

Return to Dryandra: Western Shield review—February 2003

TONY FRIEND¹ AND BRETT BEECHAM²

¹ Principal Research Scientist, Department of Conservation and Land Management, 120 Albany Highway, Albany, WA 6330. tonyf@calm.wa.gov.au

² Ecologist, Department of Conservation and Land Management, PO Box 100, Narrogin, WA 6312. brettb@calm.wa.gov.au

SUMMARY

The *Return to Dryandra* project was established in order to reintroduce five threatened marsupials, extinct in the south-west of Western Australia, to Dryandra Woodland. The target species are the bilby (*Macrotis lagotis*), western barred bandicoot (*Perameles bougainville*), boodie (*Bettongia lesueur*), mala (*Lagorchestes hirsutus*) and banded hare-wallaby (*Lagostrophus fasciatus*). Dryandra was seen as a suitable site from which to spearhead the reintroduction of these species into the southwest because:

1. It is a large area where fox control has been shown to cause mammal recovery.
2. It is within the former range of the five selected species.
3. Suitable habitat is present, in good condition.
4. It is close to a District office of the Department of Conservation and Land Management (CALM), so District staff can provide necessary support.
5. It is relatively close to Perth and has high ecotourism potential that would be enhanced by the presence of rare mammals.

The concept was to establish populations of these five species in a 20-hectare predator-proof enclosure within Dryandra, provided with supplementary food and water, so that mammal densities could rise well above those found in the wild. Thus high numbers of site-adapted animals could be generated in order to provide translocation stock for release into Dryandra. The original concept allowed for spotlight walks through the breeding enclosure as a low-level eco-tourism activity, to provide educational opportunities and to involve the community. The *Return to Dryandra* project was to be run jointly by CALM's Narrogin District and Science Division staff.

Subsequently, the aims of the project were enlarged in two directions:

1. to include the construction of a separate viewing enclosure and visitor centre, to be built in partnership with a corporate sponsor
2. as well as providing animals for reintroduction to Dryandra Woodland, the breeding enclosure would also supply stock for translocations to other reserves in the south-west under the *Western Shield* program.

The breeding enclosure was built during 1997 and founder groups of the five species were introduced in 1998. Feeding, monitoring and other routine procedures were established. Predation by diurnal raptors and owls caused some early losses, but breeding commenced and the populations, with the exception of the banded hare-wallabies, which were heavily preyed on by raptors, began to grow.

Plans for a visitor centre/viewing enclosure were developed in 1997 and CALM's Executive Director presented a sponsorship proposal to a potential corporate sponsor. This proposal was kept alive for over a year but eventually failed. A funding application for the centre to the Commonwealth Regional Tourism Program was prepared and submitted in 1999 and \$85 000 was granted on a dollar-for-dollar basis. During this process the management and planning of the visitor centre concept was separated from the *Return to Dryandra* project. The visitor centre/viewing enclosure, known as Barna Mia, was opened by the Minister for the Environment on 14 December 2002.

This review will deal with the *Return to Dryandra* project, touching on Barna Mia only where issues of supply and exchange of animals arise. It was prepared for the *Western Shield* review and information contained within was accurate as at February 2003.

Objectives

The objectives of the *Return to Dryandra* project as originally stated, are as follows:

1. Reintroduction of five species of locally extinct mammals to Dryandra, via a large enclosure to breed animals on site for release. These species are:

<i>Macrotis lagotis</i>	Bilby (dalgyte)
<i>Perameles bougainville</i>	Western barred bandicoot (marl)
<i>Bettongia lesueur</i>	Boodie (burrowing bettong)
<i>Lagorchestes hirsutus</i>	Mala (rufous hare-wallaby)
<i>Lagostrophus fasciatus</i>	Banded hare-wallaby (merrnine)

2. Use of reintroductions to Dryandra to test alternative reintroduction methodologies.
3. Involvement of the local community, through a Friends of Dryandra group and volunteers from other places, through Landscape Expeditions and possibly Earthwatch.

Later, the public involvement aspect was expanded by including the development of an interpretive centre with an animal viewing area within Dryandra.

Achievements

- Design and construction of the breeding enclosure.
- No entry by cats or foxes into the breeding enclosure in five years.
- Establishment of intensive captive breeding colonies of western barred bandicoots and bilbies at Kanyana Wildlife Rehabilitation Centre as part of *Return to Dryandra*.
- Genetic variation in Kanyana bilby colony maintained by exchanges of bilbies with other breeding colonies at Monarto Zoo and Yookamurra Sanctuary, SA; the Territory Wildlife Park and the Alice Springs Desert Park/Arid Zone Research Institute, NT; and the Peron Captive Breeding Centre.
- Establishment of breeding populations of all five species within the Dryandra breeding enclosure.
- Establishment of suitable feeding regimes within the breeding enclosure.
- Establishment of an effective monitoring regime within the breeding enclosure.
- Bilby health monitoring program established through collaboration with Murdoch University.
- Production of sufficient surplus animals for releases of bilbies, western barred bandicoots and the proposed release of boodies.
- Reintroduction of bilbies from the breeding enclosure into Dryandra Woodland.
- Comparison of success of ‘soft’ and ‘hard’ release techniques for bilbies completed.
- Elimination of the use of collars for attaching radio-tags to bilbies, in favour of tail mounts, a practice then followed by *Project Eden*.
- Participation in disease investigations on chlamydia and a wart-like syndrome found in western barred bandicoots.
- No re-appearance of the wart-like syndrome in the western barred bandicoot population within Dryandra breeding enclosure since 2000.
- Provision of animals for the public viewing enclosure at the Barna Mia interpretive centre.
- Development of strong partnerships with Kanyana Wildlife Rehabilitation Centre and Pingelly Marsupial Retreat.

Difficulties

- Predation of enclosure animals, particularly hare-wallabies, by diurnal and nocturnal birds of prey.
- Difficulty in planning releases due to uncertainty about the numbers of animals that could be produced.
- Limits to the numbers of animals of each species that can be held in the breeding enclosure.
- Occurrence in western barred bandicoots in the enclosure of a wart-like syndrome, also found in other captive and wild populations.
- Significant mortality of released bilbies caused by radio-collars
- Bilbies proved difficult to monitor by alternative means (e.g. trapping, searches for burrows and sign) once tail-mounted transmitters failed or fell off.

Potential economies

This project has been run extremely efficiently and has been heavily subsidised from Narrogin District and Science Division resources (see ‘Return to Dryandra Draft Strategic Plan’) to the extent that it is clear that the base funding of the project is far from adequate. Two ways in which costs to CALM could be reduced are:

- Greater use of volunteers in monitoring enclosure populations and animals released outside. This would need to be carefully managed to retain a sense of ownership of the project by CALM staff. On the other hand it would generate more public awareness and community support. However this would only reduce costs marginally as vehicle running has been the greatest cost associated with the monitoring of animal populations, particularly when animals are released from the enclosure into Dryandra Woodland proper.
- Reduced frequency of monitoring, recognising that this will reduce the ability to predict numbers available for translocation.

However, in order to carry out reintroductions into Dryandra and continue the research to develop better reintroduction techniques that have already benefited other programs such as *Project Eden*, greater personnel input is required. Similar work is being undertaken as in *Project Eden*, but with only 0.5 FTE dedicated to captive breeding and monitoring released animals, compared with at least 2.0 FTE at Denham. The operating (non-salary) budget available for *Return to Dryandra* can support the operation and monitoring of the breeding enclosure, but cannot support the implementation and monitoring of translocations.

Potential improvements

The requirements of the project have not been recognised in its level of funding, and the project has been heavily subsidised from District and Science Division resources.

More resources are required, particularly for monitoring released animals. The many aspects of the project require more than half of one person's time in the District, as well as the input from Science Division. The budget for the project should allow the allocation of at least one FTE, and it would be most efficient if this were a single person.

A substantial increase in the operational budget is also required, as the project should not continue to divert resources from other areas.

INTRODUCTION

Background to the project

The 1996 *Western Shield* plan (Burbidge *et al.* 1996) proposed the reintroduction of 13 native mammal species to 40 areas of the south-west of Western Australia over approximately five years. Translocations of some of these 13 species (e.g. numbat *Myrmecobius fasciatus*, chuditch *Dasyurus geoffroii*, woylie *Bettongia penicillata* and quenda *Isoodon obesulus*) using direct release had already been performed with success. Other species, however, such as those that only survive on offshore islands, were likely to be much more difficult to reintroduce due to behavioural differences and the high cost of obtaining sufficient numbers from the wild.

Seven species, all in this 'difficult' category, were listed in Burbidge *et al.* (1996) as extinct in the southwest and requiring reintroduction from other areas. Reintroduction of five such species in various combinations, *Bettongia lesueur*, *Lagorchestes hirsutus*, *Lagostrophus fasciatus*, *Macrotis lagotis* and *Perameles bougainville*, was proposed to five fauna reconstruction sites in the south west (Dryandra Woodland, Dragon Rocks Nature Reserve, Fitzgerald River National Park, Kalbarri National Park and Lake Magenta Nature Reserve). The document did not specify how these reintroductions should be performed.

The *Return to Dryandra* proposal presented a method of implementing the reintroduction of these species to the south-west, utilising closely monitored, staged releases from a large breeding compound situated at a south-west release site. This approach is desirable for these five species because the following:

- The western barred bandicoot, banded hare-wallaby and boodie have only survived on islands that are free of mammalian predators. Consequently, it is logistically difficult to obtain sufficient numbers for translocations and the animals themselves are likely to be predator-naïve. Wild-wild translocation may result in high initial mortality, even if lack of acclimatisation to the translocation site causes no problems.
- Bilbies are still found over wide areas in the Pilbara and Kimberley, particularly around the fringes of the Great Sandy Desert. They live in small, widely dispersed colonies, however, and the location and capture of even a few individuals is a costly exercise.
- *Lagorchestes hirsutus* is found on Bernier and Dorre Islands in Shark Bay, but captive colonies of the central

Australian form (mala), which is extinct in the wild, exist in Alice Springs and, until 2001, in a 1 km² enclosure on the Lander River in the Tanami Desert, NT. As the south-western subspecies, *Lagorchestes hirsutus hirsutus*, is extinct, it was considered that the central Australian subspecies, having been more recently exposed to a range of predators than the island populations, would be the best choice for reintroduction at Dryandra. More recently, genetic work has indicated that the island populations, despite being more numerous, exhibit less variation but fall within the range of variation of the mainland animals (Eldridge *et al.* 2003). Although these animals are quite readily available, the wide climatic differences between the Tanami and Dryandra suggests that reintroduction into the south-west should allow acclimatisation, and preferably on-site breeding of animals for release.

Dryandra Woodland was proposed as an ideal choice of site because:

1. It is a large area where fox control has been shown to cause mammal recovery.
2. It is in the former range of the selected species.
3. It is close to a CALM District office, and there is an onsite CALM staff presence, so District staff can provide necessary support.
4. It is relatively close to Perth and has high ecotourism potential that would be enhanced by the presence of rare mammals, sensitively displayed on spotlight walks through an enclosure.

Project management

The project *Return to Dryandra* was born on 14 October 1996, when CALM Corporate Executive approved initial funding for the original proposal. The *Return to Dryandra* Steering Group (Committee) was formed in March 1997. The original committee comprised the District Manager, Narrogin (chair), Manager, Wildlife Branch, a research scientist from Science and Information Division, and Parks, Planning, Recreation and Tourism officers from Wheatbelt Region and State Operational Headquarters. The role of the steering group was outlined in the minutes of the first meeting as follows:

- To establish a planning/managing role to keep the operation 'on track'.
- To keep appropriate directors and others informed.
- To liaise and plan with appropriate personnel, both within and outside CALM.

It was also agreed that the Narrogin District Manager (DM) would chair the group.

This committee met five times in 1997 in Perth during the planning phase and during the construction of the breeding enclosure. The breeding enclosure construction was implemented through the District Manager, Narrogin. Planning and negotiation for the acquisition of animals and the development of the monitoring protocol was the

responsibility of Science Division. Animal husbandry procedures were developed jointly.

The 'Return to Dryandra: A *Western Shield* Project - Project Brief' of late 1997 included a section dealing with the approvals process, and stated that the steering committee would answer to the Director, Nature Conservation via the Regional Manager, Wheatbelt. It also recognised that the project spanned several departmental programs, and that every endeavour would be made to keep relevant directors informed.

In June 1997 the Return to Dryandra plan was presented to the National Parks and Nature Conservation Authority (NPNCA). The NPNCA passed a motion to note the nature conservation elements of the program and to endorse the tourism component.

Subsequent meetings of the Steering Committee were held in Narrogin in February 1998 and March 1998, chaired by Acting DM Narrogin.

The Return to Dryandra Steering Committee was not recognised in the management structure provided in the '*Western Shield* Strategic Plan' (July 1999), although the analogous *Project Eden* Management Committee appeared in the plan of responsibilities.

The Return to Dryandra Steering Committee did not meet again until 2001. During this period, the viewing enclosure project (Barna Mia) was developed under the auspices of Narrogin District with input from the Wheatbelt Region and Parks and Visitor Services Division. The then Dryandra Woodland Focus Group, a body incorporating local government representatives from seven shires from the vicinity of Dryandra, local businesses, Chamber of Commerce, Heartlands and Central Southern Tourist Associations and the Wheatbelt Development Commission, was also important in developing the Barna Mia marketing position.

The next meeting of the Return to Dryandra Steering Committee was held in August 2001. The committee was chaired by the Acting DM Narrogin, with representation from Narrogin District, Science Division and Wildlife Branch. This meeting included a review of the membership, roles and responsibilities of the steering committee.

In October 2001, the *Western Shield* South West Management Committee (WSSMC) reviewed the structure and reporting arrangement for the Return to Dryandra program. The initial proposal from the WSSMC was that the Return to Dryandra Steering Committee be reconstituted with the following membership:

- Chair - District Manager, Narrogin
- Regional Leader Nature Conservation, Wheatbelt
- Technical Advisor, Science Division
- *Western Shield* Project Manager
- *Western Shield* Zoologist.

This proposal was subsequently modified on the grounds that three of the five members of this proposed Return to Dryandra Steering Committee were also part of the WSSMC. It was therefore recommended that the

Return to Dryandra Steering Committee be subsumed into the WSSMC, and that the DM, Narrogin be responsible for the day-to-day management of the project. The *Western Shield* Strategic Committee (WSSC) endorsed this recommendation.

The draft 'Return to Dryandra Strategic Plan 2002-2005' (May 2002) provides a clear statement of the current project management roles and responsibilities within this structure. Current arrangements between Narrogin District and Science Division officers promote close liaison in the management of the Return to Dryandra program.

Plans and changes

Planning instruments relating to the *Return to Dryandra* project are as follows:

1. '*Return to Dryandra – a Western Shield Project*' (Friend T, Bowra T, 11 August 1996), the original proposal presented on 14 October 1996 to Corporate Executive and approved for funding under the 'New Initiatives' funding scheme.

Aims:

- Reintroduction of five species of locally extinct mammals to Dryandra, via a large enclosure to breed animals on site for release.
- Use of reintroductions to Dryandra to test alternative reintroduction methodologies
- Involvement of the local community, through a Friends of Dryandra group and volunteers from other places, through Landscape Expeditions and possibly Earthwatch.

2. '*Return to Dryandra – Project Brief*' (Moncreiff D, 11 November 1997). The original proposal was expanded to incorporate the establishment of a visitor centre. Community involvement through recruitment of volunteers and fee-paying eco-expeditioners was dropped from the aims.

Aims:

- Reintroduction of five species of locally extinct mammals to Dryandra, via a large enclosure to breed animals on site for release.
- Use of reintroductions to Dryandra to test alternative reintroduction methodologies
- To provide controlled access to visitors to allow them an intimate nature based experience
- To run the facility in a cost neutral manner by collecting tourist revenue.

This updated plan contained a detailed proposal for a separate viewing enclosure and visitor centre, integrating the reintroduction and science themes with a public awareness and cost recovery theme.

3. '*Return to Dryandra. Phase I: Breeding Enclosure. Operations/Procedures Manual*' (Anthony C, Friend T, 1999). The aims of the *Return to Dryandra* project were stated as follows:

- To re-establish self-sustaining populations of at least five medium-sized mammal species (now extinct in the Wheatbelt) in Dryandra Woodland.
- To compare the success of different reintroduction methodologies for each species to develop optimal release strategies.
- To provide stock for other *Western Shield* reconstruction sites.
- To involve the community in order to increase public awareness and to provide educational opportunities.

The concept of using the Dryandra breeding enclosure to provide animals for reintroductions in other reserves in the south-west arose soon after the project was approved, and the *Western Shield* translocation overview tables reflected this from at least as early as November 1997. This was not acknowledged in the aims for the project prior to this document.

4. 'Return to Dryandra: Strategic Plan 2002-2005' (Durell G, Friend T, 2002), the draft plan for the next three years.

This plan restates the aims of the 1996 proposal. The *Western Shield* Project Manager required that the plan should not include the viewing enclosure project (Barna Mia), although there is reference to the need to supply animals from the breeding enclosure to the viewing enclosure and further exchange of animals to reduce the chance of inbreeding within the Barna Mia enclosure.

The objectives of the plan relate mainly to consolidation of the breeding program, the supply of animals for translocation into Dryandra Woodland and the implementation of those translocations.

The objectives for the breeding enclosure for the next three years are to:

- provide sufficient numbers in 2002/03 and 2003/04 to translocate and establish wild populations of bilbies and boodies whilst maintaining sufficient numbers within the breeding enclosure as a breeding colony; and
- re-establish and undertake a breeding research program to provide sufficient numbers of banded hare-wallabies, rufous hare-wallabies and western barred bandicoots within the breeding enclosure for release into the wild in 2004/05 and 2005/06.

Return to Dryandra in relation to Western Shield

The 1996 *Western Shield* proposal (Burbidge *et al.* 1996) focussed on extending fox control, developing cat control methods and establishing a fauna monitoring system covering fauna recovery sites and fauna reconstruction sites. Although fauna reconstruction sites require translocations, these were not described or costed in the proposal. While it was clear from current knowledge that

many species could be transferred through wild-wild translocation from recovery sites to reconstruction sites, this strategy would not be appropriate or possible for another group of species. Seven species were listed in Table 1A of Burbidge *et al.* (1996) as 'Extinct in the south-west, require re-introduction from islands or areas outside the south-west'. The practical difficulties in obtaining these species in sufficient numbers for reintroduction, and the issue of acclimatisation suggested a field breeding system involving large pens in natural habitat. By 1996, field breeding was already being used successfully by CSIRO and the Useless Loop community at Heirisson Prong to provide boodies for release to the wild (Short *et al.* 1994). Thus the *Return to Dryandra* project filled an obvious gap in the 1996 *Western Shield* proposal.

When translocation plans were later developed for the *Western Shield* project, they incorporated the expectation that individuals of the five *Return to Dryandra* species would be available from the Dryandra breeding enclosure for release in Dryandra and other areas

The *Return to Dryandra* project is also closely aligned with the strategic plan for the *Western Shield* Fauna Recovery Program. Its activities encompass many of the strategies supporting the objectives of *Western Shield* established in the strategic plan, including:

- Undertake translocations to fauna reconstruction sites (Objective 1).
- Develop captive breeding facilities where necessary for threatened fauna (Objective 1).
- Develop and implement a protocol for monitoring native fauna populations that allows meaningful measurement of population trends in introduced predator controlled areas (Objective 1).
- Integrate *Western Shield* predator control and fauna monitoring operations with species recovery plans (Objective 4).
- Wherever possible utilise *Western Shield* predator control and fauna monitoring operations to add value to compatible research projects (Objective 4).
- Establish cooperative arrangements with community groups, wildlife carers, wildlife sanctuaries and Perth Zoo to achieve fauna recovery and educational outcomes (Objective 5).

Links between Return to Dryandra and recovery plans

National Recovery Plans

The *Return to Dryandra* project has links with the national Recovery Plan for the Bilby (Southgate 1994, 1995; Paltridge 2000), which proposes Dryandra as a reintroduction site for the species.

The national *Mala Recovery Plan* (Langford 1999) lists Dryandra, Peron and the Monte Bello Islands as proposed translocation sites for mainland mala (i.e. the undescribed subspecies of *Lagorchestes hirsutus* from the

Tanami Desert, NT, a highly threatened taxon now listed as Extinct in the Wild). The plan envisages the ongoing management of the captive breeding program at the Dryandra compound, and the translocation of mala into Dryandra Woodland, Dragon Rocks Nature Reserve and Lake Magenta Nature Reserve.

Return to Dryandra project personnel from Science Division have represented CALM on the national Bilby and Mala Recovery Teams. This has allowed the project to develop strong links with recovery work on these species in other States. There is a need, however, for better dissemination of information from these forums to reach a broader audience within CALM, particularly at a management and operational level. In addition, no published recovery plan is available for the bilby.

It is also essential that operational staff establish and maintain links with other state-based programs supporting the national recovery of threatened species.

State and other recovery plans

The remaining three species, western barred bandicoot, boodie and banded hare-wallaby do not have recovery plans or recovery teams guiding their management. However all three do have published recovery outlines (Maxwell *et al.* 1996). It is essential that recovery objectives and actions be set for these species to provide clear direction for the role of *Return to Dryandra* in their management.

Although a draft report 'Translocation Priorities for *Western Shield* 2001-2003 Wheatbelt Region' (Orell 2001) provides a framework for planning translocations under *Western Shield*, it is necessary that prior to the development of translocation proposals, interim recovery plans at the very least should be developed for species without a plan.

The workshop on disease in western barred bandicoot populations held on 16 July 2002 also recommended that the Department's endorsement be sought for the formation of a western barred bandicoot recovery team and writing of a recovery plan.

Resourcing the *Return to Dryandra* program

Initial funding provided by CALM's Executive Director to start the *Return to Dryandra* project comprised \$40 000 in 1996-97 and \$15 000 per year for three years thereafter. These figures were based on a preliminary budget request that contained no salary component. A

revised budget was formulated for the next four years (1997/98 to 2000/01). This budget included 0.5 FTE salary in Narrogin District to carry out enclosure maintenance and monitoring but did not include other wages/salary support provided by the District or Science Division. Another 0.5 FTE was granted by the Director, Parks and Visitor Services to carry out interpretive work within Dryandra Woodland not related to *Return to Dryandra*. This allowed the employment of a CALM Graduate Recruit, Clare Anthony, to carry out both of these roles.

The *Return to Dryandra* program was not able to function without budgetary input from both Narrogin District and Science Division. When District costs increased due to the extra monitoring required for the bilby releases in 1999/2000, 2000/01 and 2001/02, the extra expenditure was borne by the District. For example, the District allocated \$18 300 in 2000/01 for salaries/wages and plant to the program, and \$20 500 (including \$5600 materials) in 2001/02.

Science Division budgetary input also increased. This was buffered to some degree by the availability of Coles Supermarkets 'Save the Bilby' funds through the national Bilby Recovery Team (\$11 500 in 1999/2000 and \$11 450 in 2000/01, \$0 in 2001/02), although this also funded bilby monitoring trips to the Pilbara. In 2001/02, no funds were allocated from *Western Shield* for the Science Division input to *Return to Dryandra*, but to compensate, \$15 000 was allocated from Science Division budgets.

The role of Kanyana Wildlife Rehabilitation Centre

Kanyana Wildlife Rehabilitation Centre is a privately owned (incorporated, not-for-profit) wildlife rescue facility at Gooseberry Hill, near Perth. It is owned and run by June and Lloyd Butcher with the help of over 90 volunteers. While the main emphasis is on saving injured and orphaned wildlife and releasing them back into the wild, captive breeding colonies of western barred bandicoots and bilbies have been established there and function as an integral part of the *Return to Dryandra* program.

The western barred bandicoot breeding colony was established in 1994 as part of the CALM Science Project 'Genetics and ecology of the Western Barred Bandicoot', run by Tony Friend. The purpose of the breeding colony was to carry out an inter-island hybridisation experiment, measuring the success of crossing bandicoots from Bernier

TABLE 1

Return to Dryandra allocated budget (enclosure costs). WS = *Western Shield*, ED = Executive Director

SOURCE	COST CENTRE	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02
WS	Narrogin		42 000	30 000	30 000	30 000	30 000
WS	Woodvale	40 000		11 000	11 000	11 000	
ED	Woodvale		15 000	15 000	15 000		
Science	Woodvale						15 000
Totals		40 000	57 000	56 000	56 000	41 000	45 000

and Dorre Islands. This experiment was finished by late 1997, and the colony, which was producing young reliably, provided an opportunity to breed animals for the Return to Dryandra project.

The bilby breeding colony at Kanyana was established specifically to provide animals for the Return to Dryandra program. The first bilby was an orphaned young female rescued at Jigalong and forwarded to Kanyana in a poor state of health. Other founder animals were acquired through the disbanding of a breeding colony at the CALM Broome office, from the wild at Shay Gap in the Pilbara, and from the captive breeding colony at the Arid Zone Research Institute in Alice Springs. All of the bilbies used in the *Western Shield* project originate from wild populations in Western Australia and the Northern Territory, as the national Bilby Recovery Team has decided that bilbies from the genetically distinct Queensland populations will be managed separately.

The two breeding colonies at Kanyana have been funded from a variety of sources, including *Return to Dryandra* funding. Since the inception of *Return to Dryandra*, the project has funded the Kanyana bilby and western barred bandicoot breeding colonies at the rate of \$2.00 per animal per week. This comprises about \$6000 per year, a substantial contribution towards food items that need to be bought (mealworms, minced meat, cheese etc) rather than donated by local supermarkets. Other running costs have been provided from Kanyana's income from appeals and donations, and the Coles Supermarkets 'Save the Bilby Fund' through CALM. Cages have been funded from a variety of sources, including CALM and a WWF Threatened Species Network Grant (western barred bandicoot cages), BBC TV Natural History Unit, Tony Bomford Productions, Magellan GPS, and the Environment Minister's Community Conservation Grants (bilby cages). Volunteers provide a great deal of time, as the bilby maintenance regime, including daily feeding, is labour-intensive. The bilbies are kept on a deep bed of coarse river sand and daily removal of faeces from the surface and weekly sifting of the entire substrate to remove faeces is required.

As of February 2003, the Kanyana breeding colonies had supplied 45 bilbies (including 6 bred elsewhere or wild-caught) and 18 western barred bandicoots to the Return to Dryandra enclosure.

The role of Pingelly Animal Refuge

The Pingelly Animal Refuge is owned and run by Howard and Bev Robinson, who rehabilitate injured and orphaned wildlife, specialising in kangaroos. Howard is a CALM employee in Narrogin District. He was part of the team building the enclosure and other infrastructure and is often involved with monitoring program within the enclosure. Howard and Bev often take pouch young, thrown during monitoring sessions, for hand-rearing to weaning and

eventual release back into the enclosure. Up to February 2003, Pingelly Animal Refuge had cared for six boodies, four mala, one banded hare-wallaby, one western barred bandicoot and five bilbies from the Dryandra breeding enclosure.

Collaboration with Murdoch Vet School bilby health monitoring project

After the release of bilbies from Kanyana into the Dryandra breeding enclosure, CALM was approached to collaborate in an ARC SPIRT grant application. The application involved Dr Kris Warren and Prof Ralph Swan (Murdoch School of Veterinary Sciences), Dr Tony Friend (CALM) and Mrs June Butcher (Kanyana), with industry funding from BHP and CALM. The project involved monitoring disease conditions and other health parameters in bilbies at Kanyana, in the Dryandra enclosure, after release in Dryandra, and in wild populations in the Pilbara. Bilbies were examined under anaesthetic on site and blood, urine and faecal samples were taken so that a range of health parameters (haematology, blood biochemistry, parasite loads etc) could be recorded.

The collaboration was extremely valuable, not only in providing very detailed knowledge of the progression of disease states in bilbies through the captive breeding and reintroduction process, but through having strong input from specialist wildlife veterinarians into all aspects of the *Return to Dryandra* program. Perhaps the most valuable contribution made by Kris and Ralph has been into the disease issues confronting western barred bandicoot conservation (see below). Kris and Ralph took the lead in investigating the occurrence and treatment in the bandicoots of chlamydiosis and the wart-like syndrome, respectively, through collaboration with other vets, pathologists and disease specialists in Australia and abroad. Their work has provided sufficient understanding of the disease issues to allow informed management decisions to be made regarding the captive colonies and translocations of the western barred bandicoot.

The Murdoch work has not revealed any such serious problems for the conservation of the bilby or the management of bilby translocations. One issue, however, was the occurrence in some Kanyana bilbies of *Cryptosporidium muris*, an enteric parasite that can cause death, and which was most likely transmitted to the bilbies by mice in the Kanyana enclosures. This infection was successfully treated with dimetridazole in the bilbies at Kanyana and they were released at Dryandra, where there has been no subsequent occurrence of the disease (Warren *et al.*, in press).

The collaboration has also assisted in the management of the enclosure, as the pelletised food provided for the animals was designed by Warren Potts of Glen Forrest Stockfeeds in consultation with Kris Warren and Tony Friend.

OVERVIEW OF THE PROGRAM AGAINST ORIGINAL TARGETS

Reintroduction of five species of locally extinct mammals to Dryandra, via a large enclosure to breed animals on site for release

The *Return to Dryandra* proposal was for a five-year project, during which time the breeding populations would be established in the 20 ha enclosure and release groups of each species produced. At that stage, it was not possible to predict accurately the numbers of animals that the breeding enclosure could produce. The original plan anticipated that production of young within the breeding enclosure would generate release groups of 20 animals of each species within 2-4 years. While the species were capable of producing young at that rate, survival of young within the large enclosures was not guaranteed.

Design, location and construction of the enclosure

The enclosure was designed to be fox and cat-proof. No breach of the fence was considered acceptable due to the potential damage that might occur to breeding populations before the predator was removed. The enclosure covers 20 hectares, and an internal fence divides it into two 10 ha areas. The 1.8 km fence around the enclosure is 2.4 m in height, with a 900 mm overhang towards the outside, with two electrified and one earth wire near the outer edge. The internal dividing fence is also 2.4 m high, but is not electrified and does not have an overhang. The fence is constructed of rabbit netting attached to posts 4 m apart. At the base of the fence the netting is spread as an apron extending horizontally to about 500 mm from the base, both inside and outside the enclosure. Bird netting is attached over the lower 500 mm of rabbit netting to prevent the escape of small bandicoots through the rabbit netting. This design was the result of discussions between CALM staff of Narrogin District and Science Division and June Butcher of Kanyana, with final plans being ratified by the Return to Dryandra Steering Committee. Plans were drawn up by a design draftsman who also recommended some changes that were implemented.

Access to the enclosures is via a gate at the north-eastern end and another gate in the dividing fence provides access between the 10-hectare sections. A shed, used for storage of feed and other materials and equipment required for maintenance and monitoring of the animals, is situated outside the enclosure, at the north-eastern corner. Feed hoppers set up in each section of the enclosure and water drippers fed from a rainwater tank at the shed provide supplementary food and water for the animals.

The construction of the fence was completed in February 1998. The cost in materials was \$55 000 and the labour component, provided by Narrogin District personnel, was approximately the same.

Once the fence was completed and electrified, brushtail possums (*Trichosurus vulpecula*) and woylies within the fence were trapped and removed. The internal perimeter sand track was brushed regularly and used to detect remaining medium-sized mammals. Reptiles were not removed, with the exception of a carpet python (*Morethia spilotes*).

Disease considerations

One of the concerns with the translocation of animals is that disease could be transmitted into the resident populations. Discussions were held in 1997 with wildlife veterinarians Dr Graham Phelps and Dr Andy Keefe regarding possible measures to be taken prior to any translocations into Dryandra. The consensus was that the screening of the individuals to be translocated prior to movement was impractical, given that the number of potential disease agents that might be screened for was unmanageable. Dr Phelps recommended that serum be collected, prior to any movement of fauna, from as many resident animals as possible, to allow before-and-after comparison if any disease agent were subsequently found. This strategy was not preventative, but would help in understanding the disease process and in avoiding further dissemination.

To this end, veterinarian Dr Ian Hutchinson spent two days at Dryandra with Narrogin District staff during a *Western Shield* monitoring in March 1998. Blood was collected from 24 woylies and 5 brushtail possums, and the serum is now in storage.

Establishment of breeding populations in the enclosure

Animals were sourced from a variety of locations including Bernier and Dorre Island, in Shark Bay, wild populations on the mainland and captive populations on the mainland. The transfer of animals from the island nature reserves to the breeding enclosure was approved by the Director, Nature Conservation and ratified by the National Parks and Nature Conservation Authority. Transfers of mala from the Tanami Desert enclosure and bilbies from the Great Sandy Desert were also approved by the Director, Nature Conservation.

Boodie

The boodies were captured and flown from Dorre Island. Twenty animals from Dorre Island were released into the northern enclosure on the 30 April and 1 May 1998.

Banded hare-wallaby (merrnine)

The banded hare-wallabies were also captured and flown from Dorre Island. A total of 18 animals were released into the southern enclosure over an 18-month period. Five animals were added in April/May 1998 and 13 animals were added in September 1999.

Mala (rufous hare-wallaby)

Nineteen mala were released into the breeding enclosure in March 1998. These animals came from a captive population located on the Lander River in the Tanami Desert, managed by the Northern Territory Parks and Wildlife Commission.

Western barred bandicoot (marl)

Western barred bandicoots were sourced from wild populations on Dorre Island and Bernier Island and captive populations at Kanyana Wildlife Rehabilitation Centre and Heirisson Prong, providing 27 founder animals. Seven Dorre Island animals were introduced into the breeding enclosure on 30 April 1998, together with 11 animals from the Kanyana Wildlife Rehabilitation Centre. Two Bernier Island animals from the *Project Eden* captive colony near Denham were added on 5 May 1998, followed by seven animals from Kanyana on 9 December 1998. Western barred bandicoots transferred from Kanyana were the result of crossing Dorre and Bernier stock.

Bilby (Dalgyte)

A total of 45 bilbies were introduced to the breeding enclosure between November 1998 and April 2002. All were transferred from the captive-breeding program at Kanyana Wildlife Rehabilitation Centre, including two individuals originally taken from wild populations in the Pilbara.

Maintenance of the enclosure and animal husbandry procedures

Procedures for the routine maintenance and monitoring of the animals, including radio-tracking of a proportion of newly introduced animals, are described in detail in Anthony and Friend (1999). The day-to-day maintenance tasks are carried out by the Return to Dryandra field officer (Narrogin District) and involve replenishing the supplementary food supplies after recording consumption, and checking the integrity and operation of the fences and the water system. Monitoring the animal populations is carried out jointly by Science Division and Narrogin staff and involves trapping (using cage and Elliott traps) at three-month intervals in the northern and southern sections of the breeding enclosure. This procedure monitors boodies, western barred bandicoots, bilbies and banded hare-wallabies efficiently. Mala can only be reliably captured by luring them into soft traps baited with fresh lucerne at the end of summer, when green pick is virtually absent from the enclosure. Monitoring of animals radio-tagged for the initial period after release is primarily carried out by the Return to Dryandra field officer, supported by other trained Narrogin District staff.

Dynamics of enclosure populations

The populations in the breeding enclosure have now been monitored regularly for four years, providing information about population dynamics as summarised in Figures 1–5.

Bilby

Bilbies were first released, in November 1998, into the northern section of the enclosure only. In August 1999, three bilbies from Kanyana were released into the southern section to avoid breeding with closely related animals in the northern section. Subsequently both sections were used for bilby releases.

Survival of bilbies released into the enclosure has been good, with only three radio-collared bilbies found dead. This may underestimate mortality, because burrows are not dug up in the enclosure to retrieve transmitters because of their importance as refuges for bilbies.

The population grew slowly at first, then between December 1999 and March 2000 the total number of bilbies in the enclosure doubled. During the first release of bilbies into Dryandra Woodland, 18 bilbies were removed from the enclosure in April/May 2000, followed by another 8 in July and 10 more in October. There was a further drop in bilby numbers after this as some of the older females became infertile. However numbers increased again and have been quite stable since at 30–40, even though another 10 animals were released in October 2001. Throughout this time, small groups of 4–6 Kanyana-bred bilbies were released into the enclosure every few months.

Bilbies are doing well under the conditions provided in the breeding enclosure. They are protected from diurnal raptors by being underground during the day, and they are too big for most owls to tackle.

Western barred bandicoot

All bandicoots were radio-collared before release and 7 were found dead during the tracking period. Birds of prey were responsible for three mortalities, although two were of animals newly released from Kanyana during a period when eight captive bandicoots died from toxoplasmosis resulting from a batch of infected minced meat. If the newly-introduced bandicoots contracted the disease prior to release, its effects may have made them easier targets for birds. One bandicoot was eaten by a carpet python inside the enclosure.

All bandicoots were initially introduced into the northern section of the enclosure, but a male was recorded on the southern side of the dividing fence in March 2000. Subsequently other animals crossed the barrier, probably by squeezing under the gate, and a breeding population eventually became established there. This has probably been of benefit to the breeding program, because individuals of both sexes are aggressive towards each other and this probably limits the number of bandicoots that can coexist in a confined area.

Seven animals were removed in 2000, comprising five transferred to a soft release enclosure and two found with wart-like symptoms and taken to Kanyana. Twice numbers have dropped to low levels for no apparent reason. Predation by owls may be heavy at times and could account for dips in population numbers.

The western barred bandicoot population is low, but this may be due to social factors. New animals are recorded at most monitoring sessions, and pouch young are usually

present as well. Monitoring radio-collared animals in the enclosure will reveal causes of mortality and this may suggest changes in management. The graphs show decline in numbers over summer. It has been suggested that the water-drippers may be too high for bandicoots, and so they may be suffering from a lack of water, which they will need when eating the high protein omnivore pellets. This possibility was addressed during summer 2002/3 by providing water in bowls on the ground.

Boodie

The boodie population has grown steadily throughout the period. On two occasions groups of animals were removed. Eight boodies were transferred to Yookamurra in March 2000 in exchange for eight numbats (for the Stirling Range NP reintroduction). In November 2001 and January 2003 14 boodies were sent to Adelaide to be part of an investigation into the suitability of several potential surrogate species for cross-fostering Gilbert's potoroo. Each time the boodie population recovered quickly to its previous level and continued to increase. The proportion of females with pouch young fluctuates, but new animals are found at almost every monitoring session.

The boodie population appears strong enough to support a reintroduction soon and one is planned for spring 2003.

Mala

These animals are very flighty and can damage themselves in cage traps. They are also not strongly attracted by peanut butter-based bait. Consequently Bromilow 'soft' traps baited with fresh lucerne are used to trap mala. This is done only once a year, in February, when green pick is

scarce and the lucerne is very attractive to browsing mammals.

Mala numbers appear to be declining slowly. Young animals are regularly recorded, but they may not be reaching adulthood and the old founders are now disappearing. Four of the eleven collared animals died, three due to raptor predation. Mala nest in scrapes underneath bushes and appear to be vulnerable to predation by wedge-tailed eagles. The remains of one mala were found outside the enclosure, presumably dropped by a large raptor. More precise information on causes of mortality can be gained through radio-tracking individuals. Such studies, particularly on young animals, are required so that an informed decision may be made on the future of the rufous hare-wallaby colony.

Banded hare-wallaby

All 18 banded hare-wallabies were radio-collared before release, and seven died within the six-month life of the radio-collars. Raptors definitely accounted for three of these deaths, and one at least was a wedge-tailed eagle, as the carcass was found 500 metres outside the enclosure. Banded hare-wallabies rest above ground, sitting under bushes during the day. Damaged collars belonging to two other banded hare-wallabies were found, indicating predation, presumably by raptors.

Two deaths were due to injuries sustained during the capture on the islands, probably due to damage by landing nets.

Banded hare-wallabies are slow breeders and this, combined with their tendency to sit in semi-exposed situations during the day and hence sustain a high level of predation may make it very difficult to run a strong breeding colony.

TABLE 2

Summary of animals released into the enclosure, new animals recorded and current numbers, Dryandra breeding enclosure 1998–2002.

SPECIES	NUMBER RELEASED	RELEASE DATE	NEW ANIMALS RECORDED TO DECEMBER 2002	NUMBERS KNOWN TO BE ALIVE (KTBA) DECEMBER 2002
Bilby	45	1998–2001	85	43
Western barred bandicoot	27	1998	60	19
Boodie	20	1998	75	50
Mala	19	1998	44	14
Banded hare-wallaby	18	1998–99	6	0

TABLE 3

Fate of radio-collared animals released into the *Return to Dryandra* breeding enclosure.

SPECIES	NO. RADIO-TAGGED AT RELEASE	DEATHS OF RADIO-TAGGED ANIMALS	CAUSE OF DEATH
Bilby	25	3	U, UP
Western barred bandicoot	27	8	RA, U, UP, CP
Boodie	12	0	
Mala	13	4	RA, U
Banded hare-wallaby	18	7	RA, CA, U

U Unknown cause of death
 CA Capture injury
 UP Unidentified predator
 CP Carpet python
 RA Raptor
 HA Handling death

Reintroductions into Dryandra Woodland

Prior to the introduction of animals into the enclosure, a schedule of releases was drawn up for planning purposes. This schedule was optimistically based on the highest projections of animal production (Table 4).

Timetable for introductions into Dryandra enclosure (italics in Table 4)

26 March 1998	20 mala from Tanami Desert
Early April 1998	10 western barred bandicoots from Kanyana
30 April 1998	30 boodies, 2 pairs of banded hare-wallabies and 10 western barred bandicoots from Dorre Island
September 1998	12 bilbies from Kanyana/Pilbara or Kimberley
March 1999	16 banded hare-wallabies from Dorre Island

Timetable for releases into Dryandra Woodland (bold in Table 4)

March 1999	20 western barred bandicoots
April 1999	30 boodies
September 1999	20 mala
March 2000	20 banded hare-wallabies
March 2002	20 bilbies

Figures 1–5 show that these breeding projections were not achieved in this time scale. In fact no species was sufficiently numerous for a translocation group to be removed until March 2000, when the bilby population in the enclosure surpassed 40 animals. This translocation commenced in April 2000 and is summarised below (Bilby reintroduction).

Bilby reintroduction

A Translocation Proposal for bilbies into Dryandra Woodland was prepared (Friend and Orell 2000b) and approved by the Director, Nature Conservation. A summary of events, reported more fully in Friend (2000a, b) follows.

First release

The first releases of bilbies from the enclosure into Dryandra proper were set up as an experiment to compare the average dispersal distance and survival of animals released in two different ways. One group would be placed in a one-hectare ‘soft release’ enclosure with artificial burrows, food and water for two weeks before release by opening gates. The other group would undergo ‘hard release’, being placed into artificial burrows with no enclosure, although with food and water provided. All bilbies would be fitted with radio-collars (see Discussion). In April 2000, eight bilbies were moved from the breeding enclosure into the soft-release enclosure. One was later removed for treatment, however, as its foot had become caught under its collar. On 3 May 2000, the release gates were opened. On the same day another group of nine bilbies was released into hard-release burrows in another part of Dryandra Woodland, followed by two more the next day.

Six of the bilbies moved quickly out of the main block of Dryandra into the surrounding farming area. Five were captured and brought back but a fox took one before he could be found. Many bilbies settled at first in old rabbit warrens around the perimeter of Dryandra, while some settled in burrows in farmland near the Woodland boundary. By June, most bilbies were surviving, so another release was carried out.

Second release

Eight bilbies were released into burrows previously dug by bilbies, four unfenced and four within the release enclosure but with the gates open. Food and water were provided at all sites. Less dispersal occurred this time, and bilbies tended to stay within the Woodland, settling near other bilbies.

From early July 2000 until late August, however, a total of 9 deaths were caused by foot entrapment in collars following weight loss. Remaining bilbies were trapped, their collars were tightened and supplementary food provided. It seems that at the time of the release in autumn, grasshoppers were abundant in the farmland.

TABLE 4

Schedule for translocations to and from Dryandra breeding enclosure (dated 4 February 1998).

SPECIES	1998	1999	2000	2001	2002	2003
Boodie	<i>Dryandra enclosure</i>	Dryandra 30	Lake Magenta 40, Dragon Rocks 40			
Bilby (dalgyte)	<i>Dryandra enclosure</i>	Lake Magenta 20	Fitzgerald River 20	Dragon Rocks 20	Dryandra 20	
Mala	<i>Dryandra enclosure</i>	Dryandra 20	Dragon Rocks 20	Lake Magenta 40		
Western barred bandicoot (marl)	<i>Dryandra enclosure</i>	Dryandra 20	Dragon Rocks 20	Cape Le Grand 20 Fitzgerald River 20	Cape Arid 20	
Banded hare-wallaby (Merrine)	<i>2 pair into Dryandra enclosure</i>	<i>Dryandra enclosure</i>	Dryandra 20	Dragon Rocks 20	Lake Magenta 40	Fitzgerald River 20

With onset of cold weather, food became scarce and weight loss occurred.

Nevertheless, four females were recorded with pouch young. The end result of the two releases was that four colonies were established (Figure 6), although two were of only two animals.

Third release

The strategy for a third release, designed to lessen the risk of foot entrapment, was to place high-powered collars on the bilbies for the first week to trace dispersal, after which the animals would be recaptured, collars removed and tail transmitters attached instead.

Ten bilbies were fitted with collars and tail tags. Five were released in burrows in the release enclosure with food and water provided, while five were released in burrows dug and recently used by other bilbies. Six of the bilbies dispersed long distances, two outside Dryandra, while four didn't move far and none stayed in the release enclosure.

The main cause of mortality in spring was predation by carpet pythons. Two residual colonies existed by spring 2001. Another release followed in October 2001, using powerful tail transmitters of a new design. However, the transmitters failed early and contact with the bilbies was lost. Some were located by trapping at burrows, so burrow searches were instigated, trapping when an active burrow was found. This method was very labour-intensive, with little result. It was found that brushtail possums were also using the burrows, so signs of activity at a bilby burrow do not always provide evidence of bilby presence.

Discussion

The bilby releases in 2000–2001 encountered several problems, in particular, foot entrapment in radio-collars after weight loss, predation by carpet pythons, and premature failure of tail transmitters.

Thorough research into transmitter attachment was carried out before tags were ordered for the Dryandra Woodland release. In their reintroduction manual for bilbies, Southgate *et al.* (1994) recommended two attachment types, a soft collar and a hard collar. Southgate had used collars in all his releases of captive-bred bilbies in the Northern Territory, without problems. Peter McRae used radio-collars extensively on bilbies in the south-western Queensland population during 1995–97 without problems. Both collar types recommended by Southgate *et al.* (1994) were used extensively in the *Return to Dryandra* breeding enclosure during releases of bilbies from Kanyana in 1998 and 1999 (Table 8), without any problem apart from chafing in a few animals that put on weight.

In 1997, during a release of four bilbies into coastal sand-dune habitat on Thistle Island, SA, three bilbies died or suffered injury through foot entrapment. The South Australian workers then began using tail-mounted transmitters, but these had limited range and fell off after 1–2 months (J. van Weenen, DoE & Heritage, Adelaide, pers. comm.). The decision to use collars initially at

Dryandra was made on the basis of experience and the greater practicality of the collar attachment. Collars were also purchased for the Peron bilby release in 2000, but tail tags were used for that release after the events at Dryandra were reported (C. Sims, CALM, pers. comm.).

Subsequent development of tail transmitters through the Return to Dryandra project has resulted in a model that will be used first in a release in 2003. These powerful, six-month, activity-sensing tail tags will optimise the tail mode of attachment and provide safety for the animals.

Predation by carpet pythons has been a feature of the late spring, as these reptiles attain maximum activity during and after the mating season. It is unlikely that there is any solution to this problem, apart from carrying out releases in areas where fewer carpet pythons are encountered.

The task of monitoring bilbies after the loss of their tail-transmitters will add challenge to the reintroduction of this species to unfenced areas. Indirect methods, like burrow searches followed up with hair tubes may be the only choice, rather the more traditional trapping and radio-tracking techniques.

Western barred bandicoot reintroduction

A Translocation Proposal for western barred bandicoots into Dryandra Woodland using stock from the Dryandra breeding enclosure, the Peron Captive Breeding Centre and Kanyana was prepared (Friend and Orell 2000a) and approved by the Director, Nature Conservation.

The translocation was planned as a comparison of soft versus hard release methods. Another release enclosure, approximately 1 ha in area, was built, in an area of sandplain heath providing the dense cover preferred by western barred bandicoots. The release enclosure was surrounded by a rabbit mesh fence, 1080 mm high with a 500 mm skirt under the soil, running each way from the fence to prevent animals from digging in or out.

Five bandicoots were captured from the breeding enclosure, fitted with radio-collars and released into the small enclosure. Omnivore pellets and water were provided. The bandicoots were to be left in the enclosure for three weeks to allow them to build nests and establish home ranges before the gates were opened. Another group were to be released at the same time at an unenclosed site.

Within a week of the transfer to the small enclosure, the wart-like syndrome was discovered in western barred bandicoots at Kanyana. The bandicoots were left in the small enclosure for several months, in case the disease situation could be resolved quickly. They were recaptured, inspected and found to be free of the symptoms. However, the release was cancelled when it became clear that there was not going to be a quick resolution of important questions about the disease that would affect the release of possibly infected animals into Dryandra.

The discovery of the disease in western barred bandicoots raised many serious questions about the Department's consideration of disease management both within the *Return to Dryandra* program and more broadly across *Western Shield* and threatened fauna recovery

programs. Discussions with the veterinary staff assisting the *Return to Dryandra* program revealed many unresolved questions, including:

- The identity of the disease causing the wart-like symptoms
- Our inability to screen animals before symptoms appear
- The vector(s) by which the disease is spread (including staff)
- Identifying if any other species may be at risk.

A workshop on disease in western barred bandicoot populations was subsequently held on 16 July 2002 (Friend 2002). It was resolved that there is an urgent need to develop clear protocols for dealing with existing and potential disease threats at a Department level, as the implications of poor and uncoordinated disease risk management are significant for *Western Shield* and threatened fauna recovery. The development of these protocols was proposed as one of the outcomes of the disease workshop.

Use of reintroductions to Dryandra to test alternative reintroduction methodologies

As Dryandra was to be the first translocation site in the south-west for these species, it was appropriate to compare different release methods at each release. This way, the most successful release methods could be used in subsequent releases.

The first bilby release was set up as a comparison of hard and soft release methods. The eight soft release animals were moved from the breeding enclosure, fitted with transmitters, and placed in a release enclosure provided with artificial burrows, food and water. These eight animals remained in the enclosure for three weeks, and were trapped after two weeks to examine their condition. One had its foot caught in its collar and it was moved back to the breeding enclosure. After three weeks the gates were opened and all animals left on the first night. Only one stayed close by. She was an adult female and the only female with pouch young. On the same evening, nine radio-collared bilbies were released into artificial burrows in another part of the Woodland. The following night two more were released into the same burrows.

The distances of dispersal after two nights of the two groups of bilbies did not differ from each other (hard release, $n=10$, distance= 4.3 ± 4.3 km, soft release $n=7$, distance= 6.3 ± 4.7 km).

As the western barred bandicoot release did not proceed, no result was obtained for a planned comparison of soft and hard releases.

Involvement of the local community, through a Friends of Dryandra group and volunteers from other places, through Landscape Expeditions and possibly Earthwatch

The use of volunteers in the Return to Dryandra project has not been as extensive as originally envisaged. This is partly due to the readiness of Narrogin District personnel to be involved, particularly in the monitoring within the breeding enclosure. There is no Friends of Dryandra group, partly due to a lack of staff time available to actively encourage and support the formation of such a group. Involvement of the community in the implementation of the project has been predominantly through the input of Kanyana Wildlife Rehabilitation Centre (intensive breeding programs for bilbies and western barred bandicoots, hand-rearing of thrown pouch young and rehabilitation of injured and sick animals) and the Pingelly Animal Refuge (hand-rearing of thrown pouch young and rehabilitation of injured and sick animals). Kanyana has 90 enrolled volunteers and at times this resource has been utilised at Dryandra when help is needed. Volunteers are recruited for enclosure monitoring when a full team is not available from Science Division or Narrogin District. All volunteers are registered through the CALM Community Involvement Program.

OVERVIEW OF THE CAPTIVE BREEDING PROGRAM

Establishment of the breeding program at Dryandra

The rationale behind the captive breeding program was to establish breeding groups of locally extinct species within a protected section of Dryandra, in order to produce groups of wild, acclimatised animals for reintroduction. This was done by fencing off a suitable area of Dryandra Woodland, providing food and water *ad hoc*. and monitoring the resulting populations.

This strategy has cost advantages over intensive captive breeding in small cages, as well as the more important benefit of producing animals that are more site-adapted and wild-adapted. However, the two methods cannot be compared on equal terms. Despite the provision of unlimited food, space is limited and this has had an undeniable effect on population growth, particularly amongst boodies. This method has not been used widely before, so there are few data to allow reasonable predictions about population dynamics. However, there are some data from Dryandra (see below) and the experience at Heirisson Prong, where the enclosure-breeding method was used extensively for the first time in Western Australia (Short *et al.* 1994). For instance,

the western barred bandicoot breeding colony at Heirisson Prong did not grow beyond 20 animals, but over 120 animals were produced over 3 years for release into the surrounding protected area. This was achieved by releasing animals in a steady stream rather than in large groups (J. Richards and J. Short, CSIRO, Perth, pers. comm.) Groups of boodies were removed from the Return to Dryandra enclosure on two occasions and numbers returned to pre-removal levels within 3–6 months (Figure 3).

However, there must be some examination of the appropriateness of using a large enclosure, such as at Dryandra, for captive breeding. There would appear to be several questions about the reasons for apparent lack of breeding success of several of the species, which can only be resolved by intensive monitoring of the fate of individual animals. In practice, however, the size of the enclosure makes this difficult or impossible. Similar problems were encountered with much smaller (0.5 ha) captive breeding enclosures for the eastern barred bandicoot at Gellibrand Hill in Victoria (Backhouse *et al.* 1994). Management of the apparent impact of raptor and owl predation on population numbers is also likely to be difficult in a large open enclosure, whereas netting may be viable for smaller enclosures.

Founder numbers, breeding success and death rates within the colonies, and costs per animal produced

These parameters have been developed for comparisons between intensive breeding systems, in which births and deaths are always recorded. Although the monitoring procedures used in the Dryandra breeding enclosures allow individuals to be traced, deaths are rarely recorded and breeding success can only be measured in terms of the numbers of pouch young and new independent individuals recorded.

It should also be remembered that due to space limitations, the maximum potential output of the breeding enclosure can only be realised if animals are being removed constantly. As to date only bilbies, and to a lesser extent, boodies, have been removed, the potential output of the other species cannot be assessed. This is most likely an issue with western barred bandicoots, which are aggressive towards each other and display self-limitation to a

significant degree (J. Richards and J. Short, CSIRO, Perth, pers. comm.). It is unlikely to be an issue with banded hare-wallabies, which have been removed by birds of prey but have not been able to breed quickly enough to replace the losses.

Degree of coordination between Dryandra captive colonies and those at Shark Bay and Kanyana

The Dryandra breeding enclosure populations were established from animals from different sources. The degree of coordination in the management of the various breeding colonies has differed depending on the species concerned.

The Kanyana breeding colonies of bilbies and western barred bandicoots were established with financial support from the *Return to Dryandra* project (amongst other sources) specifically to provide animals for release in the Return to Dryandra enclosure.

Exchanges of bilbies have occurred between Kanyana, Peron Captive Breeding Centre, and a number of zoos (Monarto, Alice Springs Desert Park and the Territory Wildlife Park) as well as enclosed populations, such as Yookamurra Sanctuary in South Australia. Perth Zoo does not hold breeding colonies of any of the Return to Dryandra species.

Bilby

The Kanyana and Dryandra breeding enclosure bilby colonies have been managed in very close coordination. From the outset, Dryandra acted as a half-way house for the bilbies produced at Kanyana. Kanyana animals were released into the enclosure, where they bred. The bilby is the only species released into Dryandra so far, and almost all of the release animals have been enclosure-bred. Exchanges of animals with the PCBC breeding colony have occurred, to promote gene flow between the breeding populations.

Coordination between staff, *Return to Dryandra* and *Project Eden*, at Peron has been fairly limited. However there is the potential for much greater coordination and communication to occur, particularly amongst field staff. Better coordination may mean that operational problems are overcome more rapidly and ideas shared.

TABLE 5

Summary of production and costs, *Return to Dryandra* breeding enclosure, 1998–2002.

SPECIES	TOTAL INTRODUCED	NUMBER REMOVED	CURRENT RESIDENTS	NUMBER PRODUCED	TOTAL COST*	COST PER ANIMAL
Bilby	35	46	43	54		
Western barred bandicoot	27	7	19	-1		
Boodie	20	22	50	52		
Mala	19	4	14	-1		
Banded hare-wallaby	18	1	1	-16		
Totals	119	81	126	88	\$395 000	\$4489

*Total cost is calculated as the initial cost of the infrastructure (\$100 000), plus the total allocated budget 1997/98 to 2001/02 (Table 1).

TABLE 6
Summary of coordination between captive breeding programs.

DEGREE OF COORDINATION BETWEEN RETURN TO DRYANDRA BREEDING ENCLOSURE AND BREEDING COLONIES AT:		
	Kanyana	Peron Captive Breeding Centre (PCBC), Shark Bay
Bilby	Close coordination, as Kanyana breeds bilbies to stock the <i>Return to Dryandra</i> Enclosure	Exchange of individuals between Kanyana and Return to Dryandra breeding enclosure to enlarge gene pool and even up sex ratios
Western barred bandicoot	Close coordination, as Kanyana breeds western barred bandicoots to stock the <i>Return to Dryandra</i> Enclosure	Prior to discovery of diseases, exchange of individuals between PCBC and Kanyana to enlarge gene pool and even up sex ratios. Several animals introduced to Kanyana from Heirisson Prong. TP includes release of PCBC western barred bandicoots at Dryandra.
Boodie	No breeding colony at Kanyana	No breeding colony at PCBC
Mala	No breeding colony at Kanyana	No exchanges carried out
Banded hare-wallaby	No breeding colony at Kanyana	Proposed restocking from PCBC

Western barred bandicoot

Western barred bandicoots have been bred at Kanyana since the commencement of an experiment in collaboration with CALM Research Scientist Dr Tony Friend in 1994 to examine the potential for breeding between Bernier and Dorre Island animals. Due to Kanyana's success in breeding western barred bandicoots, the output of the colony was then directed towards providing animals for release at Dryandra.

CRITICAL ANALYSIS OF THE VIABILITY OF THE DRYANDRA SITE FOR THE PROJECT

1. Viability of the Dryandra site for the breeding enclosure

Advantages:

- Area of natural habitat in good condition available for enclosure.
- Area under intensive fox control provides an extra defence against fox incursion into the breeding enclosure.
- Proximity to Narrogin and other district activities in Dryandra facilitate frequent servicing of the enclosure. This has proved important.
- Developing nature-based tourism in Dryandra, which will generate additional support for feral predator control and for the aims and objectives of the program.
- Suitable habitat for releases is available within Dryandra. This is especially true for bilbies and boodies, both of which require the open woodland and loamy soils that are widespread within Dryandra,

including within the breeding enclosure. Sandy loams occur in Dryandra from the upper valley slopes to the valley floors.

Disadvantages:

- The presence of a rich and varied fauna in Dryandra may result in higher predation by native fauna than may occur in more depauperate areas.
- Potential risks of introducing diseases into wild populations of other fauna, including threatened species such as the numbat and woylie.

2. Viability of Dryandra as a fauna reconstruction site

Advantages:

- Proximity to Narrogin and other District activities in Dryandra facilitates frequent monitoring visits for radio-tracking released animals.
- Development of nature-based tourism in Dryandra, which will generate additional community support for feral predator control and for the aims and objectives of the program.
- Suitable habitat for releases is available within Dryandra. This is especially true for bilbies and boodies, both of which require the open woodland and loamy soils that are widespread within Dryandra. Sandy loams occur in Dryandra from the upper valley slopes to the valley floors.

Disadvantages

- Management of Dryandra is complex, due to its convoluted shape and the multiplicity of land uses within and surrounding the Woodland.

MANAGEMENT OF THE PROJECT IN RELATION TO INVOLVEMENT OF STAFF FROM DIFFERENT DEPARTMENTAL DIVISIONS

The *Return to Dryandra* project was conceived as a joint project between Narrogin District (Regional Services Division) staff and Science (previously Science and Information) Division staff based at Woodvale. The emergence of the viewing enclosure as an adjunct project invited the participation, at an early stage, of Parks and Visitor Services (previously Parks, Planning, Recreation and Tourism) Division staff. Nature Conservation Division staff were also involved in the Return to Dryandra Steering Committee. The everyday running of the breeding enclosure project is the responsibility of Narrogin District staff. The overview of the animal management and monitoring is the responsibility of Science Division staff. The project thus requires project staff to communicate outside their normal lines of responsibility and between geographically separated offices. This is not unusual within CALM, and Science Division staff frequently work closely with Regional Services staff. The best communication happens in the field, on the job, and the monitoring sessions are a great forum for communication between the operators. There is a need also, however, for discussion at a high level within the project and for communication between managers to occur. The Return to Dryandra Steering Committee was a very useful forum in the early stages and its existence expedited the development of the project. The reasons for the hiatus in its operation are not clear. The revival of the committee in 2001 was a very positive move towards restoring the momentum of the project, which had stalled somewhat over the difficulties encountered, particularly the western barred bandicoot disease issues and the high mortality of released bilbies.

The subsequent incorporation of the Return to Dryandra Steering Committee into the WSSMC was primarily aimed at providing a better forum for coordinating the role of the breeding facility in meeting the objectives of *Western Shield* and associated fauna recovery programs. The management of the breeding facility remains with the District Manager, Narrogin, and an informal committee has been established to support the project.

There still appears to be a need to clarify the role of *Return to Dryandra* beyond reintroductions into Dryandra Woodland. The WSSMC has an expectation that the breeding facilities will continue to be managed to provide animals for translocations to other sites as well as Dryandra. However the 'Return to Dryandra Strategic Plan 2002-2005' is not clear on the role of the project beyond research into the capacity of the breeding facility to produce more banded hare-wallabies, mala and western barred bandicoots and translocations of bilbies and boodies into Dryandra Woodland.

The problems encountered in the management of the *Return to Dryandra* program, particularly its place within the *Western Shield* program, are symptomatic of the overlapping and unclear roles of the various programs, branches and divisions within the Department that are involved in fauna management and threatened species recovery.

OVERVIEW OF FUTURE PLANS (STRATEGIC PLAN)

The *Return to Dryandra* project has not met the rather ambitious goals set at the outset, due to unpredicted factors reducing population growth within the enclosure, particularly bird predation, but possibly also intraspecific aggression. In the next three years it is proposed to build on the success of the bilby and boodie breeding colonies and produce sufficient animals for further translocations in Dryandra.

The objectives for the breeding enclosure for the next three years, as stated in the draft strategic plan, are to:

- Provide sufficient numbers in 2002/03 and 2003/04 to translocate and establish wild populations of bilbies and boodies whilst maintaining sufficient numbers within the breeding enclosure as a breeding colony.
- Re-establish and undertake a breeding research program to provide sufficient numbers of banded hare-wallabies, mala and western barred bandicoots within the breeding enclosure for release into the wild in 2004/05 and 2005/06.

Releases into Dryandra Woodland are planned for bilbies in autumn 2003 and boodies in spring 2003, in order to capitalise on the high numbers present in the enclosure.

Mala and western barred bandicoots in the breeding enclosure will be fitted with radio-collars and monitored closely to determine causes of mortality. An investigation will be carried out into the possibility that western barred bandicoots have been suffering from a lack of water in summer because the drippers are too high for them to reach.

Continuation of the banded hare-wallaby breeding program will require the introduction of new stock. Animals could either be brought from the islands or transferred from the PCBC. Additional shelter will be provided in the enclosure and close monitoring will be carried out to determine whether the new shelters are effective in reducing predation.

However, in order to carry out reintroductions into Dryandra and continue the research into reintroduction techniques that has already benefited other programs such as *Project Eden*, greater personnel input is required. Similar

work is being undertaken as in *Project Eden*, but with only 0.5 FTE dedicated to captive breeding and monitoring released animals, compared with at least 2.0 FTE at Denham. The provision of 0.5 FTE is sufficient for the maintenance of the breeding enclosure and provides valuable input to monitoring both in the enclosure and during releases. While it has been possible to redirect staff resources from Narrogin District and Science Division for specific short-term projects, more consistent staff input is required. Increase of the Narrogin staff component to 1.0 FTE would provide continuity, consistency, thoroughness and momentum and will allow the kind of comprehensive investigation that the project needs.

Consideration needs to be given as to whether the facilities at Dryandra are appropriate for the captive breeding of all five species involved to date. Whilst the bilby and boodie appear to be relatively successful, there are some questions about the viability of the western barred bandicoot and mala, and serious concerns about the banded hare-wallaby.

ACKNOWLEDGMENTS

We would like to thank all those who have contributed to the *Return to Dryandra* Project. Many volunteers have given their time, not only in the captive breeding and wildlife rehabilitation centres, but also in the field, putting in long hours in the sun, wind or rain. Narrogin District staff, in particular, Brian Macmahon, Howard Robinson and Martin Clarke, have done a fantastic job in building and maintenance of the enclosure and care of the animals and participating enthusiastically in the monitoring. Clare Anthony has worked tirelessly in maintaining the enclosure and feeding the animals, as well as doing the lion's share of the radio-tracking after releases. Neil Thomas of Science Division has been the backbone of the enclosure monitoring and has faithfully maintained the databases since the commencement of the project. June and Lloyd Butcher have given great support to the project by running the bilby and western barred bandicoot captive colonies. Kristen Warren and Ralph Swan have made a major contribution through the health monitoring project. We would also like to acknowledge gratefully the support of Syd Shea, Gordon Wyre and Keiran McNamara. Comments on this review were received from Clare Anthony, Howard Robinson and Kate McGregor. Constructive comments by the two external referees were very helpful.

REFERENCES

- Anthony C, Friend T (1999) 'Return to Dryandra. Phase I: Breeding Enclosure. Operations/Procedures Manual.' Unpublished report, Department of Conservation and Land Management, Western Australia.
- Backhouse GN, Clark TW, Reading RP (1994) The Australian Eastern Barred Bandicoot - Evaluation and Reorganization. In *Endangered Species Recovery: Finding the Lessons, Improving the Process* (eds. TW Clark, RP Reading, AL Clarke), pp. 251-271. Island Press, Washington.
- Burbidge AA, Start AN, Morris KDM, Armstrong R (1996) '*Western Shield* - Recovering our native fauna.' Unpublished report, Department of Conservation and Land Management, Western Australia.
- Durell, G. and Friend T (2002) 'Return to Dryandra: Strategic Plan 2002-2005.' Unpublished report, Department of Conservation and Land Management, Western Australia.
- Eldridge M, Spencer PBS (in press). Insular populations of rare species: are offshore islands arks or tombs? *Conservation Genetics*
- Friend JA (2000a) 'Reintroduction of the bilby to Dryandra.' Progress report 28 August 2000. Unpublished report, Department of Conservation and Management, Kensington.
- Friend JA (2000b) 'Dryandra Bilby reintroduction - Update: 22 September 2000.' Unpublished report, Department of Conservation and Land Management, Western Australia.
- Friend JA (2002) 'Workshop on disease in western barred bandicoot populations, held at WA Wildlife Research Centre, Tuesday July 16th, 2002.' Unpublished report, Department of Conservation and Land Management, Western Australia.
- Friend JA, Bowra T (1996) 'Return to Dryandra - a *Western Shield* Project.' Unpublished report, Department of Conservation and Land Management, Western Australia.
- Friend JA and Orell P (2000a) 'Re-introduction of bilby (*Macrotis lagotis*) to Dryandra Woodland from Return to Dryandra breeding enclosures and Kanyana captive breeding colony.' Unpublished report, Department of Conservation and Land Management, Western Australia.
- Friend JA and Orell P (2000b) 'Reintroduction of western barred bandicoot (*Perameles bougainville bougainville*) to Dryandra Woodland from captive breeding and field breeding centres in Western Australia.' Unpublished report, Department of Conservation and Land Management, Western Australia.
- Langford D (1999) *The Mala* (*Lagorchestes hirsutus*) *Recovery Plan*. Environment Australia, Canberra.
- Maxwell S, Burbidge AA, Morris KD (1996) *The 1996 Action Plan for Australian Marsupials and Monotremes*. Environment Australia, Canberra.
- Paltridge R (2000) Draft Recovery Plan for the Greater Bilby *Macrotis lagotis*. Unpublished report, Parks and Wildlife Commission of the Northern Territory.

Short J, Turner B, Parker S, Twiss J (1994) Reintroduction of endangered mammals to mainland Shark Bay: a progress report. In *Reintroduction biology of Australian and New Zealand fauna*. (ed. M Serena), pp. 183-88. Surrey Beatty & Sons, Chipping Norton.

Southgate R, Bellchambers K, Romanow K, Whitfield S (1994) Reintroduction of the Greater Bilby. Volume 1. A field guide. Project 95. Final Report to World Wide Fund for Nature (Australia). Conservation Commission of the Northern Territory.

Southgate R, (1995) 'Recovery Plan for the Greater Bilby *Macrotis lagotis*.' Unpublished report, Parks and Wildlife Commission of the Northern Territory.

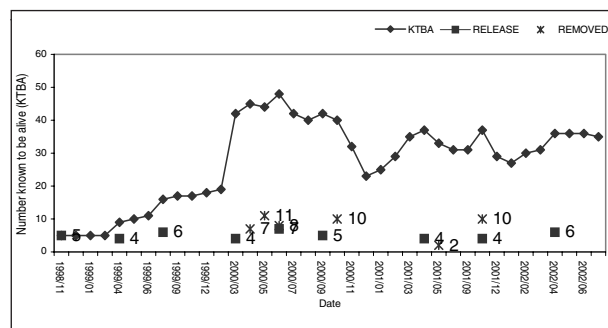
Warren KS, Swan RA, Morgan-Ryan UM, Friend JA, Elliot A (in press). *Cryptosporidium muris* infection in bilbies (*Macrotis lagotis*). *Journal of Zoo and Wildlife Medicine*.

APPENDIX

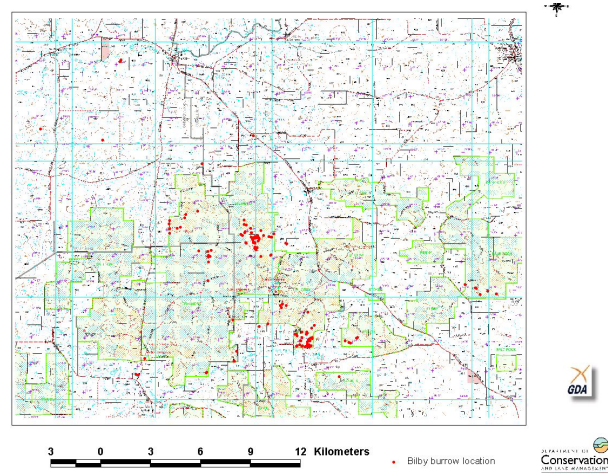
Graphic and tabular data not contained in the body of the paper that, nevertheless, provides useful benchmark information. The graphs show population sizes for each of the five species of marsupial introduced into the *Return to Dryandra* breeding enclosure. Population size is expressed as numbers Known To Be Alive (KTBA). If an animal is caught before and after a trapping session at which it is not caught, it is added to the total for the session at which it was not caught. Totals for the most recent trapping session are not shown, although animals caught in that session are taken into account in the last total shown.

The results of monitoring radio-collared animals after initial release into the breeding enclosure are also shown.

Bilby (*Dalgyte*)



Appendix figure 1b: Bilby burrow locations – Dryandra.



Appendix figure 1a: Bilby numbers known to be alive within the breeding enclosure

APPENDIX TABLE 1a: Bilby releases into enclosure.

DATE	NUMBER	SOURCE
20/11/1998	5	Kanyana, AZRI, Shay Gap
27/4/1999	4	Kanyana, Rudall River
9/8/2000	6	Kanyana
17/3/2000	4	Kanyana
8/6/2000	7	Kanyana
29/9/2000	5	Kanyana
19/4/2001	4	Kanyana
2/10/2001	4	Kanyana
29/4/2002	6	Kanyana
Total	45	
New animals recorded to 13/12/2002	85	

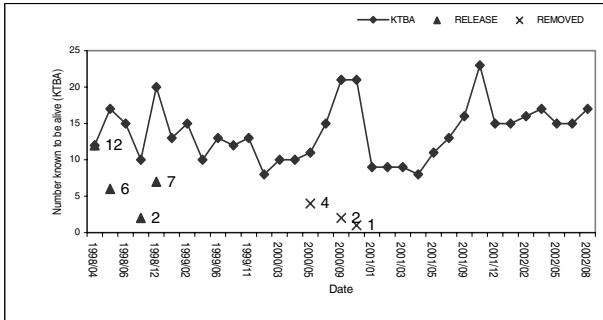
APPENDIX TABLE 1b: Bilby removals from enclosure.

DATE	NUMBER	DESTINATION
12-13 April 2000	7	Releases outside enclosure
3-4 May 2000	11	Releases outside enclosure
28-29 June 2000	8	Releases outside enclosure
25 26 October 2000	10	Releases outside enclosure
23-24 October 2001	10	Releases outside enclosure
23 May 2001	2	Returned to Kanyana
Total removals	46	

APPENDIX TABLE 1c: Deaths of radio-collared bilbies in the breeding enclosure (25 animals collared).

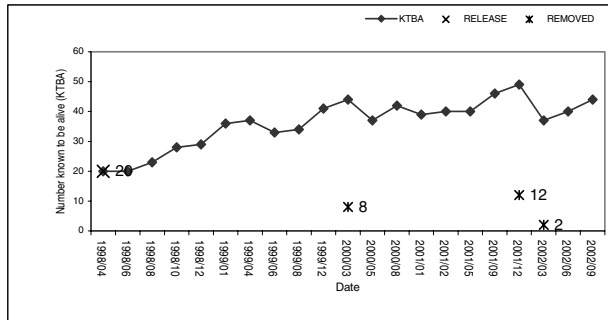
DATE FOUND	ID #	CAUSE
31/07/1999	Wilga	Unknown
10/11/1999	Meriki	Unknown
26/11/1999	Niribi	Unidentified predator
Total	3	

Western barred bandicoot (Marl)



Appendix figure 2: Western barred bandicoot numbers known to be alive within the breeding enclosure.

Boodie (Burrowing Bettong)



Appendix figure 3: Boodie numbers known to be alive within the breeding enclosure.

APPENDIX TABLE 2a: Western barred bandicoot releases into enclosure:

DATE	NUMBER	SOURCE
30/4/1998	11	Kanyana
30/4/1998	1	Dorre Island
1/5/1998	6	Dorre Island
5/05/1998	2	Peron CBC
9/12/1998	7	Kanyana
Total	27	
New animals recorded to 13/12/2002	60	

APPENDIX TABLE 2b: Western barred bandicoot removals from enclosure:

DATE	NUMBER	DESTINATION
4-5/9/2000	5	to soft release enclosure
27/9/2000 & 25/10/2000	2	to Kanyana with warts

APPENDIX TABLE 2c: Deaths of radio-collared western barred bandicoots (27 animals collared):

DATE FOUND	ID #	CAUSE
9/6/1998	0013	Died during handling
11/6/1998	0008	Found dead in nest
11/6/1998	K040	Found remains on ground
14/12/1998	K017	Raptor/toxo?
14/12/1998	K053	Raptor/toxo?
30/12/1998	K038	Carpet python
18/1/1999	K049	Raptor?
Total	7	

APPENDIX TABLE 3a: Boodie releases into enclosure.

DATE	NUMBER	SOURCE
30/4/1998	20	Dorre Island
New animals recorded to 13/12/2002	75	

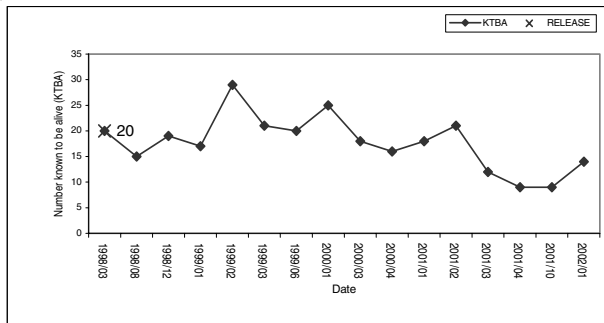
APPENDIX TABLE 3b: Boodie removals from enclosure.

DATE	NUMBER	DESTINATION
13/3/2000	8	sent to South Australia

APPENDIX TABLE 3c: Boodie deaths (no deaths amongst 13 radio-collared animals):

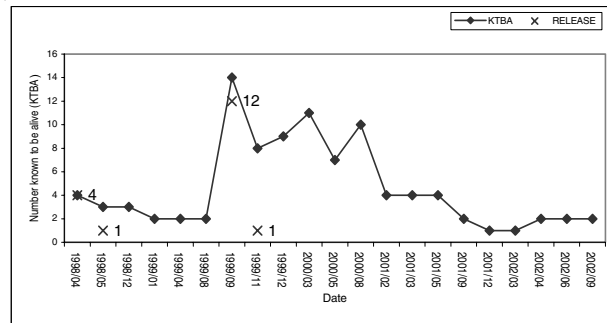
DATE FOUND	ID #	CAUSE
13/1/1999	?	Died in trap
Total	1	

Mala (*Rufous hare-wallaby*)



Appendix figure 4: Mala numbers known to be alive within the breeding enclosure.

Banded hare-wallaby (*Merrnine*)



Appendix figure 5: Banded hare-wallaby numbers known to be alive within the breeding enclosure.

APPENDIX TABLE 4a: Mala releases into enclosure:

DATE	NUMBER	SOURCE
26/3/1998	19	Tanami Mala
Paddock New animals recorded to 13/11/2002	44	

APPENDIX TABLE 4b: Mala removals from enclosure.

DATE	NUMBER	DESTINATION
Various	4	to carers

APPENDIX TABLE 4c: Deaths of radio-collared mala (11 collared at release):

DATE FOUND	ID	CAUSE
16/7/1998	N/A	Raptor predation
16/7/1998	N/A	Raptor predation
24/2/1999	N/A	Raptor predation
20/2/2000	N/A	Found mummified
Total	4	

APPENDIX TABLE 5a: Banded hare-wallaby releases into enclosure:

DATE	NUMBER	SOURCE
30/4/1998	4	Dorre Island
1/5/1998	1	Dorre Island
8/9/1999	10	Dorre Island
9/9/1999	3	Dorre Island
Total	18	
New animals recorded to 26/6/2002	6	

APPENDIX TABLE 5b: Deaths of radio-collared banded hare-wallaby (18 collared at release):

DATE FOUND	ID #	CAUSE
2/5/1998	M13	Capture injury
9/11/1998	F22	Raptor
14/9/1999	M17	Capture injury
16/10/1999	M14	Unknown predator (raptor?)
16/10/1999	M10	Unknown predator (raptor?)
11/2/2000	M15	Raptor
?	M11	Raptor
Total	7	