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Project Eden – fauna recovery on Peron Peninsula, Shark Bay: *Western Shield* review—February 2003

KEITH MORRIS[1], COLLEEN SIMS[2], KATHY HIMBECK[2], PER CHRISTENSEN[3], NIGEL SERCOMBE[4], BRUCE WARD[5] AND NICOLE NOAKES[2]

[1] Department of Conservation and Land Management, Science Division, Woodvale Research keithm@calm.wa.gov.au
[2] Department of Conservation and Land Management, Post Office, Denham WA, 6537.
[3] Ellendale Farm, PO Box 134, Balingup, WA , 6253, Centre, PO Box 51 Wanneroo WA, 6946.
[4] Department of Conservation and Land Management, PO Box 72, Geraldton WA 6531
[5] Department of Conservation and Land Management, Science Division, Locked Bag 2, Manjimup WA, 6258.

SUMMARY

The Shark Bay area was one of the more mammal rich parts of Western Australia before European settlement. Over the last 200 years, 60% of the native mammals have become locally extinct in this area. *Project Eden* commenced on Peron Peninsula, Shark Bay in 1994. Its objectives were to a) control or eradicate the introduced fauna, b) reconstruct the native fauna of the peninsula, and c) to promote nature – based tourism based on the unique Shark Bay fauna.

Control of sheep, goats and foxes has been successful. Feral cat control has been difficult in the presence of large numbers of rabbits and other prey, however significant advances in the development of an effective feral cat control method have been made. A better understanding of the factors influencing the uptake of baits by feral cats has also been achieved. A captive breeding centre was established to provide animals for translocation. This ensured that wild populations of species restricted to islands or small parts of the mainland were not detrimentally impacted by the removal of large numbers of founders for translocation. Between 1996 and 2002, nearly 70 malleefowl and 150 mammals were bred / reared in captivity and 155 have been released. Malleefowl and bilbies have been successfully reintroduced to Peron Peninsula. Mala and banded hare-wallabies did not persist due primarily to cat predation. Woylies were reintroduced from other wild populations and are persisting in low numbers. Extant small vertebrate population abundances appear to respond more to rainfall events, rather than cat predation, while larger extant vertebrates have increased since sheep, goat, fox and feral cat control has been implemented.

While feral cat control has been demonstrated for short periods, additional work is required to reduce their numbers further, and for longer periods before additional native species can be translocated. In addition to the re-establishment of native fauna and the enhancement of the remnant native fauna, *Project Eden* has provided many benefits relating to the management of pest species and native fauna in the arid zone. In light of the findings to date, it is proposed that the objectives of this project be revised and that certain actions are necessary to ensure future success. These include a refinement of feral cat control methods, the development and use of models to predict optimum bait uptake times, a review of species suitable for translocation, and the adequacy of existing staff numbers and captive breeding facilities.

INTRODUCTION

Project Eden is an ambitious large-scale conservation project that has as its primary goal the translocation and reconstruction of the pre-European fauna populations of the Peron Peninsula, an area of 1050 square kilometres within the Shark Bay World Heritage Property in Western Australia. The project was an initiative of the Department of Conservation and Land Management (CALM) and was launched by the then Minister for the Environment, Hon Kevin Minson in December 1994. It preceded *Western Shield*, which commenced in September 1996, but it is now regarded as one of the *Western Shield* component programs.

Prior to European settlement, the Shark Bay area of Western Australia had a diverse mammal fauna. Thirty-seven native terrestrial species were known to have occurred on the islands and peninsulas of the area (Baynes 1990). Most of the medium-sized species have disappeared and those that remain now, occur only on Bernier and Dorre Islands. Twenty-five native mammal species once occurred on Peron Peninsula, however, only the large euro *Macropus robustus*, widespread echidna *Tachyglossus aculeatus* and seven smaller species of bats, native rodents and marsupial mice now survive (Table 1). Another rodent, the ash-grey mouse *Pseudomys albocinereus*, has been reported as occurring on Peron Peninsula on the basis of hair samples (Peter Speldewinde, CALM, pers. comm.), but none have been trapped.

Nine species of introduced mammal have been recorded on the Peninsula, of which six still persisted in

the early 1990s (fox, feral cat, rabbit, sheep, goat and house mouse). The presence of these introduced species, particularly the fox and feral cat, is most likely to have precipitated the dramatic decline in native species over the 100 years or so preceding 1994. A clear link has been established between the decline of native mammal species and predation by foxes in the southwest of Western Australia (Christensen 1980, Kinnear *et al.* 1988, 1998, 2002, Morris *et al.* 2003). There are similar concerns about the detrimental impact of feral cats on native mammals, particularly in semi-arid and arid parts of Australia (Gibson *et al.* 1994, Christensen and Burrows 1994, Dickman 1996, Short 1999, Risbey *et al.* 2000).

The Peron Peninsula is the eastern most peninsula of the Shark Bay region of Western Australia, 900 kilometres north of Perth (Figure 1). It lies across the boundary of the Carnarvon Basin and Geraldton Sand plains IBRA (Interim Biogeographical Regionalisation for Australia) regions (Thackway and Cresswell 1995), and has been classified as having a semi-desert Mediterranean type climate (Payne *et al.* 1987). Rainfall averages 220 mm per year, most of it falling between April and September. However, even in the wettest years, rainfall is less than evaporation (3000 mm per year) and plant growth is confined to periods of available soil moisture following rainfall events. The Bureau of Meteorology regard areas with an annual rainfall of less than 350 mm as arid.

The northern portion of the peninsula comprises extensive red sand plains with tall *Acacia* shrublands, low coastal sand dunes and sea cliffs. The southern portion of Peron Peninsula has undulating plains of calcareous sand supporting low *Acacia* shrublands and *Lamarchea hakefoilia* heaths. Low lying salt pans, or birridas, lie among the sand plains throughout the peninsula. Soils in these are highly saline and gypsiferous with scrubland of saltbush and samphire (Payne *et al.* 1987).

In October 1990, the Peron pastoral lease, which covered most of the peninsula, was purchased by the Western Australian government. In 1993 the Francois Peron National Park (FPNP) was created over the northern half of this area. The southern portion remains Unallocated Crown Land (UCL). The Shark Bay Regional Strategy (Ministry for Planning 1997) proposed that the UCL become timber reserve. Recently, the Western Australian government also purchased the adjacent Nanga pastoral lease.

TABLE 1

Native and introduced terrestrial mammals recorded from the Peron Peninsula, Shark Bay. Derived from Baynes (1990), Baynes (2000) and McKenzie *et al.* (2000a).

SPECIES	STATUS
NATIVE SPECIES	
Echidna *Tachyglossus aculeatus*	extant
Euro *Macropus robustus*	extant
Woylie *Bettongia penicillata*	locally extinct
Boodie *Bettongia lesueur*	locally extinct
Mala *Lagorchestes hirsutus*	locally extinct
Banded hare-wallaby *Lagostrophus fasciatus*	locally extinct
Crescent nailtail wallaby *Onychogalea lunata*	extinct
Western barred bandicoot *Perameles bougainville*	locally extinct
Quenda *Isoodon obesulus*	locally extinct
Chuditch *Dasyurus geoffroii*	locally extinct
Mulgara *Dasycercus cristicauda*	locally extinct
Red-tailed phascogale *Phascogale calura*	locally extinct
Fat-tailed dunnart *Sminthopsis crassicaudata*	extant
Little long-tailed dunnart *Sminthopsis dolichura*	extant
Hairy-footed dunnart *Sminthopsis hirtipes*	extant
Spinifex hopping-mouse *Notomys alexis*	extant
Shark Bay mouse *Pseudomys fieldi*	locally extinct
Sandy inland mouse *Pseudomys hermannsburgensis*	extant
Ash-grey mouse *Pseudomys albocinereus*	extant ?
Lesser stick-nest rat *Leporillus apicalis*	extinct
Greater stick-nest rat *Leporillus conditor*	locally extinct
Pale field-rat *Rattus tunneyi*	locally extinct
Dingo *Canis lupis dingo*	locally extinct
Lesser long-eared bat *Nyctophilus geoffroyi*	extant
White-striped mastiff bat *Tadarida australis*	extant
INTRODUCED SPECIES	
House mouse *Mus domesticus*	extant
Feral cat *Felis catus*	extant
European red fox *Vulpes vulpes*	extant
Rabbit *Oryctolagus cuniculus*	extant
Goat *Capra hircus*	extant
Sheep *Ovis aries*	locally extinct
Cattle *Bos taurus*	locally extinct
Horse *Equus caballus*	locally extinct
Camel *Camelus dromedarius*	locally extinct

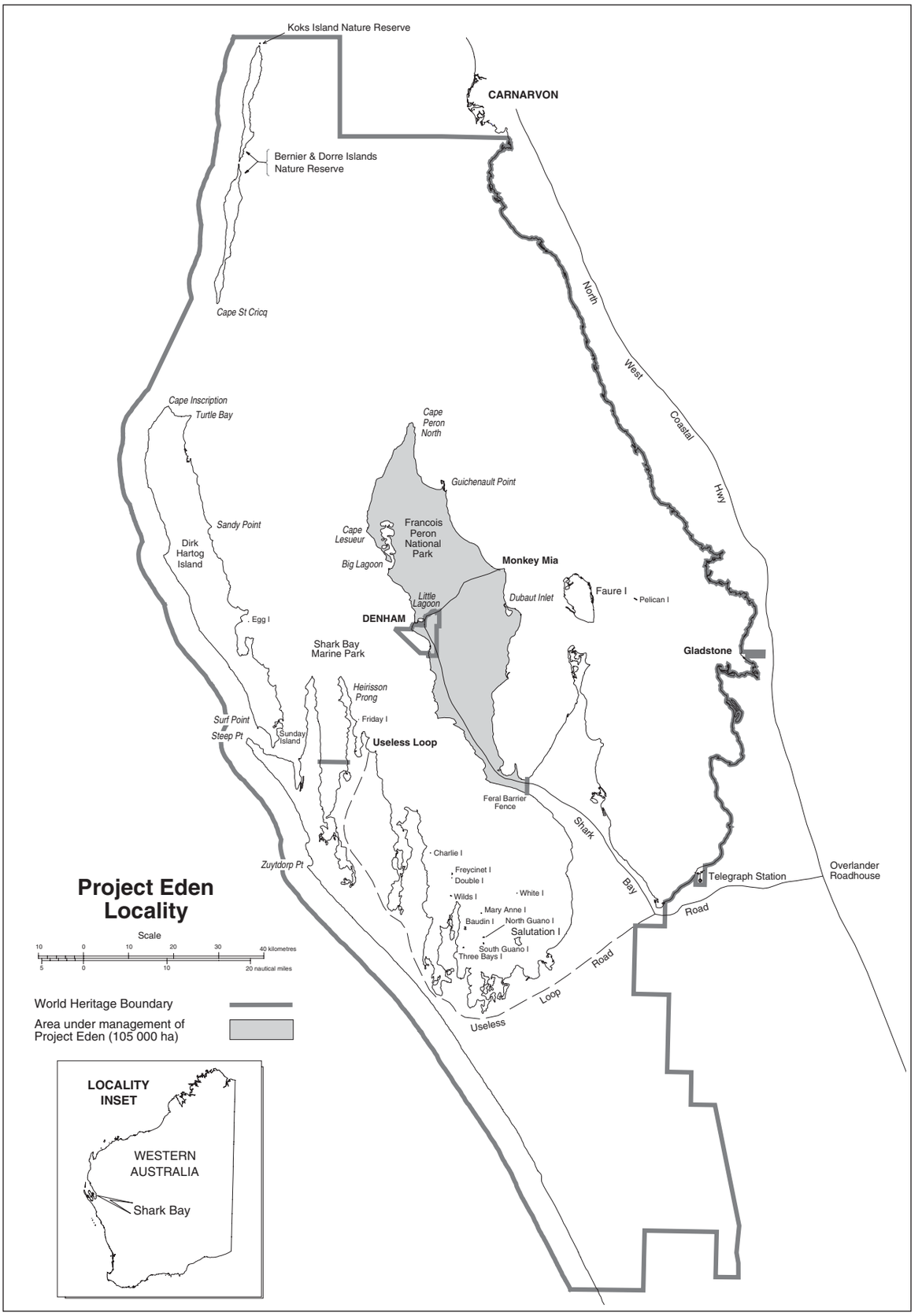

Figure 1. Location of Peron Peninsula, Shark Bay.

Project Eden commenced in December 1994 and the *Project Eden* Management Committee (PEMC), comprising staff from the Department's Midwest Region, Shark Bay District and Science Division was established to oversee the project. This committee was later expanded to include representatives from the Nature Conservation Division and a consultant (a former CALM employee who had been in charge of the project until 1998). A draft strategic plan was prepared in February 1995 (Christensen 1995) with the following objectives:

1. To control introduced predators (foxes and feral cats) and herbivores (goats, sheep and rabbits) on Peron Peninsula.
2. To re-establish a range of threatened animals, particularly mammals.
3. To foster and promote sustainable nature-based tourism to the area.

The project was seen as an 'operational experiment', rather than a research project and was to progress in three phases:

- Phase one – introduced animal control
- Phase two – fauna translocation
- Phase three – nature-based tourism.

Phase two was to be implemented based on the success of phase one, and phase three on the success of phase two.

Initially, one full time project officer was allocated to this project. However, as the work progressed it became clear that several operational staff would be required. *Project Eden* staff now comprise a project officer, a captive breeding manager, an animal husbandry officer, a translocation and fauna monitoring officer, two introduced animal control officers and part of a computer support person. In addition, the CALM Shark Bay District office in Denham provided administrative support. Volunteers have been used to assist with the captive breeding and translocation programs.

Operations Plans for each of the key functional areas - introduced animal control, fauna translocation and monitoring (including captive breeding), communication, and fire protection were also prepared. These operational plans reflected the aims of the initial *Project Eden* Plan and detailed the staff requirements, strategies, methods, budget estimates and timeframes for implementation or achievement of project milestones. The operational plans also provided the basis for meeting the requirements of the *Conservation and Land Management Act 1985* in respect to 'Necessary Operations' approval. A draft recreation and tourism operations plan for nature-based tourism was prepared in 1997, however this plan has not been progressed while the operational focus of the project remains on achieving sustained reductions in introduced predator numbers and fauna translocations.

The aims of each operational plan were as follows:

1. Introduced animal control

To develop and implement operational methodologies for the control of introduced herbivores and predators at sufficiently low levels of abundance so that:

- Existing populations of native fauna can expand to fill all available suitable habitats.
- Habitat conditions are suitable for translocation of locally extinct fauna.
- Introduced animal management is effectively integrated with other management strategies applied to the project area

For foxes and feral cats specifically, to:

- Reduce their density to an average of less than one animal per ten kilometres of transect and to retain it at, or below, this level.
- To eradicate foxes and cats within a five kilometre radius of designated translocation release sites.

2. Fauna translocation and monitoring

- To successfully translocate and reconstruct the mammal fauna of the Peron Peninsula.
- To monitor existing native mammal populations.

3. Communications

- To increase public awareness, understanding and support for *Project Eden*.
- To develop awareness and understanding of CALM as an organisation that cares for and manages the natural environment in an effective and innovative way.
- To convince local residents in Shark Bay as well as the Western Australian public to support the need for control of introduced animals in conservation areas.
- To assist the project in securing funding from the private sector to build a fence at the narrow neck of Peron Peninsula
- To promote the Shark Bay World Heritage Property as a destination for nature-based tourism.

4. Fire management

- To minimise the threat of fire to human life and property
- To minimise the risk of total incineration of the proposed mammal translocation sites at Cape Peron, Peron Road and Herald Bight
- To minimise the impacts of prescribed fire and wildfire on park users, facilities and conservation values.

This report provides a critical review of the aims, strategies, and results of *Project Eden*. It provides an analysis of *Project Eden* in the context of the overall objectives of *Western Shield* and the future of mammal conservation in Western Australia with recommendations for the future. This paper also provides an outline of a number of significant secondary outcomes from the project.

CONTROL OF INTRODUCED SPECIES

Domestic stock

Peron Peninsula has been grazed by domestic stock since 1881, and up to 22 500 sheep at a time have been grazed on the property. Since 1993, all domestic stock (18 861 sheep, 11 cattle and 19 horses) has been removed from the FPNP and south Peron UCL. Feral goat numbers have been reduced from approximately 14 600 to 200–400 animals (Brown 2001). Sheep, cattle and horses were mustered off the lease. Goats were mustered, shot from helicopter and the ground, trapped at water points and shot using the 'Judas' goat method. Ongoing goat shooting and trapping at water points is underway. However the presence of brackish soaks around the coast of Peron Peninsula means that total eradication of goats may not be possible.

Foxes and feral cats

Foxes have been present in the Shark Bay area since the mid 1920s (Jarman 1986). Feral cats probably became established in the area in the 1870s after the European settlement of 'Shark's Bay' (now Denham) in 1850 (Abbott 2002). In September 1994 a preliminary reconnaissance was made of the Peron Peninsula to assess the suitability of the peninsula for the proposed *Project Eden*. During two days of travelling on most of the accessible tracks on the peninsula, very high numbers of rabbit, fox and goat tracks were noted. Because of this it was difficult to determine accurately the extent of cat tracks. There was also an almost total absence of any tracks of small mammals and also the larger reptiles such as Gould's goanna *Varanus gouldii* and the bobtail *Tiliqua rugosa*. Despite this, a monitoring program for foxes and feral cats was commenced from October 1994. Early monitoring methodology consisted of recording the numbers of fox and cat tracks along 20–30 km 'road' transects and converting the results to number of tracks / 100 km following a methodology previously developed and used in the Gibson Desert during project Desert Dreaming (Christensen and Burrows 1995, Algar and Burrows, this publication). At this time numbers of foxes were believed to be approximately 100–120 per 100 km and cats about 6-10 per 100 km (Figure 2). A pre – fox baiting cyanide transect using the methods of Algar and Kinnear (1992) indicated that there were 2.5 foxes per square kilometre on Peron Peninsula (about 2 500 foxes in total). In July 1998 the track transect was modified so that a standard 80 kilometre transect was searched for animal tracks (= Comprehensive Track Count CTC). The CTC was also used to monitor the relative abundance of larger native fauna such as euros, echidnas, emus and goannas. Spotlight surveys were also attempted but soon abandoned because, in spite of the very high numbers of foxes, few were seen due to the density of the vegetation over most of the peninsula. Likewise, feral cats were seldom seen at night.

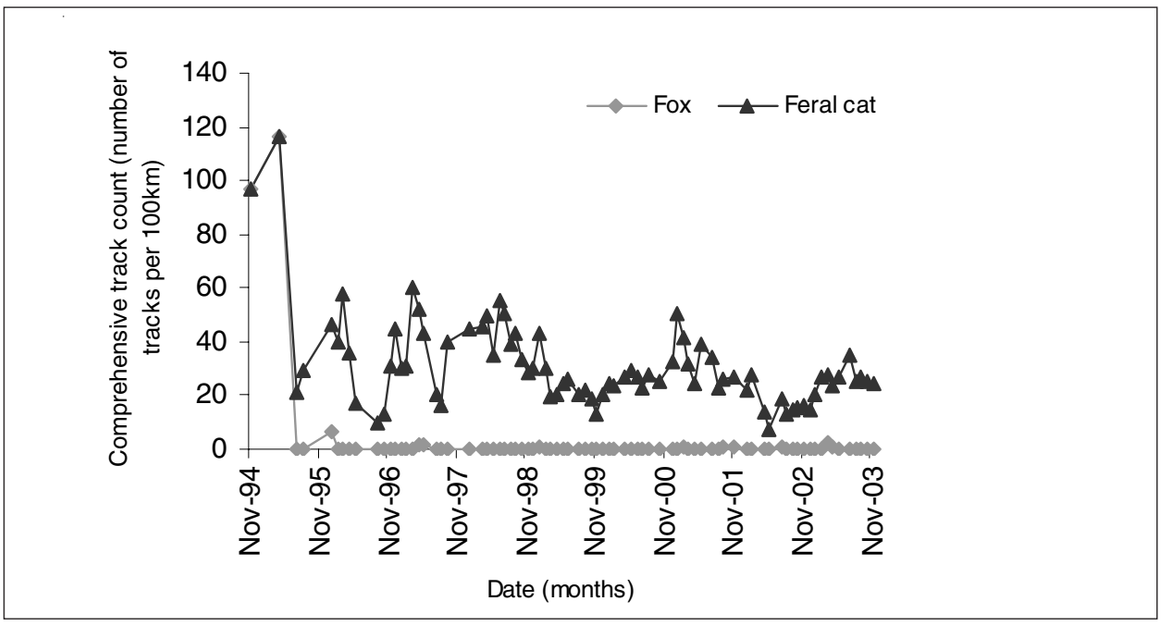

Figure 2. Estimates of relative fox and feral cat abundance on Peron Peninsula in relation to baiting control.

Because of the exceptionally high numbers of foxes present on Peron Peninsula, the initial introduced predator control strategy was to reduce fox numbers through baiting before attempting to control feral cats. The aim was to reduce and maintain fox and cat numbers to less than 10 per 100 km. At this time (April 1995) effective methods for controlling foxes over large areas were known, however techniques for feral cat control were still being developed. *Project Eden* provided an opportunity to test various feral cat control techniques. An aerial fox baiting program in April 1995 using kangaroo meat baits (10 baits per square kilometre) resulted in an estimated 95% reduction in fox abundance. Immediately after, the only signs of foxes were in the Denham town buffer strip where a set of footprints was recorded along the beach, and it is now very unusual to find evidence of foxes north of the barrier fence. The Peron Peninsula is now one of the largest areas (1050 square kilometres) of mainland Australia that is virtually fox free. Following the success of fox baiting, a three kilometre electrified barrier fence was constructed near the narrowest point of the peninsula to prevent / reduce reinvasion from the adjacent Nanga pastoral lease which at that time was not fox baited. Various trials were undertaken with chemicals, such as naphthalene, to stop foxes (and cats) from passing through the gap in the fence where the Denham road passed. These were not successful, and finally a recording of a dog barking and an ultrasonic noise emitter were installed at the gap. These are activated when there is movement across an infrared beam across the road. The success of these deterrents was monitored using sand pads, moistened with kerosene to stop the sand blowing away, to record movement of foxes and cats across the grid. The ultra-sound was not effective in preventing foxes and cats from moving through the gap, however the dog barking did appear to be a deterrent and this has been maintained on the road gap, in addition to a road grid.

Subsequent cat baiting operations (both hand and aerial baiting), and the barrier fence have been effective at maintaining foxes at very low levels on Peron Peninsula. It is now unusual for fox tracks to be detected during the comprehensive track counts (Figure 2). It was predicted that once fox and cat numbers had been reduced to very low levels, control measures other than baiting might be needed to 'mop up' the last few individuals. Two Rhodesian ridgeback dogs were procured for this purpose and in the early months of the project were trained to detect cats and foxes. Following the success with the fox baiting the dog training concentrated on the location of cats. While initial results were promising, the dogs were not able to 'air scent' the cats and this work ceased.

With the success of fox baiting it became possible to more accurately assess relative cat abundance through the use of driven transects covering a standardised 80 km of sandy track. Cat numbers appeared to increase significantly after the foxes had been removed; however at this time, an effective cat bait had not yet been developed. Feral cat control commenced in April 1996 and has involved a number of trapping and baiting regimes since. Initial cat control focussed on using small, fresh meat 1080 baits coated in 'digest' dropped from an aircraft at 10 baits per square kilometre. This regime was based on the success of previous work undertaken on cat control in the Gibson Desert (Burrows *et al.* 2003). This resulted in an approximately 75% kill of cats. The aerial baiting program was repeated in autumn of 1997, 1998, 1999, however these were less successful with only a 30-50% reduction in feral cat abundance. In addition, in 1996 a trial was undertaken with the effectiveness of secondary poisoning from rabbits killed with 1080 oats. This may have enhanced the effectiveness of the meat baits, however this technique has not been pursued because of the potential impact on non-target native rodents. Development of a cat sausage bait was completed in 1999 (Algar and Angus 2000a) and this was used in monthly ground baitings on Peron in 2000 and 2001. In March 2002, an aerial baiting using 50 sausage baits per square kilometre was undertaken and 13 of 16 radio collared adult female cats (ca 80%) were killed (Maxwell 2002). There was also a consistent decline in the CTC for cats at this time. In March 2003 and October 2003, further aerial baiting programs (50 baits per square kilometre) were undertaken and 35–60% of radio-collared cats were killed (15 and 13 adult cats radio collared in March and October respectively). However, there were not corresponding declines in the CTC at these times and the reasons for this are unclear. The extent to which the CTC is reflecting a decline in the cat population due to baiting, or natural declines due to nutritional stress (Jones and Coman 1982) or reduced breeding has not been determined, and is one of the ongoing difficulties in determining baiting effectiveness.

Aerial and ground baiting from 1996 to 2001 has not been successful in maintaining cats at sufficiently low numbers to allow translocations of most of the targeted native mammals to occur. An analysis of cat stomach contents indicated that rabbits and mice (*Notomys* and *Mus*) form the majority of prey items for feral cats on Peron Peninsula, with larger cats having a greater proportion of rabbits in their diet (Algar and Angus 2000b, Figure 3). The proportion of cats taking baits (= bait uptake) on Peron Peninsula was inversely related, primarily, to rabbit and other prey abundance. Bait effectiveness was therefore greatest in the autumn when rabbit abundance was reduced. In a simultaneous trial using non-toxic rhodamine marked cat baits, bait uptake by cats at Pimbee Station (120 km east-north-east of Peron) with low rabbit densities was significantly greater than at Peron (Algar and Burrows, this publication). Short *et al.* (1997) also predicts that bait uptake by feral cats is likely to be poor when there are high numbers of rabbits present, and Burrows *et al.* (2003) propose that seasonal variation in the abundance of major dietary items of cats in the Gibson Desert (reptiles and small native mammals) affects bait uptake.

However, even in autumn, the effectiveness of baiting on Peron Peninsula was highly variable and between 1997 and 2001 bait uptake was significantly less than in 1996

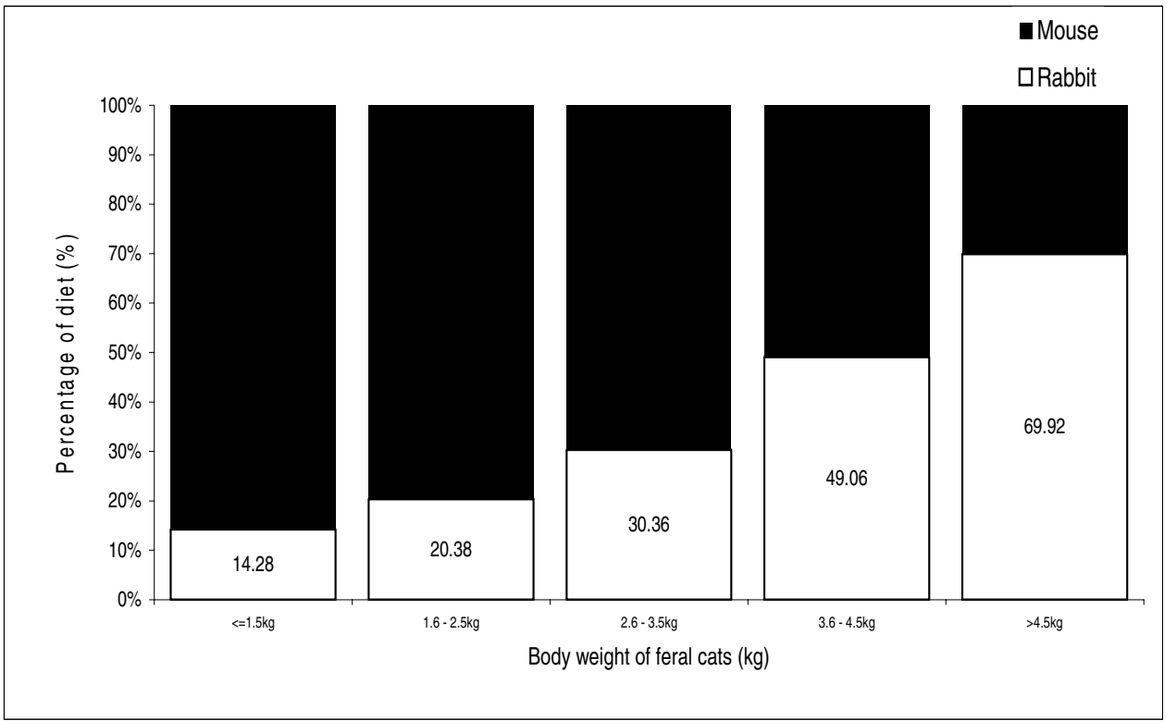

Figure 3. Composition of feral cat diet on Peron Peninsula 1994–2002 (n = 3400).

and 2002. Feral cats are able to breed throughout the year on Peron Peninsula, however most cats are either pregnant or lactating between September and November (Figure 4). Consequently the population has a great capacity to increase unless control is ongoing. The baiting in 2002 was shown to be effective in significantly reducing feral cat numbers (> 50% reduction), but that undertaken in March and October 2003, less so. At that time it was difficult to know whether the good bait uptake by cats in 2002 was because of the increased baiting intensity (50 baits per square kilometre versus 10 baits per square kilometre previously), or a particularly low abundance of alternative prey (particularly rabbits) after dry winters in 2001 and 2002 (Figure 5). Rainfall for 2001 and 2002 were 177 mm and 163 mm respectively, well below the average of 220 mm per year, and the reduced number of breeding feral cats at these times was probably as a consequence of this (Figure 4). However, a large amount of information on the abundance of small mammals and seasonal rainfall, together with previous cat baiting effectiveness has now been collected, and a model to predict the percentage of cats likely to be killed based on these variables is now being developed.

Initially, trapping was considered as a mopping up technique to get rid of the 20-30 % of cats that were not baited and there was some success with trapping for cats using cage traps baited with rabbit meat, dead quail and other baits at the start of the project. Subsequently a more effective technique using # 3 Victor 'soft catch' traps and olfactory and auditory lures was developed (Meek *et al.* 1995, Algar *et al.* 2002). All of the Peron Peninsula north of the barrier fence has been systematically trapped on a monthly basis since late 1996. In addition to the CTC referred to above, the cat trappers have also carried out cat track counts as they travel their trap lines each day (= trappers track counts TTC), usually a distance of about 20–30 kilometres.

Since 1996 the various cat control techniques have resulted in CTCs of between 10 and 60% (Figure 2). Following the April 2002 baiting, when 80% of radio-collared cats were killed, the CTC fell from 47% to 11% suggesting that the CTC was providing a reasonably accurate measure of relative cat abundance. However, because of the variability in bait uptake throughout the year, and between years, baiting has only been effective for short periods. Trapping has been the main control method and CTCs have been kept at approximately 20-30%. Despite the lack of pre-control cat track counts, this is considered to be about 30–50% of the cat carrying capacity of the peninsula. However, there is evidence that this level of cat abundance is too high to permit the successful translocation of mala (*Lagorchestes hirsutus*), banded hare-wallaby (*Lagostrophus fasciatus*) and possibly woylie (*Bettongia penicillata*). It is probably also too high for other 'cat vulnerable' species such as the greater stick-nest rat (*Leporillus conditor*) and western barred bandicoot (*Perameles bougainville*) to be released. Dickman (1996) regards the impact of feral cats to be greatest on species weighing less than 200 grams. However, in the presence of this level of cat numbers, bilbies (*Macrotis lagotis*) and mallee-fowl (*Leipoa ocellata*) have survived and increased in abundance.

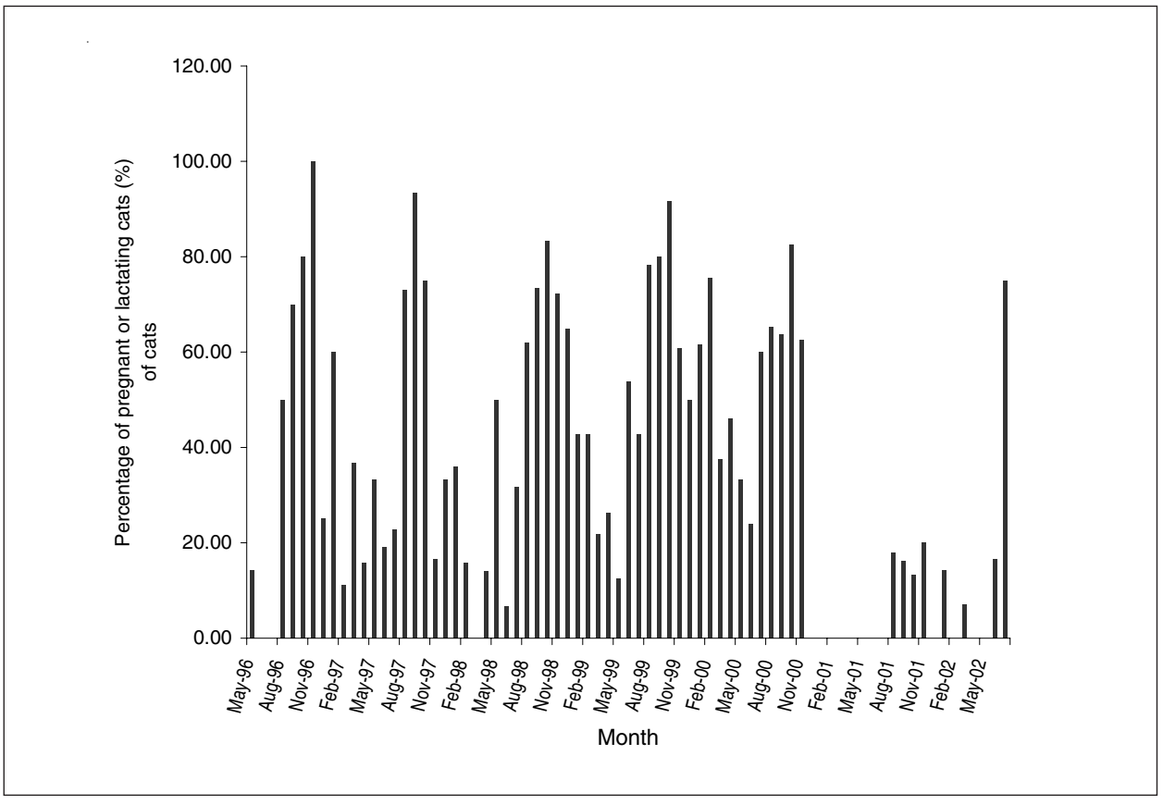

Figure 4. Seasonal percentage of pregnant or lactating feral cats on Peron Peninsula 1996–2002.

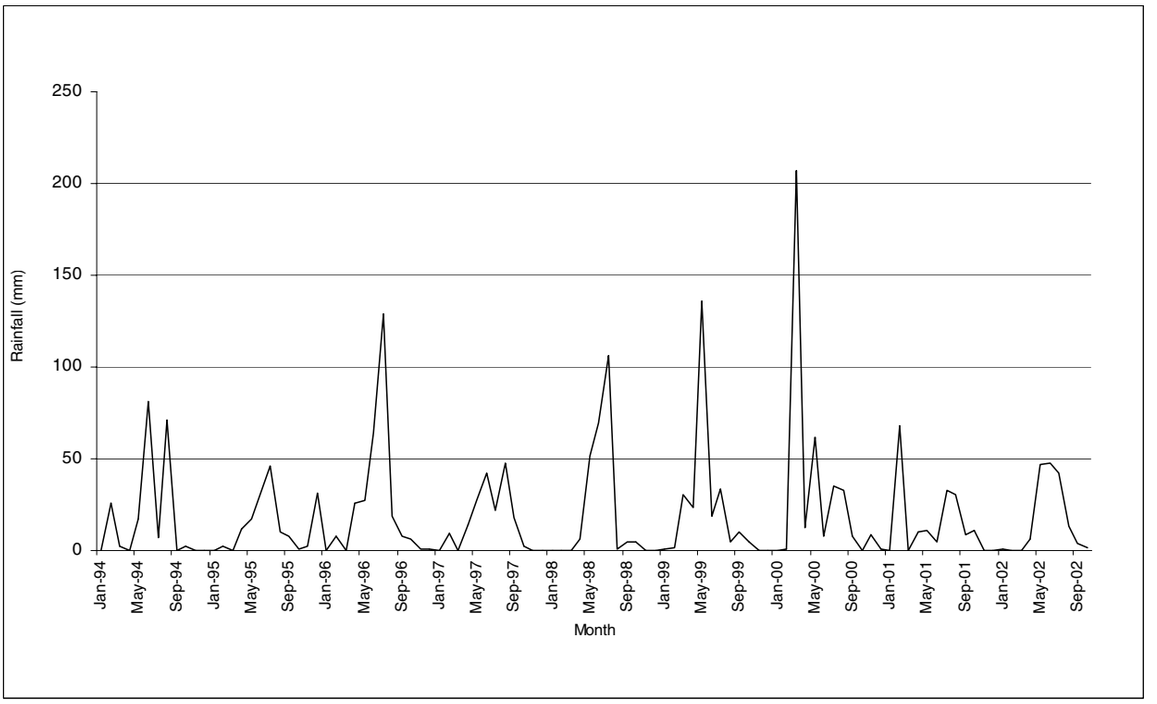

Figure 5. Annual monthly rainfall for Denham 1994–2002.

It is possible that greater control of feral cats will be achieved on Peron Peninsula through broad scale baiting with a highly attractive bait, as has been demonstrated for some islands and parts of the mainland in the arid zone (Algar and Burrows, this publication). However the effectiveness of this may vary depending on environmental conditions and rabbit abundances, and new techniques will need to be developed to target individual problem animals and maintain lower cat densities when baiting is less effective.

Despite the longer than anticipated time for effective feral cat control on Peron Peninsula, this aspect of *Project Eden* has had several benefits. In addition to allowing the establishment of additional malleefowl and bilby (and possibly woylie) populations, and enhancing remnant fauna populations, considerable progress has been made on developing an effective cat control method for Australia. *Project Eden* has provided the opportunity and location to trial various control techniques. In particular research into the variability in bait uptake has been crucial in developing baiting strategies where rabbits are in high abundance. It is the largest area in Australia (and possibly the world) where intensive cat control has been carried out almost on a daily basis for a period of over seven successive years. A significant amount of data (> 3400 cats) have been collected on cat sex, size, weight, colour, breeding condition, stomach contents and capture location. As discussed above, there are also opportunities to develop predictive models to allow managers to better use baiting as an effective cat control method. This project is one of only a few in Australia where it is being attempted to develop integrated cat control techniques at a large scale for conservation purposes in an arid environment. There have also been benefits to the extant native fauna with increases in several of the larger mammal and reptile species. If a regular, effective cat-baiting program can be developed on Peron Peninsula, the area could once again become one of the more diverse fauna regions in Australia.

Rabbits

While there was concern about the impact of high numbers of rabbits on native vegetation on Peron Peninsula, it was realised when *Project Eden* commenced that concerted rabbit control was not achievable. It was also considered that many of the species listed for translocation were capable of at least co-existing with rabbits and that it was more important to control the recognised threats of foxes and feral cats. Robley *et al.* (2002) demonstrated that high rabbit densities had no impact on population characteristics of the boodie (*Bettongia lesueur*) in Shark Bay. On Peron Peninsula, there was concern that rabbit numbers might increase significantly once foxes were removed, however research in NSW had shown that where rabbits occur at high densities (> 15 rabbits / square kilometre), predation was not a limiting factor and population numbers were limited by environmental factors (Pech *et al.* 1992). Very little pre-fox control rabbit monitoring was undertaken and the high numbers of fox tracks confounded that undertaken in 1994. Subsequent monitoring of rabbits through presence/absence at approximately four kilometre intervals along the 80 kilometre CTC transect demonstrates significant seasonal fluctuations in numbers, most likely influenced by winter rainfall patterns (Figure 6).

Unsuccessful attempts at rabbit control have been made through release of myxomatosis and rabbit calici viruses. Myxomatosis was probably always present on Peron Peninsula and in addition two infected rabbits were obtained from Heirisson Prong, and released on the peninsula in September 1994. The disease was noted the following autumn when dying rabbits with symptoms of the disease were observed. To facilitate the spread of the virus, European rabbit fleas were released in 1995 and Spanish rabbit fleas in 1996. Myxomatosis continues to have a sporadic and localised impact on rabbit populations

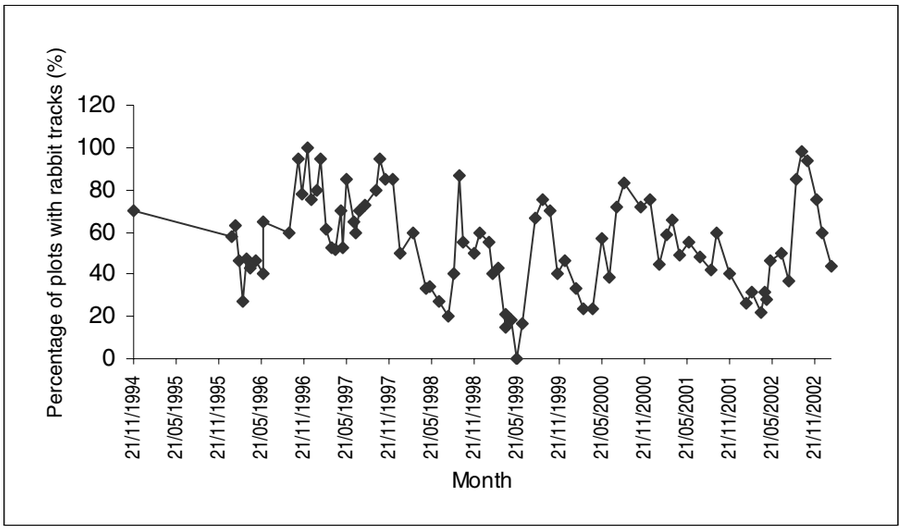

Figure 6. Relative abundance of rabbits on Peron Peninsula estimated by presence/absence at 4 km intervals along the CTC transects on Peron Peninsula.

during periodic epidemics. When rabbit calici-virus became available in 1996, Peron Peninsula was included as an official release site. However there have been no signs of the disease being effective at reducing rabbit numbers. Rabbits were tested positive for antibodies to the disease, however none were found to be dying. A second release of calici virus was undertaken in autumn 1997, but again this does not appear to have become established and was unsuccessful at reducing rabbit numbers. Given that apparent inverse relationship between rabbit abundance and bait uptake by cats, as discussed above, it is important that further work be undertaken on methods for reducing rabbit abundance on Peron Peninsula. Broad scale poison (1080 or sodium fluoroacetate) oat baiting has been considered, however there is potential for non-target species, particularly native rodents to be detrimentally impacted by this.

REMNANT TERRESTRIAL VERTEBRATE FAUNA

Introduction

The introduced animal control carried out by *Project Eden* has been focused at providing habitat that allows successful reintroduction of locally extinct native fauna. Equally important is the recovery of remnant fauna populations that had been struggling to survive competition from introduced herbivores and predation from introduced carnivores. The remnant fauna on Peron Peninsula has been regularly monitored by a series of small vertebrate monitoring grids, as well as through a road-trapping program implemented to also monitor the translocated mammal species. The comprehensive track counts (CTC) have also been used to monitor terrestrial fauna.

Six species of non-volant native mammal are extant on Peron Peninsula (Table 1). Four of these (*Notomys alexis, Pseudomys hermannsburgensis, Sminthopsis dolichura and S. hirtipes*) are monitored by regular trapping in small vertebrate monitoring grids. At least 65 taxa of reptile are known from the Peron Peninsula (Table 2) and up to 27 of these are regularly trapped in either the small vertebrate monitoring grids or road transects. McKenzie *et al.* (2000b) reported that the red sands with hummock grassland habitats on Peron Peninsula supported some of the richest herpetofaunal assemblages in the southern Carnarvon Basin bioregion. No frogs are known from Peron Peninsula, although the western toadlet *Pseudophryne occidentalis* has been recorded at Hamelin Pool at the base of Peron Peninsula (Tyler *et al.* 2000), and there are anecdotal reports of a frog inhabiting dunes near Denham and in the Francois Peron National Park.

Small vertebrate monitoring grids

Since 1995, six monitoring grids, each of 4 x 4 trap sites and comprising sixteen pitfall traps (alternating 15cm diameter PVC tubing with 20 litre buckets, each with 7m of wire netting) and sixteen Elliott traps have been used to monitor the small vertebrate fauna on Peron Peninsula. A description and location of these is shown in Table 3. These were intended to sample the major vegetation types in the northern part of the Peron Peninsula, however none were set in the extensive *Acacia ramulosa* (wanyu) shrublands. Sampling from 1995 – 2000 was at least once a year (either spring or autumn, or both). Since autumn 2001 the 6 established grids have been run in both spring and autumn. An additional three grids (grids 9, 10 and 11) were installed in spring 2001 as part of fire response research (Hill 2002), to replicate the burnt and unburnt spinifex vegetation.

The results of the small vertebrate monitoring since 1995 are shown in Figure 7. Four native species of small mammal (*Notomys alexis*, *Pseudomys hermannsburgensis*, *Sminthopsis dolichura*, *S. hirtipes*) and the introduced house mouse *Mus domesticus* have been trapped on the grids. *N. alexis* was the most commonly trapped small mammal, accounting for approximately 70% of captures. Twenty seven species of reptile have also been trapped on the grids. The most commonly trapped species include the *Diplodactylus* geckos, the skinks *Ctenotus fallens, C. schomburgkii, Lerista elegans, L. planiventralis* and *Menetia greyii*, and the dragon *Ctenophorous maculatus maculatus*. Ten other species of reptile, mainly the larger snakes and skinks have been recorded on the road transects (Table 2). A further 28 species of reptile are known from Peron Peninsula; most of these have been recorded in the southern part of the peninsula.

Mammal trap success rates fluctuated between < 5% to 30%, while reptile trap success rates varied between < 5% and 8%. Mammal trap success rates were highest from August 1996 to August 1999 and this probably reflects the good winter rains received in this period (Figure 5). Lower mammal trap success rates between 2000 and 2002 probably reflect the lower rainfall received at this time.

Hill (2002) showed that the 1997 burns to create a fire buffer across the peninsula did not reduce the richness or abundances of the four native small mammals or the introduced house mouse. Similarly it did not reduce the abundances of agamid (dragons), gekko or varanid lizards, but did reduce the species richness. The dragon *Ctenophorus maculatus* and gekko *Diplodactylus squarrosus* increased in abundance following the fire. However, skinks declined in abundance post fire.

Road transects

Road trapping transects using Sheffield cage traps placed at 200 m intervals along Cape Rose track, Woylie track, Aerial track, and Cyanide track were established in May 1997 to monitor released mammals (woylies). In April 2001 the Fauna Monitoring Trapping Program (FMTP) incorporated the existing road trapping but added more tracks within the release area to form a standardised survey that was run twice a year. From 2001, all species caught,

TABLE 2

List of reptiles recorded from Peron Peninsula (derived from McKenzie *et al.* 2000b, and WA Museum records) and those trapped during monitoring programs.

REPTILE SPECIES	TRAPPED IN MONITORING GRIDS OR ON ROAD TRANSECTS, FPNP.	REPTILE SPECIES	TRAPPED IN MONITORING GRIDS OR ON ROAD TRANSECTS, FPNP.
Gekkonidae (geckos)		**Pygopodidae (legless lizards)**	
Crenadactylus ocellatus horni		*Acyls concinna major*	
Diplodactylus alboguttatus	X	*Aprasia sp.*	
Diplodactylus ornatus	X	*Delma australis*	
Diplodactylus pulcher	X	*Delma butleri*	
Diplodactylus squarrosus	X	*Delma nasuta*	
Diplodactylus stenodactylus	X	*Lialis burtonis*	
Gehyra variegata	X	*Pletholax gracilis edelensis*	X
Heteronotia binoei	X	*Pygopus lepidopodus lepidopodus*	
Nephrurus levis occidentalis	X	*Pygopus nigriceps*	X
Rhynchoedura ornate			
Strophurus michaelseni	X	**Agamidae (dragons)**	
Strophurus strophurus	X	*Ctenophorus maculatus badius*	
		Ctenophorus maculatus maculatus	X
Scincidae (skinks)		*Ctenophorus reticulatus*	X
Ctenotus australis	X	*Ctenophorus scutulatus*	X
Ctenotus fallens	X	*Lophognathus longirostris*	
Ctenotus pantherinus pantherinus		*Moloch horridus*	X
Ctenotus schomburgkii	X	*Pogona minor*	X
Cyclodomorphus branchialis			
Cyclodomorphus celatus		**Boidae (pythons)**	
Egernia kingii	X	*Aspites ramsayi*	X
Egernia stokesii badia		*Morelia stimsoni stimsoni*	
Lerista aff. muelleri B			
Lerista connivens		**Typhlopidae (blind snakes)**	
Lerista elegans	X	*Ramphotyphlops grypus*	
Lerista kendricki			
Lerista lineopunctulata	X	**Elapidae (elapid snakes)**	
Lerista macropisthopus fusciceps		*Demansia calodera*	X
Lerista planiventralis	X	*Furina ornata*	
Lerista praepedita	X	*Pseudechis australis*	X
Lerista uniduo		*Pseudonaja nuchalis*	X
Lerista varia		*Rhinoplocephalus monachus*	
Menetia amaura		*Simoselaps bertholdi*	
Menetia greyii	X	*Simoselaps littoralis*	
Menetia surda	X	*Vermicella fasciolata*	
Morethia lineoocellata	X	*Vermicella littoralis*	
Morethia obscura	X	*Vermicella multifasciata*	
Tiliqua occipitalis	X		
Tiliqua rugosa	X		
Varanidae (monitors)			
Varanus brevicauda			
Varanus eremius	X		
Varanus gouldii	X		

not only the released mammals, were recorded and measured. Elliott traps were added in September 2002 so that extant small native vertebrates could also be sampled over a larger area. The FMTP now covers 38 km of track within the release area and is sampled for four nights in each of autumn and spring each year. Trapping results are shown in Table 4. These indicate that both bilbies and woylies have declined, at least in the survey area. Bilbies may have declined because of movements away from the trapping area, however woylies are more sedentary and the population has probably truly declined. A range of small vertebrates are also trapped along these transects and these trap success rates have generally increased.

Comprehensive track counts

As mentioned above, the Comprehensive Track Count (CTC) commenced in 1995 to assess, monthly, the relative abundance of fauna, primarily the introduced species. This method has also been used to assess the relative abundance of some larger remnant native fauna species – euro, echidna and emu. Recently, other species that have been released onto the peninsula have also been recorded, including malleefowl, woylie, hare-wallaby and bilby.

Results of the native species recorded on the CTC are shown in Figure 8. Increases in the linear average of track counts for the euro, echidna and emu suggest a higher number of these animals in the FPNP since fox/cat control was implemented.

TABLE 3

Location and description of small vertebrate monitoring grids on Peron Peninsula.

GRID #	GPS LOCATION (UTM, NE CORNER OF GRID)	DESCRIPTION	COMMENTS
1	49 754555 E71 44262 N 5.0 km north of Peron Homestead on Cape Peron track	Shrubland of *Lamarchea, Hemichroa, Scaevola, Cassytha* and *Acacia* on red/orange sands.	Long unburnt
2	49 754573 E71 44019 N 4.8 km north of Peron Homestead on Cape Peron track	Shrubland of *Lamarchea, Hemichroa, Scaevola, Cassytha* and *Acacia* on red/orange sands.	Long unburnt
3	49 753622 E71 47881 N8.9 km north of Peron Homestead on Cape Peron track	*Triodia plurinervata* with scattered *Acacia* shrubs on red / orange sands.	Long unburnt
4	49 753780 E71 48985 N 10.1 km north of Peron Homestead on Cape Peron track	Formerly *Acacia* shrubland and *Triodia plurinervata* on red/orange sands. After the burn now dominated by *Lycium australe.*	Burnt March 1997
5	49 754557 E71 63247 N 200 m south of Herald Bight camp area.	Coastal heath on white sand dune grading into *Acacia* shrubland on red sands.	Long unburnt
6	49 754370 E71 63589 N 150 m north of Herald Bight camp area	Coastal heath on white sand dune grading into *Acacia* shrubland on red sands.	Long unburnt
9	49 754312 E71 49252 N	Formerly *Acacia* shrubland and *Triodia plurinervata* on red/orange sands. After the burn now dominated by *Lycium australe.*	Burnt March 1997
10	49 754559 E71 49265 N	Formerly *Acacia* shrubland and *Triodia plurinervata* on red/orange sands. After the burn now dominated by *Lycium australe.*	Burnt March 1997
11	49 753912 E71 48627 N	*Triodia plurinervata* with scattered *Acacia* shrubs on red / orange sands.	Long unburnt

TABLE 4

Trap success rate (as a percentage) of the main species caught in traps along the road transects during the Fauna Monitoring Trapping Program on Peron Peninsula. (Note: Elliott traps only added to transects in 2002, bilbies and hare-wallabies released in 2000and 2001 respectively).

SPECIES	SEPT 1998	DEC 1998	NOV 1999	MAR 2001	SEPT 2001	APRIL 2002	SEPT 2002
Bettongia penicillata	0.25	0	0.7	2.2	1.25	0.7	0.3
Macrotis lagotis	-	-	-	1.8	1.1	0.3	0.4
Lagostrophus fasciatus	-	-	-	-	0.7	0.1	0
Notomys alexis	-	-	-	5.2	1.1	6.6	9.2
Pseudomys hermannsburgensis	-	-	-	0	0	0	1.6
Mus domesticus	-	-	-	0	0	0	1.4
Felis catus	-	-	-	0.4	0.2	0	0
Varanus gouldii	-	-	-	1.2	1.4	0.4	2.5
Tiliqua rugosa	-	-	-	0	0.5	0	1.6
T. occipitalis	-	-	-	0	0.1	0	0.3
Thick-billed grasswren	-	-	-	0.3	0.2	1.5	1.5

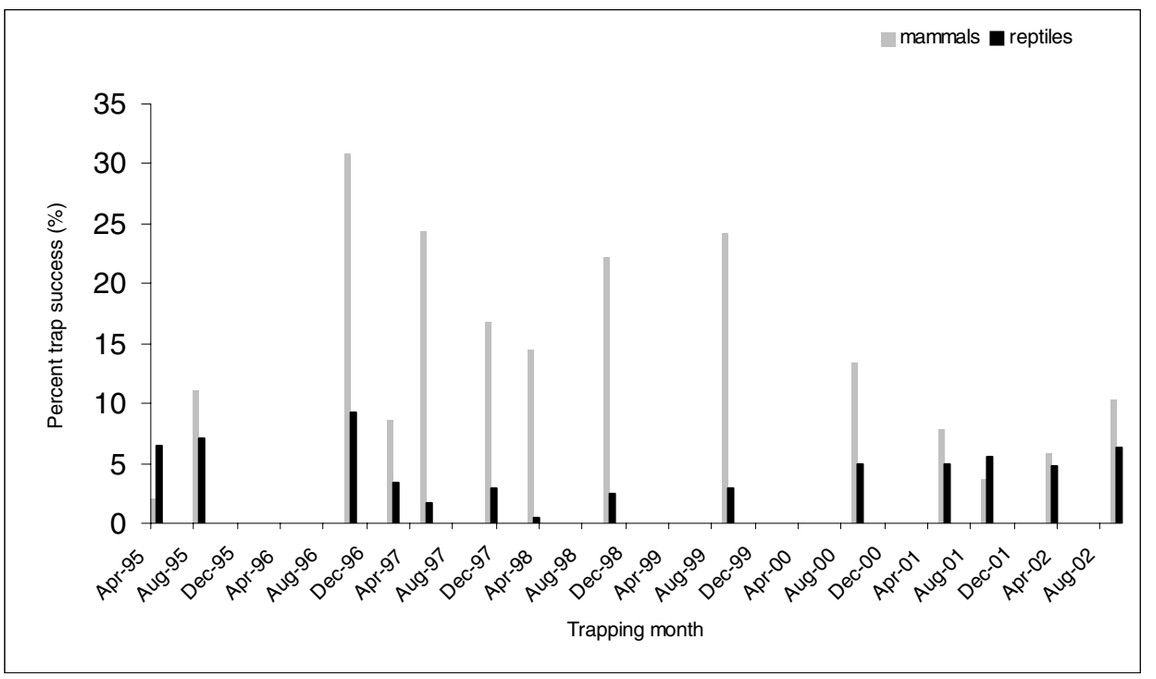

Figure 7. Small vertebrate captures on the trapping grids.

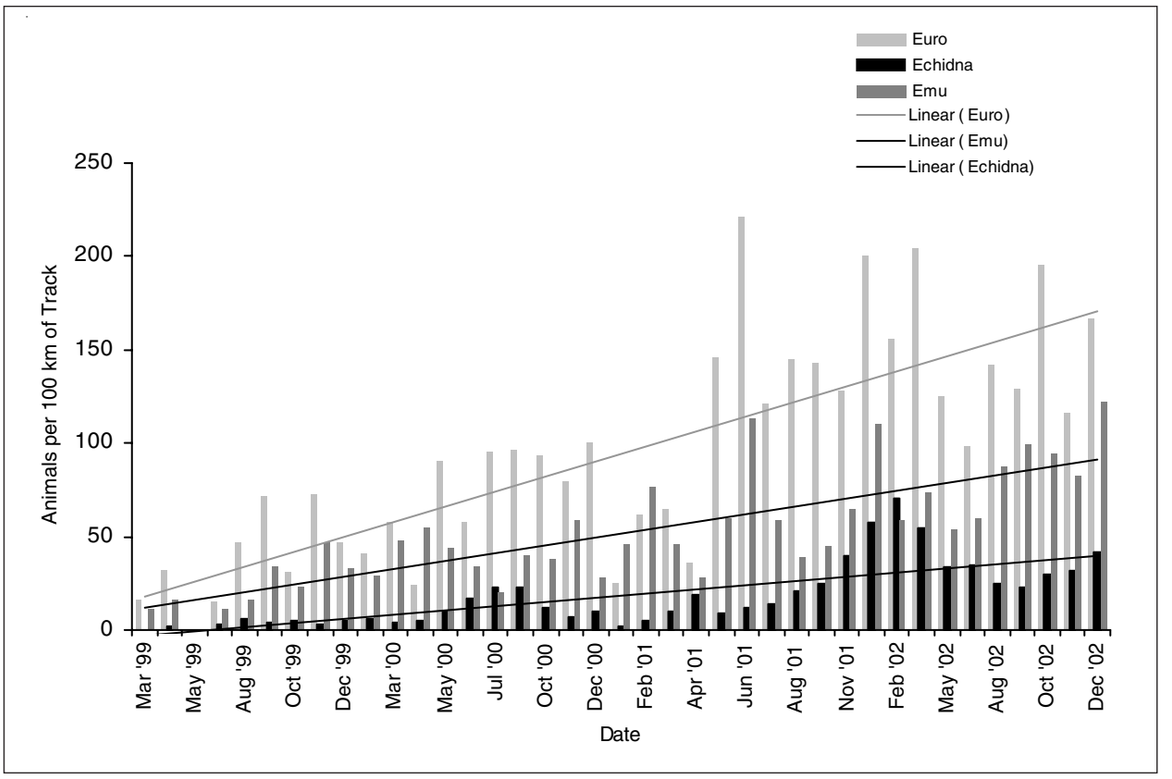

Figure 8. Average and linear trends of track counts of euro, emu and echidna on the CTC transect on Peron Peninsula.

Results and adequacy of monitoring

While there has been some variation in the frequency and timing of fauna monitoring, this aspect of *Project Eden* has been standardised since March 2001 and is now providing valuable information on fauna responses to changes in predation pressure and climatic variation (particularly rainfall) in an arid environment. This is one of the longest running fauna monitoring programs in arid areas of WA.

On the trapping grids, the small mammals and reptiles appear to respond more to rainfall events rather than reductions in fox and feral cat abundance. High trap success rates appear to follow a good rainfall year. However Risbey *et al.* (2000) has demonstrated the detrimental impact of feral cats on small vertebrates at Heirisson Prong and maintaining low numbers of feral cats (as well as foxes) on Peron Peninsula will no doubt benefit this fauna, allowing more rapid recovery after poor rainfall periods. The larger extant fauna appears to have benefited from fox and cat control.

Trapping along road transects has shown an increase in trap success of hopping mouse (*Notomys alexis*), goanna (*Varanus gouldii*), bobtail skink (*Tiliqua rugosa*) and blue tongue skink (*T. occipitalis*). Anecdotal evidence suggest that the larger king brown (mulga) snake (*Pseudechis australis)* and echidna have also increased. Opportunistic sightings of adult and juvenile woma pythons (*Aspidites ramsayii)* have also increased in the last 3–5 years and six adults were radio-tagged in 2003 to investigate habitat requirements and behaviour of this threatened species.

Future

Monitoring of fauna on Peron Peninsula will continue using the small vertebrate monitoring grids, comprehensive track counts and road transects. Two additional trapping grids were established in the dominant *Acacia ramulosa* (wanyu) shrub land in 2003 and an additional trapping session in winter will be added to the existing spring and autumn survey periods.

This comprehensive monitoring program will enable the success of translocations to be assessed as well as providing long-term information on fluctuations in remnant fauna populations in the arid zone.

CAPTIVE BREEDING

Introduction

Initially, captive breeding on site was not proposed for *Project Eden*. It was intended that animals for translocation would be sourced either directly from the wild, or from other captive breeding facilities, such as Perth Zoo, or Monarto Zoo, South Australia (Morris 1995). However, in 1996 CALM agreed to the establishment of the Peron Captive Breeding Centre (PCBC). This allowed species that were restricted to Bernier and Dorre Islands (such as the banded hare-wallaby and western barred bandicoot), or with limited mainland distributions (such as bilby and malleefowl) to be bred in sufficient numbers for translocation without compromising the viability of the small wild populations. Additional staff were employed to manage this facility and Commonwealth World Heritage Funds obtained in 1996/7 to construct the pens and to collect founder animals from Bernier and Dorre Islands. Ongoing support from the World Heritage fund had been received until 2002/03.

Of the 15 mammal species that are now extinct on Peron Peninsula, up until November 2002 the following species were sourced from elsewhere and bred at the PCBC for translocation:

- bilby *(Macrotis lagotis)*
- western barred bandicoot *(Perameles bougainville)*
- banded hare wallaby *(Lagostrophus fasciatus)*
- mala *(Lagorchestes hirsutus* mainland form*)*

Other mammal species considered suitable for translocation are listed in Table 7 and would either be captive bred elsewhere, or taken directly from the wild (see Translocation below). In addition, the malleefowl *(Leipoa ocellata)* was selected for artificial hatching and captive rearing to complement the excellent work done by community groups in the WA wheatbelt in conserving this species.

TABLE 5
Numbers of animals involved in the captive breeding program on Peron Peninsula.

SPECIES	SEX	FOUNDER #	TRANSFERRED TO OTHER FACILITIES	RELEASED ON PERON PENINSULA	RESIDENT (AS AT NOV 2002)	TOTAL ANIMALS
Western barred bandicoot	female	18	7	0	16	23
	male	12	4	0	15	19
Banded hare-wallaby	female	13	0	6	17	23
	male	12	0	12	21	33
Bilby	female	10	1	30	20	51
	male	13	5	24	15	44
Mala	female	18	0	7	26	33
	male	11	0	9	21	30
Malleefowl	not sexed	105 eggs collected, 90 hatched	0	67	0	67
TOTAL		**197**		**155**	**151**	**323**

The numbers of founders for each species are shown in Table 5. The PCBC is a member of the International Species Inventory System (ISIS) and provides updates on the breeding colony for international databases, and the Australian Bilby Studbook.

Reasons for captive breeding at Peron

Captive breeding was undertaken at Peron for several reasons:

- Financial and logistical limitations to source large numbers of animals from wild populations.
- The small size and fragility of remnant island and mainland populations, making it susceptible to decline from removal of large numbers of individuals and disturbance from capture activities necessary in translocations.
- At the time, there was no captive breeding of the required species in WA.
- Acclimation of the animals to the habitat and environmental conditions that they were to be released into.
- Significant financial support from the Shark Bay World Heritage Area and consequent Commonwealth funding.
- Requirement for the Department to maintain control over captive breeding and management of species.

Facilities

The facilities at the PCBC comprise animal breeding and holding pens covering approximately 1.5 ha. and an animal health facility. The first animal pens were those constructed in November 1996 to house malleefowl chicks. These were later used to house surplus bilbies. Thirteen dedicated bilby pens, capable of holding 33 animals, were constructed in 1997 and 1998. Thirty-two dedicated western barred bandicoot pens, capable of holding 64 animals, were built in 1998. Thirty-five pens to hold up to 95 mala and banded hare-wallabies were built in February 1998.

The animal health facility comprises two transportable buildings which house staff facilities, food preparation area, veterinary treatment room, laboratory and cage room/intensive care, and a storeroom. The facility has its own generator for power supply and battery back-up. Brackish water is provided from an artesian bore at the Peron Homestead and fresh water is carted from Denham.

Results

The total number of animals produced at the PCBC between 1996/97 and November 2002 was 216. This figure is derived from the total animal number (323) minus the number of mammal founders (107) (Table 5). The total cost of producing these animals was approximately $898 000 (Table 6), or $4157 per animal. CALM contributed 42% of these costs, or $1759 per animal. Total maintenance costs per animal, that is without capital expenditure included, was $3120 per animal.

Malleefowl

Malleefowl eggs were collected from several sites in the northern wheatbelt in December 1996 and again in November 1997, and incubated to hatching in Denham. In 1996, 56 eggs were collected and 50 of these hatched successfully. Eight of these chicks subsequently died for various reasons. In September 1997, another 49 eggs were collected and 40 of these hatched successfully. A total of 67 malleefowl have been released at 6–12 months of age.

The artificial incubation and captive rearing of chicks to 6–12 months of age proved extremely successful at PCBC. Overall success rate from 105 eggs collected to 67 birds released was 64% (86% hatching success and 74% 'fledging success').

Eggs were collected from 18 different mounds (an effective founder population of 36 individuals), providing a good theoretical representation (> 98%) of the heterogeneity of the wild population, and an excellent basis for establishing a new population. This large number of birds released with a high estimated survival of radio-tagged birds, influenced the decision to discontinue further releases unless monitoring of the released population indicated a need to supplement at a future date. Subsequent monitoring has indicated good recruitment and dispersal and there is no need for further captive breeding or translocations at this stage.

TABLE 6

Costs of establishing and maintaining the Peron Captive Breeding Centre. (External funds in 1997/98 were from the Coles Bilby fund and World Heritage funding, other years only from World Heritage).

YEAR	CAPITAL EXPENDITURE $		MAINTENANCE EXPENDITURE $		TOTAL $
	CALM	EXTERNAL	CALM	EXTERNAL	
1996/97	14 000		30 000		44 000
1997/98		140 000	62 000	30 000	232 000
1998/99		50 000	62 000	31 500	143 500
1999/00			62 000	53 500	115 500
2000/01	6 000	14 000	64 000	76 000	160 000
2001/02			64 000	99 000	163 000
2002/03			16 000	24 000	40 000
TOTAL	**20 000**	**204 000**	**360 000**	**314 000**	**898 000**

Bilby

The bilby captive breeding program commenced in August 1997 with 10 wild caught animals from the Pilbara and Kimberley regions of WA. Additions to the breeding stock have been made from other captive colonies (Kanyana, Alice Springs Desert Park, and Monarto), as well as additional wild caught animals. All have come from either WA or the Northern Territory, none from western Queensland, as these are considered to be a different stock. Up until October 2002, 72 bilbies have been raised to adult at Peron and 55 of these have been released into Francois Peron National Park. In addition, seven animals have been traded with either Kanyana or Monarto. Over the five years of this program, 32 of the total of 140 bilbies born have died, however the colony has still increased by a factor of three in this time.

The strategic plan recommended topping up the bilby population in FPNP for up to five years. Captive breeding needs to continue to allow this to occur and additional wild caught animals would benefit the colony and the Australia-wide captive animal gene pool. Captive bred bilbies from Peron could also be used for translocations to other parts of mainland WA as part of the broader *Western Shield* program.

Western barred bandicoot

Thirty western barred bandicoots (18 female, 12 male) were captured by hand on Bernier Island (Red Cliff and Hospital Landing) in April 1998 and transported to the PCBC by helicopter. Initially the rate of breeding success for the bandicoots was high, reaching sufficient numbers for translocation by early 2000 (~80 animals in the first 2 years despite the population remaining un-supplemented). However, feral cat control had not been as successful as hoped and release plans were suspended. Breeding had to cease to stop overcrowding in the pens, as there were no alternative release sites available. Efforts to re-engage the breeding program in early 2001 were unsuccessful and the captive population had declined to 42 animals by September 2002. In addition *Chlamydia* infections and a wart like disease became prevalent at the PCBC and other captive colonies (Bodetti *et al.* 2003) and an intensive research program was commenced with Murdoch University to try to determine the cause of this, and any treatment. This is an unresolved issue with this species in captivity, but a nationwide interagency working group was established for its investigation. Nearly half (41/83) of the colony has died over five years, an annual mortality rate of 11%, and the colony has only increased marginally in this time (from 30 to 42 animals). Until the issue with disease can be resolved, it is considered that this colony is currently unviable and it is being wound down, whilst still contributing to investigation of disease entities discovered in many captive and some wild populations. Faure Island has been identified as a suitable reintroduction site for western barred bandicoots, however founder stock would need to be sourced from disease free locations (possibly Heirisson Prong or Dorre Island).

Banded hare-wallaby

Twenty-five banded hare-wallabies (13 females, 12 males) were collected by hand on Bernier Island (Red Cliff Bay and Hospital Landing) in April 1998. A total of 31 have been raised successfully at Peron and 18 of these were released into FPNP in July 2001. This colony has had an annual mortality rate of 5.4% (18/74 have died over 4.5 years), however the population has still increased two fold in this time. Because of the seasonality of breeding and long pouch life in this species, rate of population increase is not as rapid as initially expected.

The banded hare-wallabies released in July 2001 did not persist because of excessive feral cat predation (Hardman 2003) and no further releases of this species will be made until feral cat abundance has been reduced significantly. Captive breeding will continue so that sufficient numbers (*ca.* 40 animals) are available for release. Captive bred banded hare-wallabies from PCBC could also be used for translocations to other parts of mainland WA. Faure Island has been identified as a suitable site for reintroduction of this species.

Mala

Twenty-nine mala (18 female, 11 male) were taken from the 'Mala Paddock' in the Tanami Desert by Parks and Wildlife Commission of the Northern Territory staff and Aboriginal custodians in July 1999. Mainland mala were selected over the Bernier / Dorre Island animals for *Project Eden* because genetic variation is greatest in the mainland form and an abundant and easily accessed population existed in the Northern Territory. It was also believed that these animals would be better arid and predator adapted than the island animals.

This species has bred well in captivity and sufficient numbers were obtained for a release in July 2001 (1.6 years). There has been an annual mortality rate of 6.3% over three years (14 / 74 have died), however breeding has continued at a high rate. The mala colony is currently beyond capacity and additional holding pens are required. Breeding is currently being restricted until suitable release options, either at FPNP or elsewhere, are found.

Future

The captive breeding program at PCBC has been successful in meeting the objectives set for it in 1997 and the animals that are produced are healthy and adapt well when released.

PCBC is able to continue its production of bilbies, banded hare-wallabies and mala under its current operations. Bilbies have been shown to be able to survive the current levels of cat abundance and ongoing restocking is required for at least the next three years. Bilbies could also be provided from the PCBC for other arid zone releases in WA. If feral cat abundances cannot be reduced below current levels, further releases of banded hare-wallabies and mala at Peron will probably not proceed. If cat control at other mainland sites is shown to be more

effective, the PCBC could provide these species for translocation. Further captive breeding of western barred bandicoots will not occur at the PCBC unless the disease issue can be managed.

The PCBC is well placed to be able to provide animals for arid zone releases. There is already substantial infrastructure and expertise in place and the animals would be acclimatised to an arid environment. It has also demonstrated that it can produce the animals when required. The PCBC has the capacity to produce large numbers of bilbies, banded hare-wallabies and mala for both ongoing *Project Eden* translocations, or translocations to other sites. However, some issues need addressing for this to proceed effectively:

- Program for release of captive bred animals at PCBC – no further release of 'cat sensitive species' such as mala and banded hare-wallabies will be made at FPNP until feral cat numbers are significantly reduced. If this cannot be achieved in the next 12–24 months alternative release sites will need to be found for these species. It is likely, however, that other potential mainland release sites will also need to be able to effectively control feral cats before any further releases are undertaken. Other options for release sites of PCBC animals include Faure Island and Dirk Hartog Island.
- The disease issue with the western barred bandicoots needs to be resolved before any further captive breeding occurs at PCBC (or elsewhere). This obviously impacts on planned translocations of this species on the WA mainland.
- The staff workload involved in managing the husbandry (especially maintaining the hygiene of enclosures) was significantly under-rated, so staffing requirements were under-estimated at 2 full-time staff. There are currently 2.5 full time staff dedicated to the PCBC and this is 0.5 to 1.0 staff short of what is required to manage 120–170 animals in captivity. This gap has been partially filled with the use of volunteers, however their availability is limited and sporadic.
- The original design of enclosures was based on the production of smaller numbers of progeny (15–20) that would be released more frequently in a flow-through type situation. Hence there is not sufficient accommodation to hold animals until the required 40–50 animals are available for a single release (while maintaining a core ongoing breeding group). This situation, along with the delayed release date for several species, has created significant overcrowding issues that aggravate the inadequate staffing situation and affect health, stress levels, and reproductive rate within the colony. An additional, large (100 ha.) pen is required to hold large numbers of animals (up to 100), an estimated cost of approximately $120 000.
- Commitment by CALM to fund the complete running costs of PCBC as continued World Heritage Funding is insecure and would be inappropriate if the PCBC was producing significant numbers of animals for release outside of Shark Bay World Heritage Area. This amounts to approximately $100 000 annually.

TRANSLOCATIONS

Introduction

The original draft Operations Plan for reintroductions (Morris, 1995) planned the translocation of seven mammal species. These species were determined on their previous presence on Peron Peninsula (Baynes 1990, Table 1) and on the availability of founder animals for either direct release or captive breeding. The draft strategic plan for captive breeding and translocations (Morris and Sims 1997) proposed 11 species of mammal and the malleefowl be translocated to Peron Peninsula (Table 7). Most of the species identified for translocation are listed as threatened under the WA *Wildlife Conservation Act* 1950 and the Commonwealth's *Environment Protection and Biodiversity Conservation* Act 1999. Since 1997, four mammal species (woylie *Bettongia penicillata*, bilby *Macrotis lagotis*, banded hare-wallaby *Lagostrophus fasciatus*, and mala *Lagorchestes hirsutus*) and the malleefowl *Leipoa ocellata* have been translocated to FPNP.

All species selected for translocation, except the bilby, were species that had been previously recorded on Peron Peninsula, either as historical or sub-fossil specimens, but were no longer present in 1995 (Baynes 1990, Blakers *et al.* 1984). Another sub-fossil deposit survey was undertaken in 2000 (Baynes 2000) to further search for evidence that bilbies may have existed in Peron Peninsula. None was found, however additional sub-fossil evidence of several additional species were found and included on the list for potential translocations. There had been an unconfirmed report of a bilby at Hamelin Station in 1980 (Peter Mawson, pers. comm.) and the habitat on Peron Peninsula was considered suitable for this species. The bilby was also continuing to decline in WA and translocation to a more secure site was considered to be beneficial to the overall conservation of this species. The translocation of this species (as a reintroduction) was approved in August 2000.

Given that the malleefowl, woylie and bilby had persisted on the mainland in the presence of introduced predators, albeit at reduced distribution and abundance, these species were selected for initial releases at FPNP. Following good early signs of persistence of these species, trial releases of the more vulnerable banded hare-wallabies and mala were undertaken in July 2001. Translocation Proposals were approved for all translocations.

Malleefowl

Release and monitoring

The malleefowl was the first species to be hand raised and released into FPNP. In 1996 and 1997, 105 eggs were collected from 18 active malleefowl mounds within the Wheatbelt, Kalbarri National Park and Nanga Station, and

TABLE 7
Speices identified as potentially suitably for translocation to Peron Peninsula.

	MORRIS 1995	MORRIS 1997	FOLLOWING 2000	TRANSLOCATED 1996–2002	PERSISTING 2002–?
Woylie *Bettongia penicillata*	x	x	x	x	yes
Western barred bandicoot *Perameles bougainville*	x	x	x		
Rufous hare-wallaby *Lagorchestes hirsutus*	x	x	x	x	no
Banded hare-wallaby *Lagostrophus fasciatus*	x	x	x	x	no
Shark Bay mouse *Pseudomys fieldii*	x	x	x		
Greater stick-nest rat *Leporillus conditor*	x	x	x		
Tunney's rat *Rattus tunneyi*		x	x		
Chuditch *Dasyurus geoffroii*	x	x	x		
Red-tailed phascogale *Phascogale calura*	?	x	x		
Golden bandicoot *Isoodon auratus/* Quenda *Isoodon obesulus*	?		x		
Brushtail possum *Trichosurus vulpecula*			?		
Mulgara *Dasycercus cristicauda*		x	x		
Bilby *Macrotis lagotis*		x		x	yes
Malleefowl *Leipoa ocellata*		x	x	x	yes
Dibbler *Parantechinus apicalis*			x		

artificially incubated at the PCBC. Between 1997 and 1998, a total of 67 individuals between 6–12 months of age, were released onto FPNP, in groups of 3–5 birds, at 14 separate release sites. All were fitted with a permanent metal leg band and 24 (36%) were fitted with a radio transmitter in the form of a perishable necklace. Bird mortality and location was monitored for up to 6 months.

Adequacy of monitoring

Radio tagged birds were tracked daily, initially, and at least weekly after this, until the collar failed. Information obtained, included mortality, general location and dispersal movement. A small number of birds were tracked more intensively to provide more accurate locational data (bi and tri-angulation) and a rough indication of home range. These data are insufficiently detailed to provide statistically significant conclusions on home range sizes, but was sufficient to provide the important information (survival, activity and dispersal) to assess early success of the translocation.

Monitoring since the end of radio-tag life, has primarily involved incidental records of malleefowl tracks and bird sightings, along with the monthly CTC, and these are the current methods for monitoring the population. The search for new malleefowl mounds is on going and *ad hoc*, based primarily around other species monitoring activities and some targeted ground searches where high track activity has been observed. All of the known mounds are regularly monitored three or four times a year for nesting activity.

The CTC provides a standard 'transect' for monitoring dispersal and relative abundance, and along with incidental bird sightings, has been sufficient to assess population health over the long term. More regular monitoring of standard off track transects/grids would have been preferred, but shortage of skilled personnel and difficulty of terrain has prevented this. Reporting of bird sightings by staff and the public has been inconsistent and probably actually declined as the species has become more commonly seen.

Summary of results

During the initial monitoring there were no records of cat predation on any of the radio tagged animals, and the survival rate of released animals in the first six months was estimated at 90%. The sighting and track reports (Figure 9) suggest that the birds have dispersed throughout FPNP and into the southern part of Peron Peninsula. The sighting of a number of sub-adult birds plus animals without leg bands suggest that this species has established well and several new chicks have been observed since the 2002/03 nesting season. The first active malleefowl mound was discovered in 2000, with a total of six active mounds recorded to date. Malleefowl may commence mound building at one year old, but generally successful breeding does not occur until animals are greater than two years old. It is considered that this reintroduction has been successful and no further captive breeding or translocations are necessary. Monitoring of malleefowl abundance from CTC track counts, bird observations and nesting mound activity will continue.

Woylie

Release and monitoring

One hundred and forty seven woylies sourced from Dryandra Woodland and Batalling State Forest have been translocated to nine release sites in FPNP under different seasonal conditions, between 1997 and 2000 (Table 8). The Batalling population had been founded on animals translocated from Perup in 1983. Thirty-four woylies were fitted with mortality sensing radio-collars. The first release of 12 radio-collared Dryandra woylies, involved releasing animals from a fenced enclosure at the release site after 1–2 weeks orientation and acclimation. After the initial trial release all subsequent animals were released directly into the wild ('hard' released), except for the group released into an opened, soft release pen in September 1999. There is no evidence that survivorship was dependent on release methodology (Table 8).

The second and third releases of 49 Batalling animals (8 radio tagged) occurred 4-5 weeks after the first (in late spring 1997). Early monitoring involved trapping along road transects near release sites and known locations of animals. The Fauna Monitoring Trapping Program (FMTP) was implemented in autumn 2001, as a biannual trapping session on a standard 'transect', run along the road network within the release area (encompassing all release sites).

Adequacy of monitoring

Animals were collared and radio tracked between 1997 and 2000. All first release animals were radio tagged and survival monitored over 2-3 wks before further releases were approved. First release animals were trapped and condition assessed prior to subsequent release. This monitoring intensity, however, failed to adequately predict the apparent poor survival of second/third release animals. Individuals from the first 2 release groups were monitored for mortality almost daily up to 9 months post release.

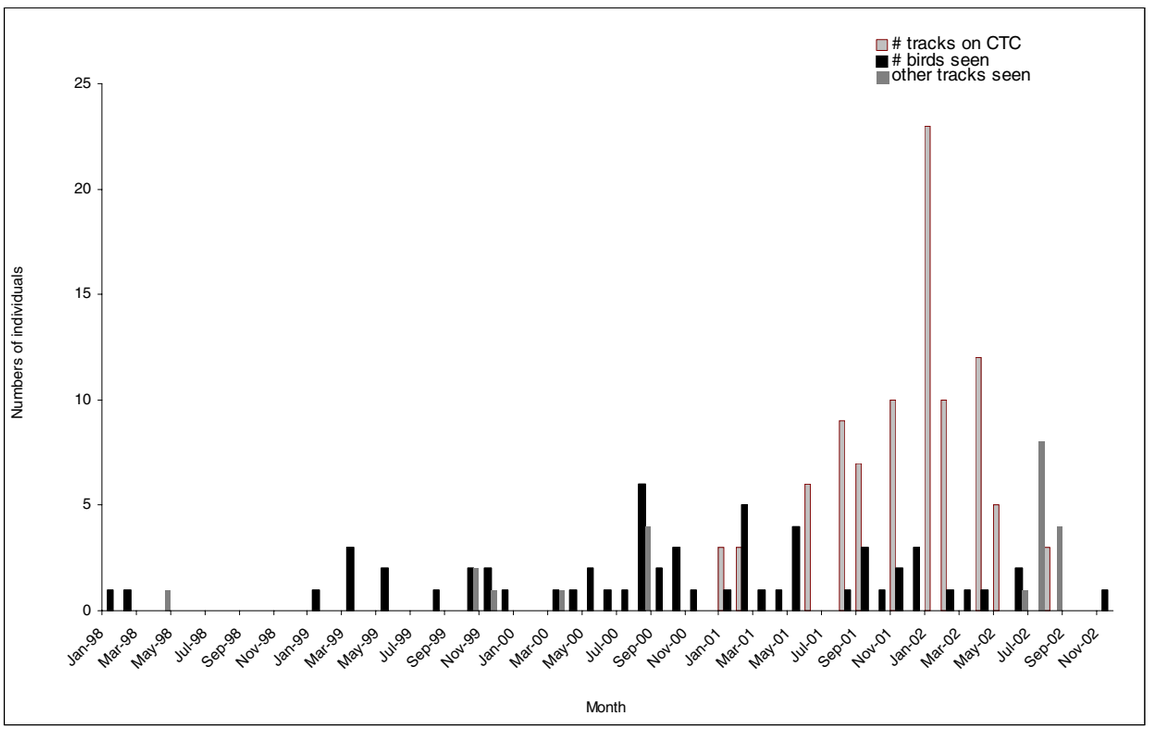

Figure 9. Number of malleefowl observations on Peron Peninsula.

TABLE 8
Details of woylies released into Francois Peron National Park.

DATE	RELEASE SITE	RELEASE TYPE	MALE	FEMALE	TOTAL	# RADIO COLLARED	SOURCE	# DEAD	KTBA AFTER 12 MONTHS
23/9/97	Woylie track	soft	8	4	12	12	Dryandra	4	5
29/10/97	Woylie track	hard	13	10	23	8	Batalling	6	1
4/11/97	Cyanide track	hard	13	13	26	0	Batalling	0	0
15/7/98	10 mile	hard	10	6	16	4	Dryandra	0	2
24/9/99	Woylie track	soft	5	8	13	4	Dryandra	1	4
24/9/99	Woylie track	hard	4	3	7	2	Dryandra	1	2
24/9/99	Aerial track	hard	4	10	14	4	Dryandra	0	1
13/9/00	Warren	hard	5	7	12	0	Dryandra	0	0
13/9/00	Cape Rose track	hard	5	7	12	0	Dryandra	0	1
13/9/00	Graveyard track	hard	5	7	12	0	Dryandra	0	1
TOTALS			**82**	**75**	**157**	**34**			

The intensity dropped off there after, to every couple of months dependent on available personnel, resulting in inconclusive identification of cause of mortality in several cases (although none were attributed to cat predation as the carcasses were intact). The releases in 1998 and 1999 only had follow up intensive radio tracking periods for the first 2–3 months, with intermittent tracking of animals every couple of months there after. Only five animals were tracked to their nests, with only 15 nests discovered.

From July 1998 to March 2000, more effort was put into trying to find the released animals through targeted trapping every 3–4 months in areas where woylies were known to be. This monitoring was insufficient to provide information on population dispersal and growth. In an effort to develop a non-biased method of monitoring the released population, the Fauna Monitoring Trapping Program (FMTP) was implemented in 2001, when a full time reintroduction officer was employed. In 2002, woylies were again fitted with mortality-sensing radio-collars and targeted trapping was employed (in addition to the FMTP) to determine the possible cause of the population decline that had occurred over the previous 18 months.

Results

The translocation of woylies to FPNP was the first time this species had been reintroduced to an arid environment within its former range. In 1999, a review of progress of woylie translocations 1997-8 to FPNP was prepared (Speldewinde and Morris 1999). Of the first 20 collared animals released, seven died within three weeks (8% of first Dryandra, and 26% of Batalling radio tagged animals), possibly due to environmental / heat stress. Of the October 1997 release only one animal out of 23 individuals was known to be alive after 12 months, compared to five out of 12 for a release that occurred one month earlier, in September 1997. Similarly, none of the 26 woylies that were released in November 1997 was known to be alive after 12 months. Woylies shelter in above ground nests during the day and by October / November daytime temperatures in Shark Bay can reach > 35°C, which could be lethal to woylies without an adequate thermal refuge. Subsequent releases were made earlier in the year, in July 1998 and September 1999 and 2000. In addition, subsequently all animals were sourced from Dryandra as these were believed to be more arid adapted than the Batalling forest stock. However of the 70 woylies released in 1999 and 2000, only 9 were still known to be alive after 12 months. Twelve woylies were found dead, but mortality was not attributed to either fox or feral cat.

Targeted trapping at release sites resulted in a maximum of 32% of the released animals being caught as well as several new recruits. Most animals were in good body condition and most females showed evidence of breeding. Table 9 shows the number of recruits caught each year, from both target trapping and the FMTP. A total of 22 recruits have been recorded since October 1998, with evidence of breeding by second-generation animals. Table 10 shows the numbers of adults trapped during the FMTP.

TABLE 9
Number of woylie recruits trapped and radio-collared on Peron Peninsula.

YEAR	NUMBER OF WOYLIE RECRUITS TRAPPED	NUMBER OF MALES	NUMBER OF FEMALES	NUMBER OF WOYLIES RADIO-COLLARED
1998	1	0	1	1
1999	7	6	1	0
2000	3	2	1	1
2001	9	3	6	2
2002	2	1	1	2
TOTAL	**22**	**12**	**10**	**6**

TABLE 10
Number of woylies trapped during the Fauna Monitoring Trapping Program.

TRAPPING SESSION	TOTAL NUMBER OF WOYLIES TRAPPED	NUMBER OF MALES	NUMBER OF FEMALES	NUMBER OF NEW ANIMALS	NUMBER OF RECAPTURES
Autumn 2001	11	7	4	2	9
Spring 2001	9	3	6	4	5
Autumn 2002	5	3	2	1	4
Spring 2002	3	2	1	1	2

A recent drop in numbers of individuals caught in both targeted trapping and the FMTP (Tables 4, 9 and 10), suggest that the population may have declined over the last 18 months. As a consequence, radio-collars were fitted to all animals (9 in total – 3 founders and 6 recruits) caught in 2002, followed by intensive monitoring. From this, the first records of cat predation (33% of collared animals in 2002) on woylies on Peron Peninsula were obtained.

The woylie is still persisting on Peron Peninsula despite several factors (recent drought, poor initial selection of release season and/or source population, fluctuating cat numbers and predation pressure), which have probably contributed to its poor recruitment and precarious long-term population status over the last five years. The current population size may not be viable, but much has been learnt from the previous translocations. However, restocking with a large number (>100) of animals at a time when seasonal conditions are favourable and predation pressure at its lowest (winter), would determine if establishment of a long term, viable population is possible under the present predator levels. Use of mixed source animals and intensive monitoring of comparative survival and condition (genetic assessment of both source populations and recruited animals) would also resolve the question of potential unsuitability of Batalling woylies for all future arid land reintroductions.

Bilby

Release and monitoring

A total of 55 (25 male and 30 female) bilbies were released into five separate release sites in FPNP (most bred at the PCBC) between 2000 and 2002 (Table 11). Tail radio-transmitters were fitted to a proportion of all release groups. Two release techniques were compared to determine the most suitable strategy for future releases. The 'soft release' option involved holding a group of animals in a 3ha enclosure for 2–3 weeks before openings were made in the fence and they are able to leave of their own volition. The 'hard release' technique simply involved releasing a similar size group directly into the wild at the same time. In both soft and hard releases, bilbies were released at dusk into artificial burrows constructed from PVC pipe.

Adequacy of monitoring

A high proportion (53%) of bilbies released were fitted with mortality sensing, tail mounted, radio transmitters, with the tag replaced when the 2–3 month battery life expired. Animals were monitored 2–3 times weekly with regular visits and recordings of the burrows used.

TABLE 11
Numbers of bilbies released into Francois Peron National Park.

DATE	RELEASE SITE	RELEASE TYPE	# MALES	# FEMALES	TOTAL	# RADIO-COLLARED	# DEAD	KTBA AFTER 6 MONTHS
12/10/00	Woylie track	soft	2	3	5	5	2	4
24/11/00	Woylie track	soft	2	2	4	1	0	1
12/10/00	Cape Rose track A	hard	2	1	3	3	0	2
16/11/00	Cape Rose track A	hard	2	3	5	4	1	4
23/5/01	Woylie track	hard	5	3	8	3	1	3
23/5/01	Cape Rose track B	hard	4	4	8	3	1	3
22/5/02	Cape Rose track A	hard	4	7	11	5	0	1
1/8/02	Cyanide track	hard	4	7	11	5	1	

Information obtained, included the type and number of burrows used, surrounding vegetation, general movement and mortality. Aerial searches were carried out when animals were unable to be found on the ground, however these are generally unsuccessful due to the limited range of the transmitters. Known burrows were trapped when emerging young were expected, and all release areas were trapped every two months.

The captures recorded in the FMTP provided a good unbiased comparison between trapping sessions to help determine the initial dispersal and survival of released Bilbies in the FPNP. However the FMTP is unlikely to be able to accurately estimate general population and recruitment levels, as it is generally recognised that 'wild' animals are extremely trap shy and captive-bred animals are generally more trappable. The recording of all tracks found through the monthly CTC and general observations by foot and vehicle throughout the FPNP is another technique used to show the distribution of dispersing animals.

The long term survival and dispersal of released bilbies was difficult to determine due to the short life and limited range of radio-tags that can be used on this species. Animals that were been tracked for up to 12 months suddenly disappeared and it was not clear if they have died or moved away. Some individuals were recaptured some distance from initial release areas suggesting that bilbies are quite nomadic and will move quite suddenly to a new area. More information on the dispersal patterns of this apparently mobile species is required, particularly if this species is to be translocated to other mainland sites. Of particular interest is the relationship between movement patterns and climatic events, such as rainfall and the impact these may have on food and refuge resources. This can only be resolved by tagging individuals with longer life (>12mths) and greater range (3–5 km) transmitters. This may require reconsidering the possibility of using an appropriate neck mounted collar transmitter, rather than the tail mounted transmitters currently in use.

Similarly, the reluctance of wild individuals (hence recruits) to go into traps made monitoring of recruitment and population dispersal difficult. The long term monitoring of burrowing/foraging activity and tracks is the most likely method that will give an indirect measure of population abundance. Continuing CTCs and a planned program of standard track surveys after rain will be employed to provide this information.

Because of the unknown movement patterns of bilbies, and their difficulty to trap, the actual location and survivorship of a high proportion of the released animals was unknown. While 81% of the released animals were known to be alive after six months, only 7% were known to be alive after 12 months. To date no radio tagged bilby has been predated by foxes or feral cats. Four bilbies have been trapped in leg hold traps set to trap feral cats, and have had to be euthanased. Another two were found dead in their burrows. Regular target trapping in the release areas has shown that the animals are in good condition and that a high proportion of the females, are carrying pouch young. There have been five known recruits to the population since 2001, with evidence of breeding by second-generation animals.

It is too early to determine the long-term success of the bilby translocation. However, there have been no mortalities attributed to foxes and feral cats. Trapped animals are generally in good condition and breeding (including second generation) and recruitment is occurring. These factors suggest that bilbies may be able to persist with the current level of feral cat abundance and successfully establish on Peron Peninsula.

Banded Hare Wallaby and Mala

Both hare-wallaby species were released almost simultaneously and monitored in a similar fashion, so are treated together here.

Release and monitoring

Eighteen captive bred banded hare-wallabies (12 males and 6 females), bred at the PCBC, were released in two groups in July 2001 into FPNP. The 'soft' and 'hard' release strategies were trialled and every individual was fitted with a mortality sensing radio-collar. In August 2001 a group of 16 mala (9 males and 7 females), bred at the PCBC, were released at one 'soft' and two 'hard' release sites. All animals were fitted with a mortality sensing radio-collar.

All animals of both species were monitored on a daily basis for the first couple of months, easing off to every second day until no animals remained. Animals missing on ground searches for more than one week were searched for by aircraft. Mortality, daytime refuge sites, night time home ranges (triangulation) and habitat preferences were obtained for all animals. Faecal pellet collection for parasites and possible diet analysis also occurred. Intensive monitoring was facilitated by this work being undertaken as a Master of Science project by a student from Edith Cowan University (Hardman 2003)

Trapping of the animals in the soft release pen occurred before they were released as well as follow up trapping in the release areas 2-3 months after all animals had been released. Target trapping continued to occur every 3-4 months there after to check on body condition and reproductive status.

Adequacy of monitoring

These two species have been monitored the most intensively of all species released on FPNP to date, and reflects the additional assistance provided by the Masters student. He was able to collect valuable information on home range, mortality and the response of the species' to reintroduction in this environment. The intensity of the radio tracking enabled early detection of mortalities and thus relatively fresh carcasses. This enabled a more conclusive assessment (than in the case of woylies) of the cause of mortality plus the opportunity, in some cases, to act on the finding.

The use of aerial searches enabled most of the dispersing animals to be found, yet four animals (three banded hare-wallabies and one mala) remained unaccounted for. The availability of a student to spend many hours searching for missing animals and gathering refugia details and home range information was extremely beneficial.

The banded hare-wallaby was relatively easy to trap and this assisted in the relative high frequency at which they were captured. The difficulty of capturing the mala, and the stress involved in handling, limited the frequency that this species was trapped. The individuals of this species that dispersed should have been captured and checked more frequently for collar refits as this may have prevented some mortalities attributed to collar complications.

Results

The banded hare-wallaby population survived for 10 months in the presence of feral cats. Most of the animals exhibited an initial drop in weight 1–2 months after release, but most of this was the excess weight the animals were carrying as a result of being captive bred. Regular trapping there after showed that all animals were in good condition and their weight stabilised. As this species is a seasonal breeder there were no signs of breeding until autumn of 2002. While all females handled showed signs of breeding, no individuals were recruited to the population.

All banded hare-wallaby mortalities were attributed to cats, but most of these only occurred towards the end of a very dry year (2001) when other prey (particularly mice) was possibly less abundant. Cat predation tended to occur in clusters, with short periods of high mortality, followed by several months of no incidents. The six banded hare-wallabies that remained, by choice, at the hard release site, survived in the presence of cats for nine months, before all were killed in a 3–4 week period.

The mala persisted for nine months in the presence of cats in the immediate release area. All recaptured females were carrying pouch young and two animals were recruited to the population. Unfortunately the numbers gradually declined due to a combination of factors including cat and wedge-tail eagle predation, stress and collar related mortalities. This species also suffered an initial loss in weight before stabilising and this loosened the fitted radio-collars to the extent that front feet became caught and animals became hung up on vegetation. When only four animals remained alive they were held in the soft release pen for two months whilst an effort was made to reduce the number of cats in the immediate area. Two cats were caught in leg hold traps and when there was no further evidence of cats in the area, the mala were once again released. The remaining four animals were dead within one month of re-release. These results mirror those found by Gibson *et al.* (1994) and confirm the high vulnerability of mala to feral cat predation.

The Average Monthly Rainfall (AMR) figure for the year 2001 was 14 mm. During the 10 months that the animals were alive the AMR was 9mm, and the preceding 12 months was 14 mm. This dry period might have had an influence on the abundance of prey that the cat would usually prefer, thus forcing the predator to look elsewhere. This dry weather might also have affected the behaviour of the two species, making them more prone to predators.

The translocations of the banded hare-wallaby and mala were unsuccessful. All animals either died or are unaccounted for. Unfortunately the release of both hare-wallaby species coincided with a low rainfall year and small vertebrate fauna abundances were low. This may have increased the predatory pressure from feral cats on alternative prey species such as the hare-wallabies. The majority of both species did not disperse far from the release sites and their weights and body condition were good, suggesting that the release habitats were suitable. The mala were able to recruit to the population in the nine months of their survival, while three banded hare-wallaby females were close to weaning their young when they were killed 10 months after release. A successful translocation may be achieved by using a larger release group (> 40 animals at a time) in a more favourable year, which may be able to produce more recruits to offset any mortality. This may be particularly so for the mala where predation was a lesser cause of mortality.

Conclusions and future translocation plans

The original timeframe identified that translocations were to commence in 1997 and be completed by 2002, with ongoing monitoring after this date (Morris 1995). The woylie and the Shark Bay mouse (*Pseudomys fieldi*) were to be the first species released in 1997, followed by the greater stick-nest rat in 1998 and western barred bandicoot, mala and banded hare-wallaby in 1999. The chuditch (*Dasyurus geoffroii*), a native predator, was to be released after these other species had become established. All translocations would be dependent on 'satisfactory feral animal control' (Morris, 1995). The malleefowl and bilby were added to the species to be translocated in 1997.

Of the five species translocated to the FPNP, the malleefowl and bilby (and perhaps the woylie) are showing signs that they might be able to persist in the presence of the current level of feral cats. Even at lower levels of feral cat abundance the two hare-wallaby species failed to persist. Consequently it is unlikely that several of the other 'feral cat vulnerable' species identified for translocation to the FPNP, such as western barred bandicoot, greater stick-nest rat, and Shark Bay mouse, will be released unless feral cats can be controlled at significantly lower levels, or suitable refuge sites are identified. The chuditch and red-tailed phascogale have coexisted with feral cats at other mainland sites and may be suitable for reintroduction to FPNP. Clearly the list of mammal species suitable for translocation to Peron Peninsula needs to be reviewed.

Another strategy for ongoing translocations of 'cat sensitive species', for example, woylies and hare-wallabies in the presence of feral cats is to only release large numbers

of founders at times of abundant food supply, alternative prey for feral cats (rabbits and small native vertebrates) and thick refugia cover. Sinclair *et al.* (1998) recommend releases of the largest number of animals to increase the likelihood of successful establishment of prey species in the presence of introduced predators. They also proposed that releases into large areas of good habitat enhance survival as predators are less efficient in large patches. However, these measures do not replace the need to reduce the numbers of introduced predators, and should not be viewed as an alternative strategy, rather a complementary one.

Consideration also needs to be given to prevailing El Nino/La Nina drought cycles when planning translocations. Perhaps the best opportunity for establishing populations of small macropods and bandicoots on Peron Peninsula would be to construct a large (> 50 ha) cat proof enclosure which could function not only as a holding pen for larger numbers of captive bred animals, but also a protected refuge for self sustaining populations. Alternatively the neck of the 'peninsula' to the west of Big Lagoon could be fenced, cats eradicated in this smaller area, and native mammals released.

CALM Policy # 29 (CALM 1995) requires that a translocation proposal be prepared for the translocation of any threatened taxa in Western Australia. While details of post-release monitoring must be provided in this document, criteria for success or failure are not explicitly required. No criteria for success or failure were established for the *Project Eden* translocations. Obviously, total or near total loss of translocated individuals would indicate a failure (as happened with mala and banded hare-wallabies), however where a population may persist at low numbers for some time (for example, the woylie), the outcome of the translocation is less clear. Morris (2000) attempted to address this by suggesting that a series of sequential criteria might be appropriate. This is an issue for other *Western Shield* translocations as well and needs to be addressed across the program.

FIRE MANAGEMENT

Early aerial photographs of Peron Peninsula indicate that there has been a long interval since fire and probably only small patches of vegetation were burnt. However, anecdotal accounts from long time residents suggested that large fires are possible and that a large portion of the peninsula was burnt in the 1950s. A fire management plan was considered necessary once *Project Eden* commenced to protect translocated fauna and facilities. Two fire buffers, each 100 m wide were established as part of that strategy and have been utilised for gathering fire succession data on plants. In addition, a cleared 20 m firebreak was installed around the captive breeding facilities.

The fire buffers traverse the peninsula in an approximate east-west direction and roughly divide FPNP into three similarly sized areas. The buffers were installed in March 1997 using a combination of vegetation rolling and burning. Attempts at burning the *Acacia ramulosa* (wanyu) scrublands using standard aerial burning techniques used in forest areas, failed to get fire to spread, possibly because of the high salt content of the leaves. High salt content retards burning of plants even when the foliage is dry (for example see: http://www.rfs.nsw.gov.au/index.cfm?cid=87&the_start=7, and http//www.risklogic.com/Dec2003.html). At the time, tests of the *Acacia* shrubs showed salt loads for these shrubs to be in the order of 40 times that of shrubs for the forested areas in the South West (Ward 1997). Fire did burn well in the *Triodia* grassland dominated areas. Recovery of this habitat type has been slow in the six years post-fire, with new *Triodia* hummocks taking three years to become visible, and average hummock size in late 2002 only 10–20 cm in diameter.

In addition to providing protection from fire, these buffers provided an opportunity to examine the response of the native vegetation and fauna to burning. Regular monitoring of plant species composition and abundance has shown a shift in species composition between burnt and unburnt areas. More than one third of the species identified in the burnt areas do not appear in the long unburnt vegetation. However, by 2001, both burnt and unburnt plots had a significant increase in species composition. This was probably due to high rainfall events which favoured plant growth. It is also likely that these good conditions are promoting the recovery of vegetation from 100 years of sheep grazing. Fifty-one percent of the new species in the unburnt plots are different to those in the burnt plots and the burnt plots have about 58% of species uniquely different from unburnt plots. The majority of these species are shrubs suggesting a general recovery of vegetation. The small difference between burnt and unburnt plots may be the result of fire-induced species.

Vegetation transects to measure cover and structure in the undisturbed wanyu shrubland indicated that a third of the plants were dead and in a senescent state, which has most likely caused a reduction in productivity. This declining health and vigour of the vegetation requires that some habitat maintenance be done to restore vitality and provide optimum conditions for developing colonies of reintroduced animals. Many mammal and bird species depend on vegetation to provide food and shelter and once habitat suitability drops off they need new more suitable areas to move into. With the long interval since fire on the peninsula vast areas of the vegetation are in a similar state of decline.

Grazing pressure was also measured on the burn buffers by measuring species diversity of plants outside of the fenced plots and comparing with results from plot data. This showed that there was a dramatic reduction (70%) in species diversity and abundance for the grazed areas. Most of the grazing was from goats and rabbits and observations showed that rabbits were digging down beside the newly sprouting plants and eating the fleshy parts below ground. This has had a serious impact on

vegetation recovery for the burnt ground and for future burning operations rabbit and goat control should be factored in as part of the operation.

It is recommended that patch burning be used in FPNP to promote plant growth and diversity, and hence provide suitable habitat for translocated fauna species. Rabbits and goats should be controlled in recently burnt areas to allow plant regeneration. Additional vegetation monitoring plots should also be installed so that all major soil associations are included. Relatively large areas of *Triodia* grassland previously burnt on south Peron in the 1990s have been invaded by buffel grass (*Cenchrus ciliaris*), with little evidence of *Triodia* re-establishing itself in these areas. Future fire management needs to include weed control strategies to prevent invasion of burnt areas by this aggressive species.

BUDGET

Introduction

The original operations plans prepared for *Project Eden* estimated some costs to run the different aspects of the project for the first few years, and a total of $500 000 over the first two years was initially allocated by the then Executive Director. A large proportion of this ($186 000) was spent on the construction of the 3.4 kilometre barrier fence at Shell Beach. However, the project commenced as an operational trial in broad-scale introduced animal management and fauna recovery, with an expectation that it would continue to evolve over time, depending on subsequent findings. Consequently there was no provision to make accurate estimates of potential costs early in its life.

The original annual budget estimates for translocations ranged between $7000 and $20 000 for four species (Table 12). However, these failed to take into account the salary and transport costs required to operate in a remote and large reserve area, particularly to provide satisfactory monitoring of released and remnant fauna populations, necessary to adequately evaluate the success of the project. The strategic plan also changed considerably as the approaches and strategies changed, and the costs associated with these increased (Morris and Sims 1997).

More realistic estimates of ongoing costs were devised in 1999 (Table 13), and these indicated that up to $250 000 per year was required for translocations. At this time, total annual costs were estimated to be $600 000 to $700 000. The annual budget allocations (CALM and external) and expenditure for *Project Eden* are shown in Table 14. Clearly, the location of *Project Eden* within the Shark Bay World Heritage Area, has allowed access to significant external funding opportunities. However this source of funding has diminished and further CALM funding support was required from 2003/04 on. Funding for the PCBC has been discussed above (Table 6), but it is worth emphasising that CALM has contributed less than half of the overall costs to date of this aspect of *Project Eden*.

An example of actual budget breakdown for the 2001/02 financial year (including external fund sources) is provided in Table 15. In this year, total expenditure was $583 088, similar to the costs estimated in 1999 (Table 13). Funding for some areas such as translocations / fauna monitoring will need to be increased if larger numbers of animals are to be released and monitored.

TABLE 12

Estimated annual translocation costs for four mammal species at Peron Peninsula (from Morris, 1995).

SPECIES	1996–97 $	1997–98 $	1998–99 $	1999–00 $	2000–01 $	2001–02 $	TOTAL $
Woylie	13 000	4150	4000	4000	4000	4000	33 150
SBM	4000	5250	1000	1000	1000	1000	13 250
GSNR	3000	4500	1000	1000	1000	1000	11 500
Chuditch	nil	nil	5000	5000	1000	1000	12 000
TOTAL	**20 000**	**13 900**	**11 000**	**11 000**	**7000**	**7000**	**69 900**

TABLE 13

Revised estimates of *Project Eden* costs.

ACTIVITY	1999–2000	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06
Introduced animal control	200 000	200 000	175 000	150 000	125 000	100 000	100 000
Administration	110 000	110 000	110 000	110 000	110 000	110 000	110 000
Captive breeding	175 000	175 000	175 000	175 000	175 000	175 000	175 000
Reintroduction	50 000	150 000	250 000	250 000	250 000	250 000	250 000
TOTALS	**535 000**	**635 000**	**710 000**	**685 000**	**660 000**	**635 000**	**635 000**

TABLE 14

Annual budget allocations and expenditure for *Project Eden* from 1994/95 to 2002/03.

	1994–5	1995–6 $	1996–7 $	1997–8 $	1998–9 $	1999–00 $	2000–01 $	2001–0 $	2002–03 $
Administration	46243	20000	40000	*[1]	101306	*	141988	141897	128165
Fox/cat baiting	41217	43450	51200	*	157500	*	125512	130810	158249
Rabbit baiting	37100	4300	10200	*	12930	*	1000	1500	1000
Fencing	77000	100450	0	*	5000	*	5000	5000	4000
Public Relations	30000	10000	6000	*	15000	*	5000	1000	*
FireControl	21440	12500	7000	*		*	*	*	*
Science Division Operations	0	0	96750	*	47441	*	49000	72449	68774
District Operations	107000	88300	99953	*	81350	*	92500	67344	129907
Total CALM)	360000	279000	311103	310000	470000	470000	420000	420000	490095
External funds	0	0	5000	*	81500	67500	102000	126000	50000
TOTAL	**360000**	**279000**	**316103**	**310000**	**551500**	**537500**	**522000**	**546000**	**540095**
% Expended	55	110	73	157	91	92	100	103	

	Budget $	**Expend $**
Total (CALM funds only) 94/95 to 2001/02	**3 040 103**	**2 742 848**
Total (CALM + external funds) 1994/95 to 2001/02	**3 962 198**	**3 302 348**

[1] Budget figures are either (a) unavailable (mostly because they don't fit the category format currently used and listed here) or (b) incorporated into management activities that would occur irrespective of *Project Eden* and thus not identifiable in the *Project Eden* budget as finite line items.

TABLE 15
Details of *Project Eden* budget allocation and expenditure for 2001/02.

ACTIVITY	BUDGET 2001–2002 $	EXPENDED JUNE 2002 $	% EXPENDED
1. ADMINISTRATION			
Project Officer salary and overheads	59 790	60 303	101
Data Management Officer (0.5FTE)	26 815	27 225	102
Consultant	13 500	12 629	94
Travel	4 000	1 580	40
Vehicle	7 500	2 967	40
Office / shed	13 900	17 548	126
Uniforms and training	7 392	3 695	50
Staff allowances	5 000	1 803	36
Radio Hire	4 000	5 077	127
TOTAL ADMINISTRATION	141 897	132 832	94
2. INTRODUCED ANIMAL CONTROL			
Fox/cat control and monitoring	129 810	158 935	160
World Heritage Funding	27 000	27 000	100
Other control – rabbits, goats, fence	7 500	3 922	52
TOTAL INTRODUCED ANIMAL CONTROL	164 310	189 857	116
3. CAPTIVE BREEDING			
PCBC Salary	51 149	48 092	97
PCBC Vehicle	15 000	13 769	92
PCBC Travel	1 300	0	0
PCBC Pen Maintenance	5 000	2 313	46
Total CALM Captive Breeding	72 449	64 175	89
World Heritage Funds	99 000	95 000	96
TOTAL CAPTIVE BREEDING	171 449	159 175	93
4. REINTRODUCTIONS			
Reintroduction officer Salary	45 444	49 104.73	108
Reintroduction Travel	1 300	1 680	129
Reintroduction Materials	9 600	7 759	81
Reintroduction Vehicles	11 000	15 454	140
TOTAL REINTRODUCTIONS	67 344	73 999.40	110
5. PUBLIC RELATIONS	1 000	223	22
TOTAL CALM BUDGET	447 000	461 088	103
TOTAL EXTERNAL FUNDS	126 000	122 000	
TOTAL 2001/02 BUDGET	**573 000**	**583 088**	**102**

COMMUNITY INVOLVEMENT AND COMMUNICATIONS

Project Eden has received considerable interest and attention from state, national and international scientists, volunteers and the media. It has involved many local school groups, and volunteer and work groups. Response has been positive and most visitors regard it as a unique and exciting conservation program. The project has also enjoyed the interest and support of all the respective State Environment Ministers and several Ministerial visits have been arranged to coincide with important activities such as cat baiting, and the first releases of bilbies. A website for *Project Eden* was established in 1999 and in 2001 it was linked to the Shark Bay World Heritage site at http://sharkbay.org/terrestrial_environment/page_06.htm. In 2002, the website was linked to the CALM Naturebase website (http://www.calm.wa.gov.au/).

Initially a staff member from the CALM Corporate Affairs Division was dedicated to *Project Eden*, however most community involvement and external communications have been integrated into all the research and operational aspects of the project, rather than a stand alone activity. While the project has maintained a solid level of community interest there is the potential to be more pro-active in this area and increase the 'flag ship' profile for conservation issues (especially arid land) in Australia. The location, world heritage status and other attractions of Shark Bay, ensure a high number of domestic and international visitors are accessible to any messages imparted by *Project Eden*. It is regarded locally as a very positive activity of the Department.

Progress updates on *Project Eden* has been provided in the Landscope magazine and regular reports to the PEMC, the World Heritage Unit, IUCN Reintroduction Specialist Group Newsletters, Arid Zone Recovery Team meetings and updates, submission of Animal Ethics applications and Translocation Proposals. There are also additional internal reports prepared on specialist activities such as animal collection expeditions to Bernier and Dorre Islands, and disease screening trips to Bernier and Dorre Islands and Useless Loop. However, few articles have been published in refereed journals.

Some of the many community involvement activities, media attention and scientific collaboration the project has engendered in its life include:

Schools and educational activities

Staff have endeavoured to accommodate and interact with school and other educational institutions wherever possible. This is often difficult with no staff dedicated to or trained in educational methodology, but many opportunities to convey a conservation message and develop an appreciation of the unique Shark Bay environment have been taken advantage of.
These include:

- University of Notre Dame Field trip.
- Michigan State University Conservation Biology student excursion.
- Biosphere Week displays and talks to the Useless Loop and Shark Bay Primary School students.
- Talks to Curtin University environmental students, Geraldton TAFE students and students at Perenjori, Eneabba and Chidlow Primary Schools.
- CALM Bushrangers – Manjimup Senior High School.
- Gumula Mirnawarni Education Project talk.
- Involvement of the Yadgalah Aboriginal Corporation in the first bilby release.
- Use of the bilby release by Shark Bay Primary school students as a topic for display at the Geraldton Museum (the students were the winners of the Clem Burns Heritage award for this work).

Volunteers and work experience

Interest from both international and state university students in Biology or Environmental Science has increased significantly as the project has become known. There are now formal links with the Murdoch University Environmental Science Association, placing students for work experience, and similar arrangements are planned with Murdoch University's School of Veterinary and Biomedical Science students, who need to complete formal vacation work experience in different aspects of animal husbandry and medicine. Students from the Frankfurt University, Germany, have undertaken research on the physiology and behaviour of the captive and free-ranging native mammals on the peninsula. CALM Landscope Expeditions have been undertaken to assist in the fauna monitoring on Peron Peninsula annually since 1996, with up to 14 volunteers participating in each trip (Morris *et al.* 2000, 2002). In addition over 60 volunteers with Greencorp and Conservation Volunteers Australia have assisted in construction of *Project Eden* facilities.

Project Eden Community Advisory Committee

The *Project Eden* Community Advisory Committee was established in 1995 to facilitate community support for the project and to ensure the community were kept informed about progress. Regular meetings were held in the first three years but have diminished since then. Maintaining community support for *Project Eden* is vital and it is proposed that the World Heritage Area focus community group take on this role. The World Heritage Community Consultative and Scientific Advisory Committees have shown considerable interest in, and support for *Project Eden*, and are regularly updated on progress at their meetings.

Media exposure

Numerous media releases have appeared in the local, State and national newspapers. Initially these focussed on the CALM proposal, the construction of the exclusion fence at Shell Beach, the release of RCD for rabbit control, and fox and feral cat control work. Later media articles focussed on the woylie, bilby and malleefowl releases. In 1997 and 2000, the Weekend Australian newspaper ran articles on Landscope Expeditions to Peron Peninsula. In 1998 the PCBC was a focus for media articles on the 'Chocolate Easter Bilby' program, which at that time was sponsored by Coles.

Project Eden has featured on several radio and television programs, including ABC Regional Radio (Karratha), ABC Radio National, the 'Postcards', 'Our WA' and 'Witness' TV programs, Swiss National TV and German ARD TV current affairs.

Popular articles

Visitor information brochures were prepared and made available to the local community and tourists. Annual *Project Eden* newsletters were produced from 1994-1997, but discontinued after this time. There have also been articles on *Project Eden* in popular magazines including Landscope, Australian Geographic, Asian Geographic, Wildlife Australia, Wildlife Magazine and Highway Magazine.

In 1994/95, several information board displays and signs were developed and placed in prominent visitor locations around Shark Bay (Overlander Roadhouse, Shell Beach, Peron Visitors Centre). The *Project Eden* Documentary 'Return to Eden' is screened regularly and is for sale at the Monkey Mia Visitors Centre, and information brochures on the Project are available both here and the CALM Denham Office.

Documentary films

Project Eden has featured in several national and international documentary films since 1999. These include 'Burning Heart' filmed for the National Geographic Society, 'Tales from a Timeless Land – Australia's great national parks' filmed for Nature WA, a Swedish Broadcasting Nature Department documentary, part of the BBC's 'Life of Mammals' documentary series, and the '10 Million Wild Cats' documentary filmed by German ARD TV.

Conference and workshop attendance, presentations and posters

Presentations on *Project Eden* have been made at several State and national forums. These include:

- the Arid Zone Recovery Team meetings in Broome1997.
- the Australian Veterinary Association Conference, Brisbane 1997.
- the Australian Mammal Society Conference, Perth 1998.
- the Dampier 300 Conference, Fremantle 1999.
- the Australian Veterinary Association Conference, Perth 1999.
- Participation in interagency workshop on Faure Island with Australian Wildlife Conservancy, 2001.
- Participation at Arid Zone Recovery Team meetings, Warburton 2001.
- Presentation to CALM Corporate Executive 2002.
- CALM seminar 2002.
- Participation in interagency Western Barred Bandicoot disease workshop March 2002.
- Poster presentation at the Australian Mammal Society Conference, Warrnambool, Victoria July 2002.

Contributions to research, scientific papers and student projects

Several student projects, unpublished reports and popular articles have resulted from *Project Eden* activities and these are included in the References for this review. These include six Honours or post graduate studies (Adams 2000, Chavand 2003, Cheng 2002, Gleeson 1999, Hardman 2003 and Hill 2002), eight unpublished reports on various aspects of *Project Eden* (Algar and Angus 2000a, b; Baynes 2000, Brown 2001, Maxwell 2002, Speldewinde and Morris 1999, Ward 1997, and Morris and Sims 1997), and popular articles (Liddelow *et al.* 1997, Morris *et al.* 2000, 2002, Smith *et al.* 1996, Algar and Smith 1998, and Thomson and Shepherd 1995). Unfortunately there are few published refereed papers resulting from *Project Eden* activities and this aspect need to be addressed.

Interagency visitors

The project has also received visits by many other interagency staff and representatives, including:

- Don Langford (Parks and Wildlife Commission NT) & elders from Tanami Desert Warlpiri people.
- Bruce Leaver (Head of World Heritage unit, Environment Australia).
- Richard Wrangham (Head of Biology) Harvard University, Boston, USA.
- Dr Larry Dill (Head of ecology unit), Simon Fraser University, Vancouver, Canada.
- Dr Janet Mann, (Psychology and Animal Behaviour Professor), Georgetown University, Washington, USA
- Professor Elke Schleucher, University of Frankfurt, Germany
- Members of the Australian Mammal Society conference, 1998.
- Dr Vincent Serventy (retired).

OUTCOMES AND BENEFITS

Project Eden has provided an important site to assess factors affecting successful fauna translocations in the arid zone. In particular, significant advances have been made in our knowledge and understanding of the levels of fox and feral cat control required, and the relative vulnerability of native mammals to predation. Factors affecting the abundances of extant small vertebrate populations have also been assessed.

Significant progress has been made against the three primary objectives of *Project Eden*:

1. Introduced animal control – sheep have been removed and goats reduced significantly. Foxes have been virtually eradicated and feral cat control had been maintained at between 20 and 30 cats per 100 km of transect for most of the last four years. Baiting has been able to reduce cat abundance below this temporarily, and we now have some knowledge of which biotic and environmental factors influence effective uptake of baits by feral cats. It has also been demonstrated that cats can also be eradicated, in the short term, from specific smaller areas using hand baiting and trapping. If the total predation pressure from foxes and feral cats prior to any control is taken as 100%, and taking into account near eradication of foxes, the predation pressure now is probably about 25% of what it was in 1994. This has benefited the remnant native fauna as well. Information obtained from feral cat control trials at Peron has assisted in the development of an effective cat control technique on large offshore islands (eg Faure Island) and has complemented other large-scale introduced predator control work in arid parts of Western Australia (Algar and Burrows, this publication).
2. Translocation of native fauna – an excellent knowledge of the original mammal fauna of Peron Peninsula has been gained and from this has developed a strategy to reconstruct the fauna of the area. Five species have been reintroduced, three of these have persisted. Monitoring has provided information on mortality, habitat use, home range movements and behaviour of little known threatened species. Valuable information has also been obtained on successful captive breeding and animal husbandry techniques for some of these species. The successful captive breeding program has also allowed for stock to be provided for translocations to other areas (e.g. Faure Island) and will provide CALM with options for translocations to the arid zone when *Western Shield* expands.

3. Education and nature-based tourism development – a large amount of information about wildlife management in the arid zone has been generated from *Project Eden* and this has been disseminated to a wide range of people. The project has a local, national and international profile and support for the work has increased as the project developed. The work has also enhanced the World Heritage qualities of the Shark Bay area. The Department's profile as an organization that cares for and manages the natural environment in an effective and innovative way has been enhanced.

Further work is required to fully achieve the objectives set, however it is important that the investments and gains that have been made, are protected.

As *Project Eden* has developed and progressed, there have been many direct and indirect benefits generated, and these will continue.

1. Many years of continuous monitoring of an arid ecosystem has provided a large amount of information on:
   - Changes in feral cat, fox, goat, and rabbit numbers.
   - Remnant fauna populations.
   - Detailed cat population demographics and diet.
   - Weather and climate history.
   - Establishment of reintroduced species and habitat use.
   - Plant succession following fire.

Integration of these data has produced a detailed knowledge of arid ecosystem changes over time, responses to variables such as rainfall, and various management activities. Continued monitoring will provide insights into longer-term interactions between introduced fauna, native fauna and climate change in an arid environment.

2. A unique location to promote a greater understanding of arid ecosystems:
   - It is readily accessible and sufficiently large to support large fauna populations.
   - It is located in a World Heritage Area and will ultimately enhance these values.
   - The opportunity to involve a wide audience including local and indigenous people, students, researchers and the general public (national and international).
   - Increased education of the general public through websites, interpretation, talks and media.
   - The provision of information and assistance to other researchers involved in arid zone reconstruction programs, e.g. Heirisson Prong biosphere reserve.
3. The development of the Peron Captive Breeding Centre (PCBC) has provided many benefits to both *Project Eden* and other *Western Shield* activities. Captive breeding, veterinary and animal husbandry skills have been brought into the Department and these have been used not only for *Project Eden* but also elsewhere in *Western Shield* and in collaborative projects with other agencies. It has also provided CALM with the ability to set its own priorities for captive breeding and translocation programs.

Specific benefits of the PCBC include:

- Staff have been assigned specifically to manage the PCBC.
- Simultaneous collection of banded hare-wallabies, boodies and western barred bandicoots from Bernier and Dorre Islands for the Dryandra captive breeding centre.
- Potential to provide captive bred animals for other release sites, e.g. Faure Island.
- Veterinary input to other District operations, e.g. post mortem examinations of marine fauna, treatment of injured wildlife.
- Ability to investigate disease issues and to provide advice on the management protocols, e.g. western barred bandicoot warts and *Chlamydia*.
- Ability to collect samples for genetic analysis, e.g. stick-nest rat, malleefowl.
- Direct links and exchanges of animals with other captive breeding facilities.

FUTURE DIRECTIONS

This review provides an opportunity to recognise the important advances made by *Project Eden* as well as the realistic limitations on future achievements, and to redefine the project's objectives to allow strategic and focused progress for *Project Eden* into the future.

The redefined objectives of the project should be:

1. To achieve and maintain a level of introduced predators that allow recovery of remnant fauna populations and reintroduction of a range of native species.
   - Achieve and maintain at least a 95% reduction of fox presence
   - Achieve and maintain a level of feral cat control that allows the successful reintroduction and persistence of a range of native fauna, including 'cat sensitive' species.
   - Retain a long-term goal of aiming for eventual eradication of feral cats on Peron Peninsula, if technology and conditions should present the possibility.
2. To reintroduce the array of native species that have the potential to survive and persist in the predator and environmental conditions achieved and maintained over time.
3. To enhance and protect the values of the Shark Bay World Heritage Area.

4. To recognize and maintain the values of the Peron Peninsula achieved so far, as a well monitored, documented and managed arid/coastal ecosystem that can be a valuable resource for understanding and testing ecosystem relationships and introduced animal control techniques.

Specifically there are a range of actions that are required to ensure progress with these objectives.

- The goat eradication program needs to be completed through intensive aerial and ground shooting activities.
- The development of an effective broad scale rabbit control program.
- The refinement and use of predictive models for feral cat control, in particular the dependence of good bait uptake on the previous years rainfall, and prey species availability.
- A review undertaken of the list of potential mammal species for translocation.
- The development of translocation programs that examine options for releases under a) current feral cat abundances, b) under significantly reduced feral cat numbers.
- Determining other *Western Shield* translocation requirements for animals bred at the PCBC, particularly to Dirk Hartog Island and mainland arid zone sites.
- Assessing the adequacy of existing staff and holding pens at the PCBC.
- Identifying sources of additional funding, particularly to cover the shortfall generated by loss of World Heritage funding.

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