, 1878 **Bryde's Whale**
t *Balaenoptera musculus* (Linnaeus, 1758) **Blue Whale**
Balaenoptera physalus (Linnaeus, 1758) **Fin Whale**
t *Megaptera novaeangliae* (Borowski, 1781) **Humpback Whale**

BALAENIDAE — 2 species

Caperea marginata (Gray, 1846) **Pygmy Right Whale**
t *Eubalaena australis* (Desmoulins, 1822) **Southern Right Whale**

SCIURIDAE — 1 species (1 exotic)

i *Funambulus pennantii* **Five-striped Palm Squirrel**

CANIDAE — 2 species (2 exotic)

i *Canis familiaris* Linnaeus, 1758 **Dingo**
i *Vulpes vulpes* Linnaeus, 1758 **Red Fox**

FELIDAE — 1 species (1 exotic)

i *Felis catus* Linnaeus, 1758 **Cat**

MUSTELIDAE — 1 species (1 exotic)

i *Mustela putorius* **Polecat, Ferret**

OTARIIDAE — 2 species

s *Arctocephalus forsteri* (Lesson, 1828) **New Zealand Fur-seal**
s *Neophoca cinerea* (Peron, 1816) **Australian Sea-lion**

Leopard Seal.

DUGONGIDAE — 1 species

s *Dugong dugon* (Muller, 1776) **Dugong**

EQUIDAE — 2species (2 exotic)

i *Equus caballus* Linnaeus, 1758 **Horse**
i *Equus asinus* Linnaeus, 1758 **Donkey**

SUIDAE — 1 species (1 exotic)

i *Sus scrofa* Linnaeus, 1758 **Pig**

CAMELIDAE — 1 species (1 exotic)

i *Camelus dromedarius* Linnaeus, 1758 **Dromedary, Camel**

BOVIDAE — 4 species (4 exotic)

i *Antilope cervicapra* (Linnaeus, 1758) **Black Buck**
i *Bos taurus* Linnaeus, 1758 **European Cattle**
i *Bubalis bubalis* (Linnaeus, 1758) **Water Buffalo**
i *Capra hircus* Linnaeus, 1758 **Goat**

KEY TO NOTATIONS

First column	*	endemic
	#	formerly in other States, now restricted to WA
	i	introduced
Second column	e	extinct
	t	declared threatened (Section 14(2)(ba) Wildlife Conservation Act)
	r	reserve list
	s	declared specially protected (Section 14(2)(ba) Wildlife Conservation Act)

TOTALS

Monotremes	1 species
Marsupials	73 species
Bats	40 species
Rodents	37 species, 4 exotic = 33 indigenous
Seals	2 species
Dugongs	1 species
Cetaceans	35 species
Other exotics	14 species

203 species, 18 exotic = 185 indigenous
147 indigenous terrestrial
29 endemic to Western Australia
7 formerly in other States, now restricted to WA
11 extinct

WESTERN GREY KANGAROO AND WESTERN BRUSH WALLABY

by Andrew Burbidge
Director - WATSCU

WESTERN GREY KANGAROO

The Western Grey Kangaroo (*Macropus fuliginosus*) occurs in southern Western Australia, southern South Australia, western Victoria, western New South Wales and a small part of southern Queensland. A similar species, the Eastern Grey Kangaroo (*Macropus giganteus*) occurs in Victoria, New South Wales, Queensland and Tasmania. The two species occur together in parts of south-eastern Australia.

The Western Grey has been studied extensively and its biology is known in detail. It was hunted by Aborigines for thousands of years and has been exploited by European settlers since the earliest days of the Swan River colony. It was a very common animal at settlement, especially in what is now the wheatbelt, but also in arid parts of its range, such as parts of the Nullarbor Plain.

Today its range has been much reduced by clearing, but it is still widespread and is managed to reduce the effects of excessive numbers on agriculture. Western Greys are especially common where bush and farms meet.

Western Greys are predominantly grazers and favour grasses in their diet. They can breed at any time of the year, but in the south west breed mainly in the summer. The oestrus cycle is 35 days and gestation is 30.5 days. Pouch life is about 42 weeks.

Western Greys are abundant and are not threatened with extinction.

WESTERN BRUSH WALLABY

The Western Brush Wallaby (Macropus irma) is restricted to the south west of Western Australia from near Shark Bay to near Esperance. A close relative, the Toolache Wallaby (pronounced too-laitch-ee) (Macropus greyi) once occurred in the south-east of South Australia and the far south-west of Victoria, but became extinct in the 1920s.

Brush Wallabies are grazers, rather than browsers, and tend to favour open forests and woodlands, but also occur in scrub, mallee and heath. They are largely absent from the karri forest, presumably not being adapted to the dense undergrowth.

They tend to be diurnal in the cooler months when activity is greatest in the early morning

and late afternoon, with animals resting in the hotter part of the day. Feeding also takes place at night, especially in the hotter months.

There have been no detailed biological studies of the Western Brush Wallaby, but its biology is thought to be similar in many aspects to the Western Grey Kangaroo. Males and fernales are of similar size, with a mean adult body weight of about 8 kg.

Brush were very common in the early days of settlement and at times very large numbers were traded commercially, e.g. 1923: 122 000, 1924: 105 000. They were fully protected in 1951.

Clearing for agriculture has severely reduced their range, but they remained common in the larger uncleared areas until recently.

Brush have clearly become less abundant over the past two decades. Data from predation ecology studies at Boyagin Nature Reserve suggest that foxes may be a significant predator, since Brush numbers increased in an area where foxes have been controlled (J.E. Kinnear, personal communication). However, there are insufficient data on predation at present to be sure that foxes are the reason for the species' decline. It is doubtful that a fox could take an adult Brush, but joeys not long out of the pouch could fall victim to this predator.

In 1991, the Threatened Fauna Scientific Advisory Committee, in recognition of the reducing numbers, recommended that the Brush be added to the Reserve List.

REFERENCE

Prince, R.I.T. (1984). Exploitation of kangaroos and wallabies in Western Australia. l. A review to 1970, with special emphasis on Red and Western Grey Kangaroos. Wildlife Research Bulletin Western Australia, No. 13. Dept. Fisheries and Wildlife, Perth.

THE ROLE OF RECOVERY PLANS IN MAMMAL CONSERVATION

by Andrew Burbidge
Director - WATSCU

INTRODUCTION

Planning for the conservation of Threatened Species in Australia is happening at four levels:
(1) Legislation,
(2) National and State Strategies,
(3) Action Plans, and
(4) Recovery Plans.

Legislation.

The WA Government, in its election platform, committed itself to introduce amendments to the Wildlife Conservation Act, which, among other things, will increase the protection for threatened fauna. A revised Act was released for public comment by the Lawrence government in 1992; comments are currently being reviewed by CALM.

Strategies.

The Inter-Governmental Agreement on the Environment provided that a National Strategy for the Conservation of Threatened Species and Ecological Communities be prepared by April 1993. The draft was prepared by an ANZECC Task Force and is currently being considered by Australian Governments. CALM has published its draft Nature Conservation Strategy, which includes sections on threatened species and communities. The Strategy has been revised and is ready to be reviewed by Government.

Action Plans.

Action Plans review the status of all species (and sometimes subspecies) in a particular phylogenetic group, recommend which ones need special conservation action and outline what work needs doing. Action Plans were originally produced only through the Species Survival Commission (SSC) of The World Conservation Union (IUCN); however, ANCA has provided money for the production of Action Plans for all Australian animal groups. The Australasian Marsupials and Monotremes Action Plan was commenced through the IUCN process and was prepared by the Australasian Marsupials and Monotremes Specialist Group of SSC. The Marsupials and Monotremes Action Plan is about to be revised. Action Plans are currently being written, with ESAC money, for rodents and bats; both should be published soon.

Recovery Plans.

These are very detailed, costed plans describing how a particular species (or group of species) will be managed to ensure that it 'recovers' from its current critical situation. CALM is a leader in this area in Australia - we currently have funded Recovery Plans for Chuditch, Woylie, Numbat, Shark Bay Mouse, Noisy Scrub-bird, Western Swamp Tortoise, Orange-bellied and White-bellied Frogs, Wongan Trigger Plant, Rose Mallee and Matchstick Banksia. We also have Interim Wildlife Management Guidelines for

two threatened wheatbelt plants and the Lancelin Island Skink. Regional and District Threatened Flora Management Programs are in place or in preparation for all the South West Land Division.

CALM Policy 44 covers the preparation and implementation of Wildlife Management Programs (Recovery Plans are one type of Wildlife Management Program).

THE RECOVERY PROCESS

The conservation of threatened species must be approached in a logical way to ensure that resources are allocated to the most threatened species and that money and staff time are put to the best use.

A sequential program is:

1. review the conservation status of taxa,
2. prepare priority lists of threatened taxa,
3. conduct the necessary research,
4. produce costed Recovery Plans,

and for each Recovery Plan

5. obtain funding,
6. implement,
7. monitor and review.

How far are we in CALM along this route?

Conservation status.

We are well advanced, with good processes in place to review the lists of threatened vascular plants and vertebrates. At present we have insufficient capability to deal adequately with listings of invertebrates or non-vascular plants.

Priority listing.

CALM has developed a Policy Statement (No. 50) on developing priorities for the conservation of threatened.

Research and Management status.

What is our knowledge of each taxon and how well is management in place? Table 1 provides a brief summary of the situation for the 30 most threatened vertebrates in the State, as worked out by a scoring system for the draft Nature Conservation Strategy.

Recovery Plans have the following advantages:

1. They clearly state the conservation problems of the species covered,
2. They provide a written prescription and works program,
3. They provide total costs over a 10 year period, and
4. They set up Recovery Teams, ensuring that all key players work together to a common aim.

+ 3 pages of tables

CALM, WATSCU

Draft Conservation Action Priorities, WA's 35 most endangered vertebrate animals (as listed in Nature Conservation Strategy)

CRITICAL

Species	Common name	CALM Region & District	Conservation action status
Ctenotus lancelini	Lancelin Island Skink	Mid-West, Moora	IWMG being implemented, research underway
Geopsittacus occidentalis	Night Parrot	not currently known from WA	No IWMG, search planned
Pseudemydura umbrina	Western Swamp Tortoise	Swan, Perth	Recovery Plan being implemented

ENDANGERED

Amytornis textilis textilis	Thick-billed Grass-wren	Mid-West, Shark Bay	No research, no IWMG
Atrichornis clamosus	Noisy Scrub-bird	South Coast, Albany	Recovery Plan being implemented
Bettongia lesueur	Boodie	Mid-West, Shark Bay Pilbara, Karratha	Some research, no IWMG
Cacatua pastinator pastinator	Long-billed Corella (southern population)	Southern Forest, Manjimup Wheatbelt, Katanning	No research, no IWMG
Caretta caretta	Loggerhead Turtle	Mid-West, Shark Bay Pilbara, Exmouth Pilbara, Karratha Kimberley, Broome Kimberley, Kununurra	Research underway, no IWMG
Dasycercus cristicauda	Mulgara	Goldfields Pilbara, Karratha	National Recovery Team preparing a National Recovery Plan
Dasyornis longirostris	Western Bristlebird	South Coast, Albany South Coast, Esperance	Research Plan being implemented, Recovery Plan to be written at completion of research work
Dasyurus geoffroii	Chuditch	Swan, all Districts Central Forest, all Districts Southern Forest, all Districts South Coast, Albany South Coast, Esperance	Recovery Plan being implemented
Erythrura gouldiae	Gouldian Finch	Kimberley, Kununurra	Recovery Plan being prepared
Falcunculus frontatus whitei	Northern Shrike-tit	Kimberley, Kununurra Kimberley, Broome	No IWMG
Geocrinia alba	White-bellied Frog	Central Forest, Busselton	Recovery Plan being implemented
Geocrinia vitellina	Yellow-bellied Frog	Central Forest, Busselton	Recovery Plan being implemented
Isoodon auratus ot *I. a. barrowensis*)	Golden Bandicoot	Kimberley, Kununurra	No IWMG
Lagorchestes hirsutus	Mala, Rufous Hare-wallaby	Mid-West, Shark Bay	National Recovery Plan in preparation
Lagostrophus fasciatus	Banded Hare-wallaby	Mid-West, Shark Bay	No IWMG
Leipoa ocellata	Malleefowl	Southern Forest, Manjimup South Coast, Albany South Coast, Esperance Wheatbelt, all Districts Mid-West, Geraldton	No IWMG
Leporillus conditor	Greater Stick-nest Rat	Mid-West, Shark Bay	National Recovery Plan being implemented
Macrotis lagotis	Dalgyte, Bilby	Goldfields Pilbara, Karratha Kimberley, Broome Kimberley, Kununurra	National Recovery Plan in preparation
Myrmecobius fasciatus	Numbat	Central Forest, Collie Southern Forest, Manjimup Wheatbelt, Narrogin Wheatbelt, Merredin	Recovery Plan prepared, requires approval

Notomys fuscus	Dusky Hopping-mouse	Not currently known from WA	No IWMG
Parantechinus apicalis	Dibbler	Mid-West, Moora South Coast, Albany	No IWMG
Perameles bougainville	Western Barred Bandicoot	Mid-West, Shark Bay	Some research, no IWMG
Petrophassa smithii	Partridge Pigeon	Kimberley, Kununurra	No research, no IWMG
Pezoporus wallicus flaviventris	Western Ground Parrot	South Coast, Albany South Coast, Esperance	Research Plan written, no resources to implement, no IWMG
Phascogale calura	Red-tailed Phascogale	Wheatbelt, Narrogin South Coast, Albany	Research underway, no IWMG
Pseudocheirus occidentalis	Western Ringtail Possum	Central Forest, South Coast, Albany	Research Plan written, no resources to implement, no IWMG
Pseudomys australis	Plains Rat	Not currently known from WA	No IWMG
Pseudomys fieldi	Shark Bay Mouse	Mid-West, Shark Bay Pilbara, Exmouth	Recovery Plan being implemented
Pseudomys shortridgei	Heath Rat	Wheatbelt, Katanning South Coast, Albany	No research, no IWMG
Psophodes nigrogularis	Western Whipbird	South Coast, Albany Wheatbelt, Katanning	Research Plan written, no resources to implement, no IWMG
Sminthopsis psammophila	Sandhill Dunnart	Goldfields	No research, no IWMG

Note: *Potorous tridactylus* (Gilbert's Potoroos) and *Dryolimnas pectoralis clelandi* (Lewin's Rail) not included in above table, since assumed to be extinct. However, both survive in eastern Australia and both should be searched for in WA.

DRAFT, UNOFFICIAL, LIST OF 35 MOST THREATENED ANIMALS, DERIVED FROM METHOD IN CALM POLICY 50.

Amytornis textilis textilis	Thick-billed Grass-Wren
Atrichornis clamosus	Noisy Scrub-bird
Bettongia lesueur	Boodie
Cacatua pastinator pastinator	Long-billed Corella (southern population)
Caretta caretta	Loggerhead Turtle
Ctenotus lancelini	Lancelin Island Skink
Dasycercus cristicauda	Mulgara
Dasyornis longirostris	Western Bristlebird
Dasyurus geoffroii	Chuditch
Erythrura gouldiae	Gouldian Finch
Falcunculus frontatus whitei	Northern Shrike-tit
Geocrinia alba	White-bellied Frog
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Geopsittacus occidentalis	Night Parrot
Isoodon auratus	Golden Bandicoot
Lagorchestes hirsutus	Mala, Rufous Hare-wallaby
Lagostrophus fasciatus	Banded Hare-wallaby
Leipoa ocellata	Malleefowl
Leporillus conditor	Greater Stick-nest Rat
Macrotis lagotis	Dalgyte, Bilby
Myrmecobius fasciatus	Numbat
Notomys fuscus	Dusky Hopping-mouse
Parantechinus apicalis	Dibbler
Perameles bougainville	Western Barred Bandicoot
Petrophassa smithii smithii	Partridge Pigeon
Pezoporus wallicus flaviventris	Western Ground Parrot
Phascogale calura	Red-tailed Phascogale
Pseudemydura umbrina	Western Swamp Tortoise
Pseudocheirus occidentalis	Western Ringtail Possum
Pseudomys australis	Plains Rat
Pseudomys fieldi	Shark Bay Mouse
Pseudomys shortridgei	Heath Rat
Psophodes nigrogularis	Western Whipbird
Sminthopsis psammophila	Sandhill Dunnart

FOX BIOLIGY, BEHAVIOUR AND BIOLOGICAL CONTROL

Nikki Marlow
CALM Woodvale

The fox was introduced into Victoria in the mid-1800's and since then has spread over much of continental Australia. It is now present in most areas except the tropical North and Tasmania (Fig.1).

Surprisingly little is known about fox biology in Australia and especially in forest areas. The reasons for this are that the predatory impact of foxes on native fauna has only recently been recognised and foxes are also extremely difficult to work with

SOME BASIC FACTS ABOUT FOXES:

Adult foxes weigh between 4-8kg and males are slightly larger than females. They breed once a year and their litter size depends upon the productivity of the area and the level of control operating but usually 3-7 cubs are produced. The timing of breeding varies with altitude and latitude, with foxes in lower altitudes and at lower latitudes breeding earlier in the season. The mating season is usually from May to September. They have a gestation period of approximately 50-60 days and juveniles disperse berween January to May.

The diet of the fox varies considerably and it is largely influenced by what is available. Foxes eat a large amount of carrion, rabbits and other small mammals, invertebrates, and a considerable amount of plant material. Foxes have been implicated in the demise of many species of small and medium sized mammals including the black-footed rock wallaby, the tammar wallaby, the woylie and thenumbat. In some areas foxes have a large impact on both reptiles and birds with goanna eggs, mallee fowl and fairy penguins suffering predation.

FOXES IN FORESTED AREAS

The scientific information available about foxes in forests is scant and deals mainlywith their diet. Brunner et al. (1975), Christensen (1980), Seebeck (1978), Triggs et al, (1984) and Lunney et al (1990) all found that foxes were eating native species at least to some extent. Philips and Catling (1991) tracked 3 foxes in Nadgee Nature Reserve and found that they had home ranges of 4.75, 5.0 and 1.3.sq km respectively. The diet of the foxes in this area also consisted mainly of small and medium-sized mammals.

FOX DENSITY

One of the most often asked but most difficult to answer questions about foxes is 'How many are there?. We have some estimates ranging from 0.2-3.9 km^2 but as yet no accurate density estimates for foxes in forested areas are available. There is a project planned that will be addressing this question later this year.

HOME RANGES

Another frequently asked question is 'How big is a fox's home range?' This is another difficult

question to answer and it depends on the method used to determine the home range and also on how long the animal is monitored for. A general guideline is from 50-1000ha, depending upon the productivity and food availability within the habitat. Males foxed generally have larger home-ranges than vixens but there is a considerable degree of variarion in size.

BIOLIGICAL CONTROL FOR FOXES

Biological control for both foxes and rabbits is being developed by the Co-operative Research Centre for the Biological Control of Vertebrate Pests. This is a co-operative venture between CALM, the APB, CSIRO in Canberra and ANU. The concept behind biological control for foxes is that if sufficient foxes are sterilised the fox population will ultimately decline to a new very low level. It is hoped that this new level will be low enough to enable prey species to survive and increase in numbers. The sterility is proposed to be imposed by a cintagious, genetically engineered virus. This virus will be fox specific and it will be genetically engineered so that it incorporated the DNA or genetic code for the fox's own reproductive proteins. When the fox raises an antibody response to the virus it also raises an immune response to its own reproductive proteins and thus sterilises itself (Fig 2).

Before this biological control method can be used there are several things we need to know about foxes. Firstly we need to know what percentage of the vixens need to be sterilised to bring about a population reduction. We also need to know if this is a significant enough reduction to enable vulnerable prey species to overcome the predation from the remaining foxes and so they can increase in density. A large-scale experiment is currently being undertaken to address these questions but it will be at least 2 years before any results are obtained.

SOCIAL ORGANISATION

We have very little information about the social organisation of foxes and this is being examined in particular because it will influence the effectibeness of biological control. There are two types of social organisation and these are the mated pair and the dominance hierarchy. The social system that occurs within an area is influenced by the productivity of the area and dominance hierarchies only seem to occur where fox densities are very high. They are characterised by one male fox living with several related vixens but only one of these vixens successfully rears cubs.

The mated pair system is characterised by one male fox residing with one female fox. Together they raise a litter of cubs. So far, the only comprehensive work that has been done on fox social structure has indicated that a mated pair system predominated in that area. The study site for that reearch was Carnarvon and it involved killing as many foxes as possible within a 200 squ km area. Cyanide baits were used, plus trapping and shooting. By examining the ratios of cubs to vixens and vixens to males its was possible to get some insight into the fox's social system. A ratio of 1 vixen to 1 male to 2.7 cubs (allowing for approximately 25% cub mortality) would indicate a mated pair system. In contrast, 1 male to 3 or 4 vixens to 2.7 cubs would indicate a dominance hierarchy. The ratio that we obtained at Carnarvon was 1:1.2:2.64 and this expected from a mated pair system.

To gain more information about the social organisation of foxes, their DNA profiles are being examined. These will be used to determine exactly which vixens are responsible for rearing cubs and whether one male sires more than one litter of cubs. This last feature can be examined by investigating the DNA profiles of the foxes within an area and determining which males are responsible for siring each of the litters of cubs.

Various other aspects of fox biology are veing investigated to help implement biological control. The incidence, timing and distance of dispersal of juveniles are being examined because these factors will greatly influence the spread of a contagious biological control agent. Also cub survival at low densities

and age specific mortality are being examined because these will determine how the fox population will respond to any reduction in density due to sterility control.

At this stage there is a slight holdup in the development of biological control for foxes because no fox-specific virus has veen found aqnd so no genetic engineering can take place. The search is still on for a suitable firus and all other aspects of the developnent of biological control proceeding.

A bait delivered sterility-induced antigen is being developed so that fox populations in areas where 1080 baits cannot be used will be able to be controlled. This work relies on a fox-specific antigen being developed, and at this stage this has not been achieved. Because biological control for foxes may take some time to develop and implement, in the interim we need to concentrate on controlling foxes in strategic areas so that the re will still be some species available to translocate when Australia wide fox control is finally achieved.

CURRENT DEVELOPMENTS IN CONVENTIONAL CONTROL

To enhance our current conventional methods of fox control we are conducting research into various aspects of fox biology and these concentrate on examining the timing of recolonisation of areas cleared of foxes. The data obtained from these investigations will be used to develop an optimum baiting strategy that will remove a maximum number of foxes while simultaneously reducing the cost of baiting and reducing the amount of toxins released into the environment. These baiting regimes will be important in quantifying how many sterilising baits need to be laid and whether buffer zones will be effective in maintaining some particularly 'high-risk' areas free of foxes.