WESTERN AUSTRALIAN WILDLIFE MANAGEMENT PROGRAM NO. 18

RECOVERY PLAN FOR THE NUMBAT (*Myrmecobius fasciatus*)

1995-2004

by

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for
The Numbat Recovery Team

Department of Conservation and Land Management

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FOREWORD

The Western Australian Department of Conservation and Land Management (CALM) publishes Wildlife Management Programs to provide detailed information and management actions for the protection of certain exploited or threatened species of flora and fauna.

Recovery Plans delineate, justify and schedule management actions necessary to support the recovery of an endangered or vulnerable species or ecological community. The attainment of objectives and the provision of funds is subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery Plans do not necessarily represent the views nor the official position of any individuals or agencies represented on the Recovery Team. They represent the position of the Department of Conservation and Land Management only after approval by the Executive Director, the National Parks and Nature Conservation Authority and the Minister.

Approved Recovery Plans are subject to modification as directed by new findings, changes in species' status and completion of recovery actions.

A draft Wildlife Management Program was produced for the Numbat in 1991 but had not been published when the recovery plan format was introduced. This Recovery Plan draws on material in the draft management plan, and the author acknowledges the contribution made by members of the previous planning team, Dennis Hilder, Greg Mair and Sue Moore.

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SUMMARY

Current Species Status: Endangered (ANZECC 1991 and listed in Schedule 1, Part 1 under the Endangered Species Protection Act 1992). Threatened species (W.A. Wildlife Conservation Act 1950). At the time of European settlement, the Numbat was found across much of southern Australia. It is currently restricted to a small area of the south-west of Western Australia, where there are two surviving populations and colonies at four re-introduction sites, of which only one can be described as self-sustaining. In South Australia, a further release in a 1113 ha predator-fenced area in mallee woodland has recently been carried out. Total numbers of the species do not exceed 1500. There is only one captive colony, at Perth Zoo.

Habitat Requirements and Limiting Factors: Numbats occurred where termites were plentiful, in many habitat types across their historic range, including forest, woodland, tall shrubland and hummock grassland. Populations survived in remnants of natural vegetation over 13 000 ha in area, where there was an abundance of hollow logs and undergrowth (particularly *Gastrolobium* spp.) providing cover from introduced predators. Frequent fire reduces cover through loss of logs and thickets. In the western wheatbelt of WA, reduction of fox numbers by selective poisoning has been shown to cause Numbat population numbers to increase. Feral cat control may also be necessary before Numbat populations can be re-established in the eastern wheatbelt of WA and in the arid zone.

Recovery Objectives: Downlisting from Endangered to Vulnerable (ANZECC) within 10 years, by

(i) ensuring that the species persists within its present range

(ii) increasing the total number of self-sustaining populations to at least nine, encompassing a wide range of habitats previously occupied by the species. "Self-sustaining" is defined as maintaining numbers without the nett addition of individuals. Re-introduction sites chosen are such that if Numbats colonise all suitable habitat, the global population will approximate 4000.

Recovery Criteria:

(1) At Dryandra, sighting rates of over 5 sightings/100 km on the monitoring route in November/December.

(2) At Perup-Kingston, sighting rates of over 1 sighting/100 km on the monitoring route in November/December.

(3) At Boyagin, where a self-sustaining population has already been established by translocation, sighting rates of over 4 sightings/100 km on the monitoring route in November/December.

(4) Self-sustaining populations established in six sites additional to the three above. Translocation programs have already been commenced to Karroun Hill Nature Reserve (NR), Tutanning NR, Batalling block in State forest and Yookamurra Sanctuary (S.A.). Allowing for failure of some re-introduction attempts, translocations will be carried out to Dragon Rocks NR, Julimar Conservation Park and sites in the northern and central jarrah forest.

Actions Needed: A recovery team comprising members from WADCALM, SADENR, Perth Zoo, ANCA and WWFA has been established to co-ordinate and supervise the following actions:

(1) Management of existing populations and habitat.

(2) Genetic survey of existing populations.

(3) Translocations to establish at least six further self-sustaining populations.

(4) Disease survey and health monitoring of all populations.

(5) Captive breeding to provide animals for display and to supplement the translocation program if necessary.

(6) Establishment and support of public awareness and sponsorship programs.

Estimated Cost of Recovery:

(1994 prices in $000s/year. TC=total cost, ESP=Endangered Species Program funding required.

	Action 1		Action 2		Action 3		Action 4		Action 5		Action 6		Total	
	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP
1995	57.4	7	0	0	79.5	60.7	3.6	1.5	60	0	5.3	1	205.8	70.2
1996	57.9	7.1	0	0	86.6	67.9	3.6	1.5	60	0	4.3	0	212.4	76.5
1997	70.2	23.9	0	0	92.5	76.2	4.2	2.1	60	0	4.3	0	231.2	102.2
1998	71.4	25.3	0	0	96.8	78.1	4.2	2.1	60	0	5.3	1	237.7	106.5
1999	71.6	24.8	7.1	5	94.7	78.3	4.2	2.1	60	0	4.3	0	241.9	110.2
2000	64.8	22.5	0	0	90.5	74.1	5.1	3	60	0	4.3	0	224.7	99.6
2001	51.6	9.9	0	0	94.7	77.5	5.1	3	60	0	5.3	1	216.7	91.4
2002	51.7	10.1	0	0	70.5	58.5	5.7	3.6	0	0	4.3	0	132.2	72.2
2003	45.1	8	0	0	68.8	56.8	5.7	3.6	0	0	4.3	0	123.9	68.4
2004	45.2	8.1	12.1	10	68	56	5.7	3.6	0	0	4.3	0	135.3	77.7
Total	**586.9**	**146.7**	**19.2**	**15**	**842.6**	**684.1**	**47.1**	**26.1**	**420**	**0**	**46**	**3**	**1961.8**	**874.9**

Biodiversity Benefits: Habitat protection and management for Numbat conservation benefits many other species. Fox control for Numbat conservation also benefits other species of medium-sized mammals (e.g. Woylies, Chuditch, Brush-tailed Possums, Brush Wallabies, Southern Brown Bandicoots) and ground-nesting birds (e.g. Bustards, Bush Thick-knees). Digging out hollow logs, trunks and branches by Numbats creates hollows for smaller animals, such as small dasyurids, passerine birds, skinks and geckos.

1. INTRODUCTION

1.1 DESCRIPTION OF SPECIES

1.1.1 Description

Numbats are small marsupials of distinctive appearance. Adults have a head and body length of 200-250 mm and tail length of 150-180 mm. Males attain slightly higher body weights than females (maximum 700 g and 550 g respectively).

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

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

Distinctive features of the Numbat's body shape include the pointed nose and elongate jaw, housing 50-52 teeth, the largest number recorded in any Australian land mammal. The tongue is exceptionally long, and can be extended at least 5 cm beyond the tip of the nose (about the length of the head). The teeth are poorly developed, and many do not protrude above the level of the animal's gums.

1.1.2 Taxonomy and relationships

From the time of its first discovery, the Numbat has aroused interest in both the scientific and popular literature, because of its distinctive appearance and its unique lifestyle. This interest resulted in the choice of the Numbat as the mammal emblem of the State of Western Australia in 1973.

The first specimen of the Numbat to attract scientific attention was captured a short distance north-east of present-day Brookton, Western Australia, by Ensign Richard Dale and George Fletcher Moore during a trip of exploration in 1831 (Dale 1833, Moore 1884, Friend 1989). The discovery was described as follows:

> "Two of these animals were seen within a few miles of each other; they were first observed on the ground, and on being pursued, both directed their flight to some hollow trees which were near. We succeeded in capturing one of them; the other was unfortunately burnt to death in our endeavour to dislodge it by fumigating the hollow tree in which it had taken refuge. The country in which they were found abounded in decayed trees and ant-hills" (Dale, quoted in Waterhouse 1841).

G.W. Waterhouse described the species *Myrmecobius fasciatus* Waterhouse 1836 on the basis of this specimen (Waterhouse 1836), which was on loan to him from Dale and has since disappeared.

Most of the museum specimens collected subsequently have come from south-western Australia, but a significant number were collected in arid and semi-arid areas of Western Australia, South Australia and New South Wales. Several differences between the desert specimens and those from the south-west of Western Australia prompted Finlayson (1933) to separate the desert form as a new subspecies,

Myrmecobius fasciatus rufus, largely on the basis of its much redder coloration. It appears that this taxon is now extinct (Friend *et al.* 1982).

Waterhouse (1836) considered that the Numbat was closest to the family Dasyuridae (the carnivorous marsupials). It exhibits a number of anatomical features that set it apart from the other dasyurids, however, and this led Gill (1872) to establish a new family, the Myrmecobiidae, with the Numbat as its only member. This arrangement has not always been followed (e.g. Ride 1970), but current opinion (Archer and Kirsch 1977, Mahoney & Ride 1988) favours the retention of the Myrmecobiidae.

The fossil record sheds no light on the issue of the Numbat's relationships. The only known material occurs in sub-fossil deposits from dolines and owl deposits and dates back only to the latest Pleistocene (Archer 1981; A. Baynes pers. comm.).

The Numbat was believed by zoologists last century to be an unmodified survivor of a group of Mesozoic mammals (Owen 1840-45), because of its high number of teeth and the simple morphology of its molars. This conclusion has since been shown to be unsound, and several lines of evidence suggest that the Numbat is phylogenetically close to the dasyurids. This evidence includes cranial and dental morphology and findings from serology and allozyme electrophoresis. It appears that the Numbat is descended from dasyurid stock, and that many of the anatomical differences that exist now between it and the dasyurids are the result of adaptation to a specialised diet of termites (Calaby 1960, Griffiths 1968, Friend 1989). A recent investigation of the morphology of Numbat sperm, however, shows significant differences from the dasyurid pattern, justifying the retention of the Myrmecobiidae (D. Taggart, pers. comm.).

The name *Numbat* (recorded as *noombat* by John Gilbert, in Whittell 1954) was used by Aboriginal people in the York and Toodyay districts in the Avon valley north-east of Perth. It has remained in common use amongst European settlers and their descendants in the south-west since last century. Gilbert also recorded the name *waihoo*, used for this species by tribes in the Albany area. Other Aboriginal names known for this species include *walpurti*, used widely by desert language groups (Ngaanyatjarra, Pitjantjatjarra, Pintubi, Manytjilytjarra) from parts of Western Australia, South Australia and the Northern Territory and *karritji*, *mutjurarranypa*, and *partjlaranypa* used by Pintubi people (Finlayson 1961; Burbidge and Fuller 1979; Friend *et al.* 1982; Burbidge *et al.* 1988). The scientific name *Myrmecobius fasciatus* is derived from several Greek and Latin words: *myrmex*, ant, *bios*, life, and *fasciatus*, striped or banded. The species has been known by a number of English names, including Banded Ant-eater, Striped Ant-eater and Ant-eater. The extinct desert form has been called the Rusty Numbat.

1.2 DISTRIBUTION: PAST AND PRESENT

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

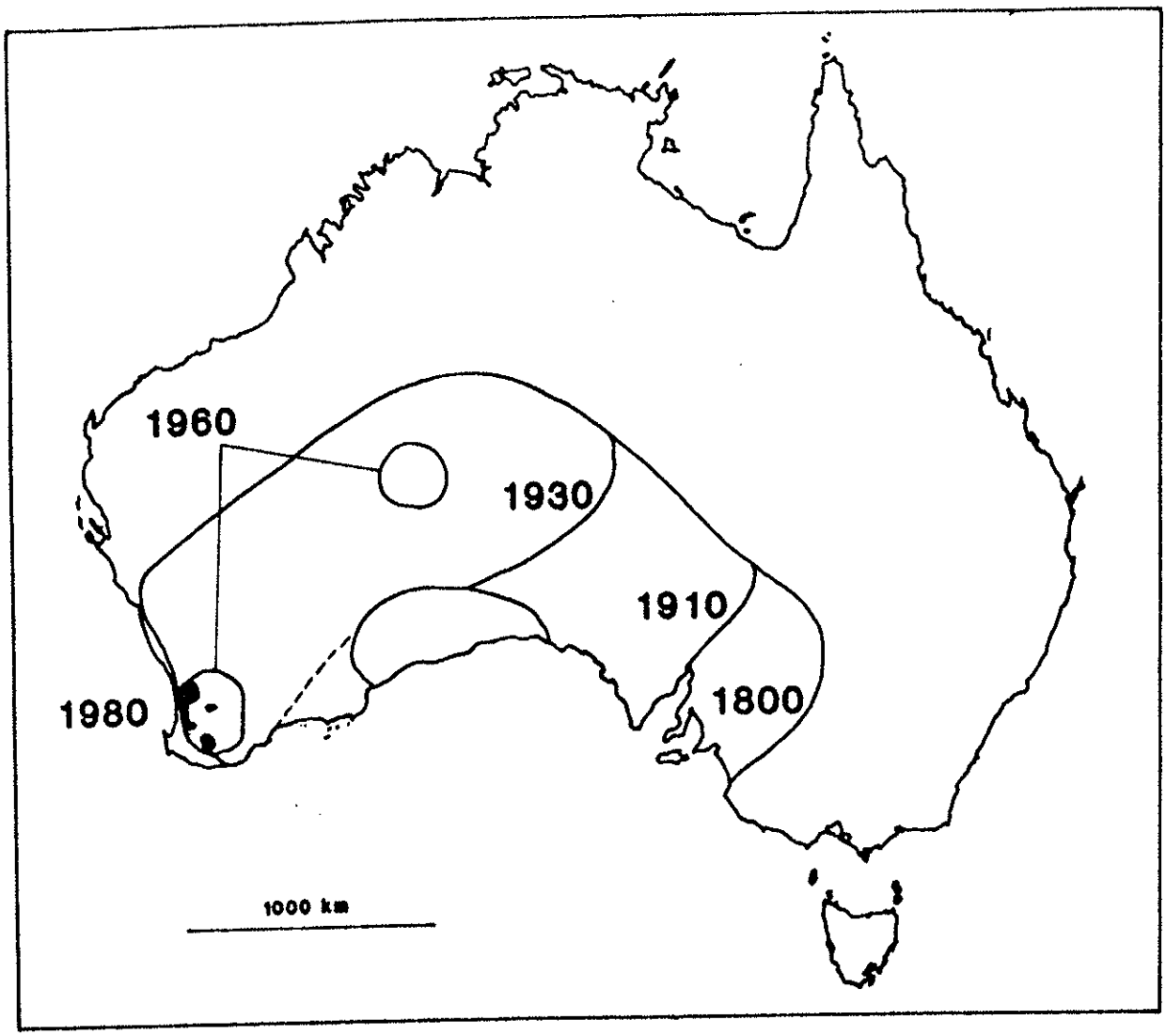

Figure 1. Contraction of the range of the Numbat since European settlement in Australia.

(1866) of mammals found near the Murray-Darling confluence in 1856-7 records the Numbat from further up the Darling although he was not able to obtain any specimens. The most recent museum specimen from New South Wales was collected in 1900 from the border with South Australia. By that stage Numbats had already disappeared from the vicinity of Adelaide (Jones 1923), although they were to survive in the north-west of South Australia until well into this century, becoming extinct there between the 1930s and the 1950s (Finlayson 1961). In Western Australia the species was still quite widespread in the 1950s, although the clearing of land for agriculture was reducing its habitat rapidly. At that time the Numbat was described as "one of the more abundant medium-sized mammals in the south-west" (Calaby 1960).

Between the 1950s and the 1970s, Numbats became extinct in the arid zone. The most recent report of the *walpurti* relates to an animal sighted in the Gibson Desert in the mid-1960s (Friend *et al.* 1982). This extinction was part of the dramatic collapse of the mammal fauna of the arid zone that occurred between 1940 and 1960 (Finlayson 1961; Burbidge *et al.* 1988).. This phenomenon is believed to be due to several factors, including a widespread change in fire regime following the demise of the nomadic lifestyle of the Aboriginal people, and the arrival of the fox. The rapid progress of land clearing between 1945 and 1970 greatly reduced available habitat in the last stronghold of the species in the wheatbelt of Western Australia. Surviving populations, such as the well-known colonies in the Dryandra Woodland near Narrogin and in the Perup area east of Manjimup, appeared to be maintaining numbers nonetheless.

In the mid-1970s, there was a dramatic decline in Numbat sightings. In the Perup area, lowest population numbers appear to have been reached in 1975 and at Dryandra in 1979 (Christensen 1980; Friend 1990). Both of these populations subsequently recovered, but others became extinct during the same period. Amongst them were colonies at Boyagin Nature Reserve near Brookton, in remnant bushland in the Pingaring area (including Dragon Rocks Nature Reserve) and soon after, at Tutanning Nature Reserve near Pingelly. Subsequent research has indicated that the decline of the Numbat and simultaneous declines in other medium-sized mammals were due to increased predation by the introduced Red Fox *Vulpes vulpes* (Christensen 1980; King *et al.* 1981; Kinnear *et al.* 1988; Friend 1990).

Knowledge of the present distribution of the Numbat was gained through surveys during the 1980s based on recent museum specimens and reports from the public in response to appeals in the media. All reports were followed up with a search for the distinctive diggings near the sighting location. These surveys revealed that Numbats were confined to Dryandra Woodland and some small reserves nearby, to a small area of uncleared land on the Swan coastal plain near Jandakot on the southern fringes of Perth, and to parts of the jarrah forest between the Great Eastern Highway in the north and the Perup area in the south (Connell & Friend 1985). More recent surveys (1992) have failed to locate Numbat populations in the northern jarrah forest, however, and there have been no sightings of Numbats on the coastal plain since 1985. The only original Numbat populations still surviving appear to be those at Dryandra and Perup.

1.3 HABITAT

The Numbat's distribution once encompassed a number of habitat types, including eucalypt forest, eucalypt woodland, *Acacia* woodland and *Triodia* grassland.

Known Numbat populations occupy several different habitat types, but only a small proportion of the range of habitat types previously occupied by the species. The habitat types in which populations have been recorded since 1980 are shown below. This list includes areas where Numbats have recently become extinct (Jandakot and the northern jarrah forest), and re-introduction sites (Boyagin and Karroun Hill).

Dryandra Woodland and Boyagin NR:

Woodland on valley floors and slopes, dominated by *Eucalyptus wandoo* (wandoo) and *E. accedens* (powder-bark), with a patchy understorey of shrubs including *Gastrolobium* species (poison plants). Adjacent upland vegetation types are used to a lesser extent. At Dryandra, Numbats are found in *E. astringens* (brown mallet) plantations, especially in areas low in the landscape.

Northern jarrah forest and Perup area:

Upland forest sites dominated by *E. marginata* (jarrah) and *E. calophylla* (marri), with open lower canopy of *Banksia grandis.* In the Perup, the shrub understorey includes *Bossiaea ornata, B. linophylla, Hakea lissocarpa* and *Leucopogon capitellatus* (Christensen *et. al* 1984).

Jandakot area:

Banksia attenuata, B. menziesii and *B. ilicifolia* woodland with emergent *E. marginata* and *E. todtiana* (prickly bark), with an open understorey including *Adenanthos cygnorum, Melaleuca scabra* and *Stirlingia latifolia* (Ninox Wildlife Consulting 1986).

Karroun Hill NR:

A range of vegetation types including:

Eucalyptus loxophleba (York gum) and *Callitris columellaris* open woodland with an open understorey of *Acacia linoealata, A. obtecta, A. prainii, A. resinomarginea* and *A. graffiana* over *Alyxia buxifolia* and *Hakea recurva.*

Tall closed shrubland of *Allocasuarina acutivalvis, Melaleuca uncinata* and *Acacia resinomarginea.*

Eucalyptus salubris (gimlet) woodland with occasional *Callitris columellaris* over a very open understorey including *Templetonia egena*

While these habitat types vary greatly in vegetation structure, the areas used by Numbats are situated on fairly heavy soils, with the exception of the Jandakot area, where the population occurred on the Bassendean sands of the Swan coastal plain. The most important feature is the abundance of termites in the soil. Where present, hollow logs are used extensively by Numbats, but they are not essential and at some semi-arid sites, hollow logs are uncommon or even absent.

1.4 LIFE HISTORY/ECOLOGY

1.4.1 Diet and feeding activity

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

During a feeding session, a Numbat moves around an open area, nose to the ground, every now and then stopping to investigate a spot, then often digging rapidly with both forefeet, while sitting on its haunches. After making a small excavation, the Numbat puts its nose into the hole, which has breached a shallow termite gallery, and extracts

termites by pushing its tongue rapidly and repeatedly into the gallery. Termites within reach stick to the Numbat's tongue, and are pulled into the slightly open mouth. The jaws are then closed and the insects are held in the mouth by the slightly ridged palate, as the tongue is protruded again. The extraction of termites from a gallery, from the first excavation to the end of feeding, takes about 2 seconds (Friend, unpublished observation). The excavations are distinctive in appearance, and are shallow-conical, rarely over 50 mm in depth, and of a similar diameter.

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

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

1.4.2 Home range and interactions

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

The male pattern of adjacent home ranges overlaps the female pattern. Although use of habitat by each sex changes during the year (females contract their area of movement in summer, males in winter), the overall result is that there is approximately one pair of established adults per 50 ha of high-quality habitat. These data were obtained by radio-tracking 15 Numbats in wandoo woodland in Dryandra and Boyagin Nature Reserve (Friend unpublished), but the results of tracking two Numbats in Perup Nature Reserve indicate a home range size of the same order in jarrah forest (Christensen *et al.* 1984).

1.4.3 Reproduction and dispersal

Knowledge of the reproductive ecology of Numbats is largely due to research in Dryandra Woodland since 1981 (Friend & Burrows 1983; Friend, unpublished). Production of young by Numbats is a highly synchronised event. At Dryandra, all young are born in January or early February, and most in the second half of January. Development of the young while attached is relatively slow compared with other marsupials. The female deposits her young in a nest (usually in a burrow) in late July and continues to suckle them each night. In early September, the young come to the entrance of the burrow each morning after the female has emerged, often before she has left on her daily foraging trip. During the first week or so, they do not move more than a few centimetres from the burrow mouth, but as time goes on, they make longer excursions. By mid-October, the young Numbats are supplementing their mother's milk with termites that they dig up for themselves, and moving up to 100 metres from the nest, still within their mother's home range. The female often moves her litter to a succession of nests in logs, trees or other burrows, particularly after the loss of any young to predators.

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

Dispersal appears to take place as straight-line movements, while the animal is moving through bush. A dispersing juvenile Numbat at Dryandra was followed over several days, during which time it moved four kilometres from its natal area straight to the edge of farmland. It then moved along the forest-farmland boundary for two kilometres before reaching the area in which it established its home range. Radio-tracking other dispersing Numbats has shown that they rarely cross farmland, but often end up in suitable habitat at the edge of cleared land. This evidence indicates that the farmland-forest interface is an important barrier for dispersing Numbats, and suggests that corridors of native vegetation will be used by dispersing young because they tend to move along the edge of the bushland.

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

Females come into oestrus during January. In captive animals, the onset of oestrus has been established by monitoring the sudden increase in epithelial cells in the urine. If mating does not occur in the following 48 hours, young are not produced. The gestation period is 14 days, after which the young are born, pink, hairless and measuring about 10 mm in total length, and attach themselves to the four teats (Friend & Whitford 1985, 1993).

The greatest longevity observed in the wild so far is 5 years. Most Numbats do not achieve this age, however.

1.4.4 Causes of mortality

The most reliable way to assess cause of mortality of a mammal species in the wild is to monitor radio-collared individuals over a long period and attempt to interpret the evidence left at the site where the radio-collar is found after death. Even this method has its limitations: if the collar is found with no remains, the cause of death must be determined from the state and position of the collar alone. In many cases, predation is clearly the cause, but it is not possible to determine the species responsible from scratches or tooth marks on the collar alone. In addition, bias can be present as some predators, like foxes, are more likely to destroy the collar causing signal failure, than are others, such as pythons,. Figure 2 shows the frequency of different causes of death recorded by this method in Numbats at Dryandra and at two re-introduction sites.

Fox control was carried out in all three of these areas during the period of data collection. Cat control was not being carried out effectively anywhere, although only at Karroun Hill were cat kills recorded. Carpet Pythons are relatively common at Dryandra, but have not been recorded at the other two sites. The most significant predation of Numbats appears to be by raptors, particularly Brown Goshawks and Little Eagles. Collared Sparrowhawks and Brown Goshawks are significant predators of newly emerged young, as they probably always have been.

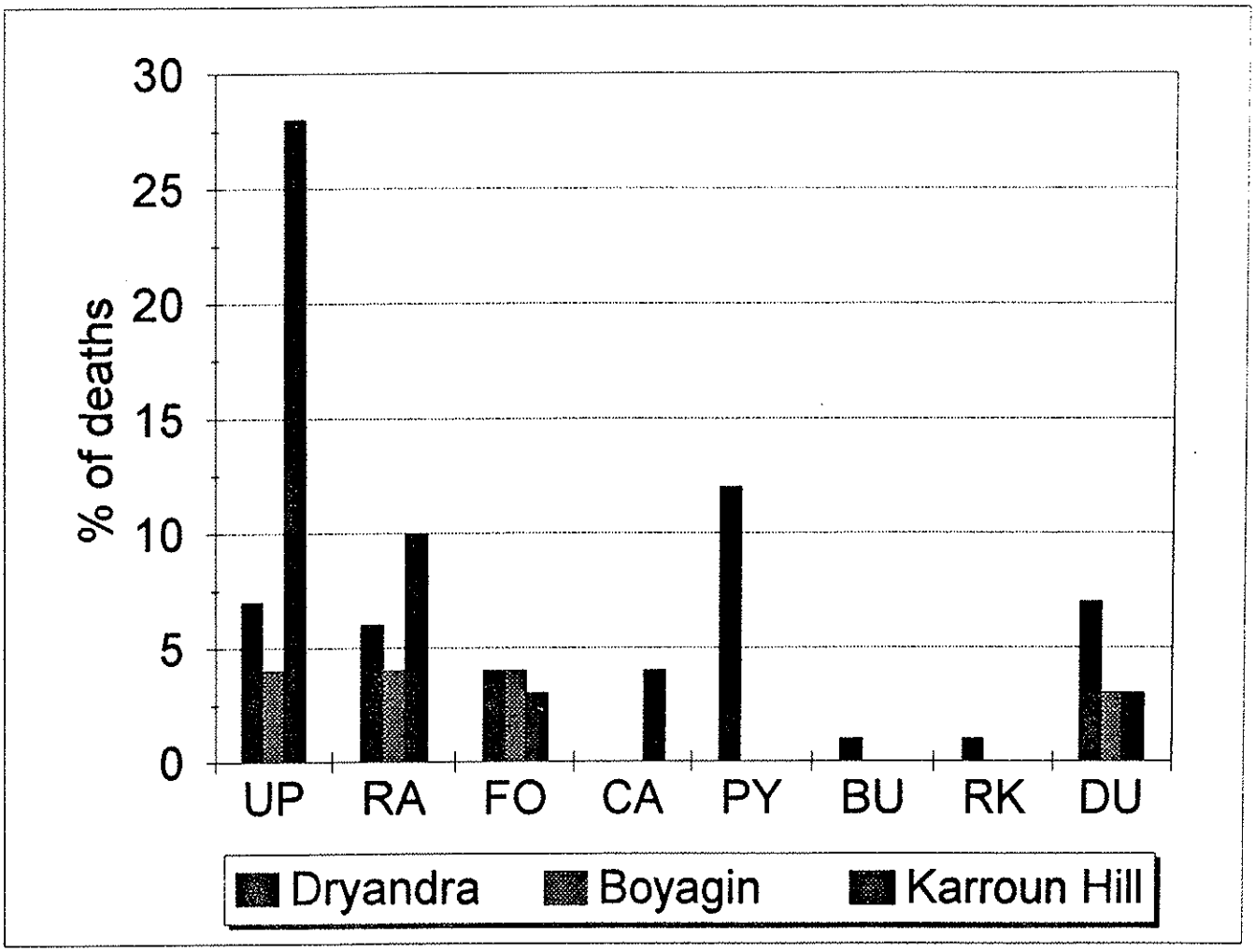

Figure 2. Cause of death of radio-collared Numbats at Dryandra, Boyagin and Karroun Hill. UP: unidentified predator, RA: raptor, FO: Fox, CA: Cat, PY: Carpet Python, BU: burnt in fire, RK: roadkill, DU: death unexplained.

1.4.5 Refuge and nesting requirements

Numbats use hollows and burrows for a number of different purposes. These include nesting at night, resting during the day and as refuges when under threat of predation. When the young are too large to be carried by the mother on her daily foraging trips, they are left in nests in hollows or burrows during the day, and suckled there at night. In areas that lack logs, or in summer, some Numbats rest during the day under shrubs and fallen foliage. They sometimes even take refuge from threat under this kind of cover, but there has been no record of Numbats nesting at night in such a position. Nests are made in hollows with only one entrance, and an internal diameter of 60-80 mm. Hollows in trees are used, up to 5 metres above ground, as well as hollow logs on or near the ground.

Numbats construct their own burrows. A typical burrow consists of a single, gently sloping shaft 1-2 metres long widening out into a roughly spherical, terminal chamber about 25 cm in diameter. A nest fills the chamber, and consists of readily available plant material such as grass, leaves or shredded eucalypt bark (Glauert 1935; Christensen 1980; Friend & Burrows 1983; Christensen *et al.* 1984). Both males and females dig burrows, and they are used particularly in winter. Nests of similar materials are also made in nest logs.

1.4.6 Fire ecology

The dependence of Numbats on hollow logs for shelter and on litter-feeding insects for food means that the species is potentially vulnerable to fire in its habitat. The chief mechanisms by which individual Numbats might be endangered through fire are:

a) Incineration or suffocation during fire
b) Starvation through lack of food after fire
c) Predation through lack of cover (logs or thickets) after fire
d) Competition from individuals moving from burnt home ranges after fire.

Research carried out at Dryandra Woodland to quantify the threat posed by prescribed fire showed that death during the fire and competition from displaced animals were not significant threats in the fires studied. All animals surviving fires remained in good physical condition, and all continued to use their pre-fire home ranges. Only one out of 10 animals monitored died during the fires, but there appeared to be a more significant loss through predation after fire. It is likely that if shrub cover is significantly reduced after fire, birds of prey cause a much higher loss of young Numbats in the nursery area in September-November than if that cover were intact.

The fate of hollow logs has been monitored through fires in jarrah forest at Perup and in wandoo woodland at Dryandra.

The Perup fire was a hot autumn burn designed to regenerate heartleaf poison (*Gastrolobium bilobum*) thickets. Twenty-four logs with hollows of suitable size for Numbats were marked before the fire. Seventeen were destroyed by the fire, but their replacement was not monitored.

At Dryandra, the effect of fire on the abundance of suitable hollow logs was assessed in two separate experimental burns. A control site was established for both, to monitor the change in log abundance in the absence of fire.

During an October burn, 25% of the logs on marked transects were destroyed, but only 3% of the original total replaced by falling trees. After 5 years, no more had been replaced. By contrast, in a March burn, 50% of the logs were destroyed, but half of these were replaced by trees falling during the fire, and after two years, log abundance

had almost reached its value before the fire. There was no change on the control transects.

Termite abundance after both March and October burns was not significantly different from the abundance beforehand, or from that in a control area.

Regeneration of sandplain poison (*Gastrolobium microcarpum*) thickets was only patchy in the areas burnt in autumn and virtually non-existent in the spring burn. Studies by Burrows *et al.* (1987) on these thickets at Dryandra indicated that autumn fires at intervals of 20-30 years would allow them to attain their maximum development.

In summary, prescribed fire in Dryandra does not have a significant impact on the availability of termites for Numbats, or on the Numbats' nutritional status. However, the loss of cover, in the form of both logs and thickets, appears to increase mortality through predation. Spring burns can cause an overall loss of logs, whereas the abundance of logs soon returns to previous values after intense autumn burns. Long intervals between fires would increase cover from predators through increased thicket development..

1.4.7 Effect of mallet harvesting at Dryandra

Timber from the brown mallet (*Eucalyptus astringens*) plantations at Dryandra is utilised for tool-handles, fence-posts and firewood. The harvesting operation involves the removal of selected large trees for tool-handles, then later removal of small trees for fence-posts. The logged area is then opened for public firewood collection.

A study of movement and feeding activity of Numbats in a mallet plantation before, during and after harvesting showed that in the area in which logging activity occurs, usage by Numbats decreases significantly during the harvesting operation, but returns to pre-logging levels when use of machinery and regular human activity in the area ceases. Radio-tracking showed that Numbats actually leave the area being logged. This disruption lasts about six months during a typical operation. Current levels of mallet harvesting at Dryandra result the disturbance of less than 10% of the total area of mallet plantation each year. The draft Dryandra Woodland management plan requires the production of a strategic plan for mallet plantation management by December 1995. This plan will state the annual cut from the mallet plantations, and contain management prescriptions that will address silvicultural and conservation needs (CALM 1994).

1.5 REASONS FOR LISTING AS ENDANGERED

Like many medium-sized Australian mammals, the Numbat has suffered an extensive decrease in range and population numbers since European settlement. This has been due to a number of factors, including altered fire regimes, predation by introduced mammals and in some areas, clearing of bush for agriculture.

In 1973 the eastern form of the Numbat (*Myrmecobius fasciatus rufus*) was declared to be "fauna which is likely to become extinct, or is rare" under Section 14(2)(ba) of the Wildlife Conservation Act 1950, Western Australia. By this time, the subspecies was probably extinct. Concern about the status of the Numbat in the south-west after the decline in remnant populations during the late 1970s prompted the extension of this classification to the full species (*Myrmecobius fasciatus*) in 1983. The Numbat is on the ANZECC List of Endangered and Vulnerable Vertebrates (ANZECC 1991) in the Endangered category (in danger of extinction and will probably not survive if it continues to be threatened), is listed in Schedule 1, Part 1 (Endangered) of the Commonwealth Endangered Species Protection Act 1992, and is listed as Endangered in the IUCN Mammal Red Data Book (IUCN 1982).

In re-examining the IUCN threatened species categories, Mace and Lande (1991) proposed the use of the categories Critical, Endangered and Vulnerable, based on the probability of extinction over time. To be categorised as Endangered, a species must satisfy two of the following criteria:

(i) total effective population[1] (N_e) below 500
(ii) population fragmented, having five or fewer subpopulations, each with N_e less than 100 and immigration rates of less than one per generation
(iii) population declining at a rate of over 5% a year for 5 years or over 10% per generation for two generations
(iv) population subject to catastrophic crashes.

The Numbat certainly satisfies the first two of these conditions. Using the method of Lehmkuhl (1984), N_e for Numbats is approximately 0.16 times the censused population size, N (Friend 1987). That is, $N_e/N=0.16$. The total Numbat population (N) is estimated to be less than 1500, corresponding to N_e less than 235. There are only three self-sustaining Numbat subpopulations, the largest of which is at Dryandra. In 1993, the census at Dryandra gave N=400 for the main block, or $N_e=62$, although numbers had been higher in the previous year. While the population is not declining steadily (criterion (iii)), there have been a number of crashes (criterion (iv)) in the last twenty years that have reduced numbers greatly at both Dryandra and Perup. In Section 2.7, the means to increase the size and number of Numbat populations in order to move the species into the Vulnerable category are discussed.

2. EXISTING CONSERVATION MEASURES

2.1 Inclusion of Numbat habitat in CALM-managed public lands

The two surviving Numbat populations (at Dryandra and Perup-Kingston) occur mainly on land under CALM's management. This land currently includes State forest and Nature Reserve. In those two areas, Numbats are also found on small areas of adjacent land of other tenure, including water reserves and private property. Bushland inhabited by the re-introduced population at Boyagin is entirely on Nature Reserve. More than 90% of the world population of Numbats, however, exists on land managed by CALM. An area of 29 000 ha in the Perup area was declared a Nature Reserve in 1992. While most of Dryandra is currently State forest, it is managed primarily for nature conservation, with the exception of the brown mallet (*E. astringens*) plantations. The draft management plan for Dryandra Woodland, covering 10 bush blocks near Dryandra settlement and seven blocks 20 km away near Highbury, was published in March 1994 and was open for public comment until 6 May 1994 (CALM 1994). The draft plan proposes that 16 337 ha near Dryandra settlement, approximately 60% of the combined area of the 10 Dryandra blocks currently reserved as State forest, be converted to National Park.

2.2 Habitat management

Management of natural vegetation in Dryandra Woodland has been formulated to benefit nature conservation. Certain regulations are currently enforced in addition to those that apply in all State forest. Dogs are not allowed, and firewood collection is restricted to areas allocated for the purpose in recently thinned mallet plantations. If

[1]The effective population size N_e is the size of an "ideal" population that would undergo the same amount of random genetic drift as the actual population, of size N. In an "ideal" population, all individuals mate randomly, and the population has no non-breeders, equal numbers of each sex, no variation in number of young per family, and no overlapping generations. The N_e/N ratio is used to compare the genetic viability of populations of species with different life histories.

the proposed declaration of some areas as National Park is implemented, appropriate regulations will come into force there.

Prescribed burning in areas of natural vegetation at Dryandra is restricted to strategic buffer strips 50-100 metres wide, and areas immediately adjoining the Settlement and recreation sites. The draft management plan proposes two experimental burns in the next 10 years aiming to regenerate *Gastrolobium* thickets. A similar strategy, using low-fuel buffers, is in place at Boyagin. The wildfire prevention strategy used by CALM in the Perup area employs a mosaic of blocks on either seven-year or 14-year intervals between fires, and aims to reduce wildfire risk while enhancing the development of thickets.

Timber harvesting is carried out in mallet plantations within Dryandra Woodland currently inhabited by Numbats, moving through plantations at a rate of 5-10% each year. Under the draft management plan, a strategic plan to phase out mallet harvesting from Dryandra Woodland and return most of the plantations to a woodland of natural species over 100 years will be produced by December 1995.

2.3 Fox control

An experiment carried out at Dryandra in 1982-85 demonstrated that removal of foxes leads to an increase in Numbat numbers (Friend 1990). At the beginning of 1989, the area of woodland subject to fox control was extended from 2000 ha to over 15 000 ha and the baiting program was taken over from research personnel by CALM Narrogin District staff as part of the management of Dryandra. The Numbat sighting rate on standard vehicle surveys increased from 0.14 per 100 km in 1979 to 11.75 per 100 km in 1992 , although it has since fallen to 5.5 per 100 km in 1993 (Figure 3). Currently, Boyagin NR and Tutanning NR, Perup NR and adjacent forest, and 14 000 ha of State forest centred on Batalling block in Collie District are also baited on a regular basis by CALM Operations Division staff. A community-based baiting program is being carried out under the guidance of the Agriculture Protection Board with twice-yearly application of baits through much of the agricultural land in the Great Southern district, adjacent to these CALM reserves. The implementation of the Operation Foxglove baiting program over 450 000 ha of the northern jarrah forest in mid-1994 will benefit proposed translocations of Numbats to those areas.

An ongoing fox control program is an essential part of any Numbat re-introduction project.

2.4 Re-introduction

A re-introduction program commenced in 1985, with releases of 35 Numbats (one captive-bred and 34 wild-caught) between 1985 and 1987 at Boyagin NR near Brookton, where the species became extinct in the early 1970s (Friend 1990). This experimental project was funded by World Wide Fund for Nature Australia (WWFA). A self-sustaining population appears to have been established in the reserve, as numbers have continued to increase with no significant addition of animals. The sighting rate in driven surveys had risen to 5.5 per 100 km by November 1993. The second re-introduction was to Karroun Hill NR, 400 km north-east of Perth, commencing in 1986, as the second phase of the WWFA project. Other translocation programs are now under way, to Tutanning NR (1990) and Batalling block in State forest near Darkan (1992). A further release was carried out in late 1993 in South Australia at Yookamurra Sanctuary, a 1113 ha predator-fenced area in mallee woodland .

A re-introduction protocol has been developed through these projects. The protocol in a large area is to release 15-20 Numbats (comprising 50% females, 25% first-year males and 25% 2+ year-old males) into the area in November/December each year for

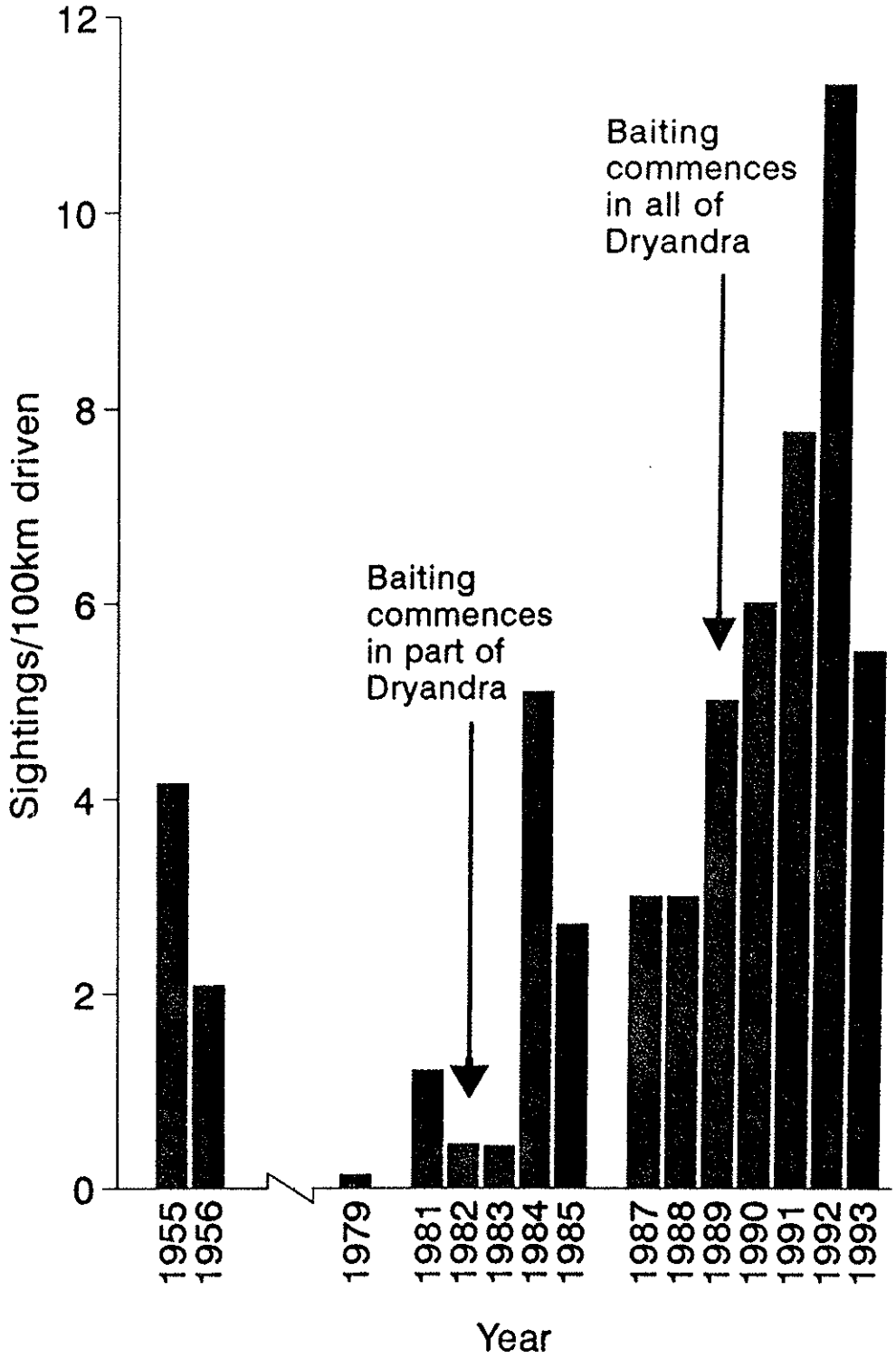

Figure 3. Numbat sighting rate during driven surveys in Dryandra, 1955-56,1979-93. Data for 1955-56 provided by J Calaby; 1979 data collected by J. Turner; 1981-1993, CALM Science and Information Division.

three successive years. Translocation during these months mimics the natural dispersal of young, and also utilises the only time of year when females do not have dependent young. All animals are radio-collared before release. In January, when they have established new home ranges, the Numbats are located by use of a light aircraft fitted with radio-tracking equipment. Release enclosures are not used, due to the difficulty of providing sufficient food within the enclosures to support the translocated animals for the necessary time. Numbats dispersing to areas remote from others can be moved back to the release area in April-June, when they are less likely to disperse again. Young born to radio-collared females at the re-introduction site are captured before dispersal and also fitted with radio-collars. The young Numbats are also located in January by use of the aircraft. Monitoring by checking for survival at least every two to four months is continued as long as collars can be maintained on the animals. Estimates of mortality rate can be made using these data, to allow predictions about the fate of the population using population viability analysis. Subsequent monitoring is carried out by systematic searches for sign (diggings, scats) and driven surveys (if track access is sufficient). Five years after the third release year, an assessment may be made of the success of the translocation.

2.5 Population monitoring

Annual monitoring of the Numbat population at Dryandra by driven survey has been carried out by research personnel since 1981. A standard circuit has been used since 1987 to allow comparison of sighting rates between years. The Perup population was surveyed by similar methods for the first time in 1993, although data from incidental sightings in the area are available for the period 1972-1981 (Christensen *et al.* 1984). Due to the greater density of the understorey, sighting rates in jarrah forest at Perup are lower than in wandoo woodland at Dryandra . Monitoring is also carried out at re-introduction sites. Driven surveys have been carried out at Boyagin since 1992. The commitment of time to monitoring will increase as more populations are re-established and it is proposed that this function is progressively taken over from CALM Science and Information Division (SID) staff by District staff, possibly assisted by volunteers.

2.6 Captive breeding

Numbats were bred and raised to adulthood for the first time during a project funded by WWFA and run by the Department of Fisheries and Wildlife, then CALM, at the Western Australian Wildlife Research Centre, Woodvale in 1984-6. An artificial diet, based on egg and low lactose milk powder supplemented with termites, was developed during that project. Since 1986, the captive colony has been housed at Perth Zoo, with transfers of animals in 1989, 1990 and 1992 to Woodvale for breeding. Numbats bred at Woodvale in 1985, 1989, and 1990 (Friend and Whitford 1993). The first breeding at Perth Zoo was achieved in 1993. Alternative diets, one based on an analysis of termites and another on an artificial diet for Echidnas, are currently being trialed. A contribution to the support of the Numbat breeding program by McDonalds Family Restaurants (W.A.) to the value of $180 000 over 3 years was received in November 1993. These funds will enable the high level of commitment given by Perth Zoo to the Numbat captive breeding program in recent years to continue. Due to the availability of Numbats from the wild for the re-introduction program, captive breeding will be used to develop and maintain a genetically viable captive population. Its primary role would be to provide animals for translocation should the availability of wild animals for translocation be reduced. Regular incorporation of wild animals into the captive colony will be required to maintain its genetic viability. The captive colony will also be used to provide animals for display and public education at Perth Zoo.

The 1994 Australasian Species Management Program (ASMP) Regional Census and Plan lists five zoos as proposing to add Numbats to their collections. These zoos provide opportunities to decentralise the captive breeding operation and gain increased

awareness of the Numbat Recovery Plan through their display and public education functions. Captive bred Numbats may be transferred to these zoos within the life of the Plan. Arrangements for establishing Numbats in other zoos and for their subsequent management would be the subject of a Species Management Plan which would be developed as part of the ASMP.

2.7 Formation of the Numbat Recovery Team

The Numbat Recovery Team was appointed in July 1993, to oversee the production of this Recovery Plan and to coordinate the research and management of the Numbat as outlined in it. The team comprises representatives from CALM Science and Information Division, Nature Conservation Division and relevant Regions, Perth Zoo, the Australian Nature Conservation Agency Endangered Species Program and the World Wide Fund for Nature Australia. In September 1993, the South Australian Department of Environment and Natural Resources was invited to nominate a representative, as a translocation of Numbats to South Australia was being planned. Other organisations that become involved with the program in the future may be invited to join the Recovery Team.

The Numbat Recovery Team reports annually in January to CALM's Corporate Executive and to funding agencies.

2.7 Strategy for recovery

Current population estimates for the Numbat in each of the known populations put the species in the Endangered category of Mace and Lande (1991), on the basis of total numbers, number of populations and numbers in each population (Section 1.5).

Before the Numbat can be downgraded from Endangered to Vulnerable using the criteria established by Mace and Lande (1991), all of the following must occur:

- total numbers must rise above 3200 (N_e=500)
- the size of at least one subpopulation must rise above 640 (N_e=100)
- the number of subpopulations must increase beyond five.

A translocation program to achieve these goals is central to the strategy for recovery for the Numbat outlined in this Plan.

Source of animals for translocation

The draft policy on translocation of threatened flora and fauna in Western Australia states that wild populations, rather than captive breeding colonies, should be used if possible as a source for animals for translocations. In order to effect an overall increase in Numbat numbers, it is necessary to maintain the existing populations in a growth phase so that they can withstand the removal of individuals for translocation to other areas. The existing self-sustaining populations (Dryandra, Perup and Boyagin) require protection from predation by foxes and habitat management to optimise conditions for population growth.

Selection of re-introduction sites

Re-introduction sites should be within the recorded range of the Numbat, they must contain sufficient suitable habitat to support a viable population and there must be sufficient resources and expertise available to provide protection from introduced predators and to provide other necessary habitat management. For long-term security, land managed by the State conservation agencies is preferred, although there is a role for private landholders to manage sufficiently large parcels of private land for the same purpose.

Figure 4. Recorded distribution of the Numbat. Circles: museum specimens collected alive. Squares: recent bone deposits. Closed triangles: literature records without specimens (Calaby, 1960; Finlayson, 1961; Krefft, 1866). Open triangles: information from Aboriginal people (Friend *et al.*, 1982; Burbidge *et al.*, 1988).

Historic accounts and specimen records indicate that the Western Australian wheatbelt was the stronghold of the Numbat (Figure 4). The high degree of clearing that has occurred there, however, has left only a small number of reserves with suitable habitat that are sufficiently large to support self-sustaining Numbat populations.

Re-introductions to Boyagin, Tutanning and Karroun Hill Nature Reserves have already been carried out or are still under way. Climate, soils and dominant woodland vegetation associations at Boyagin and Tutanning are similar those at Dryandra, and re-introduction has a high chance of success, but can contribute only a small increase in total population numbers. Re-introduction sites in the east of the Western Australian wheatbelt will be more expensive to maintain, but offer much larger areas of suitable habitat. The establishment of populations in those areas as well as further west will also broaden the range of selective pressures influencing the evolution of the species. Karroun Hill NR, where a re-introduction program has already been commenced, is large (300 000 ha), relatively close to management resources, and contains suitable Numbat habitat. The species was recorded near the reserve in the early part of this century in an anecdotal account (Maddock, 1987), backed up by the recent discovery of skeletal remains there(Youngson and McKenzie 1977).

Compared with their preferred habitat at Dryandra, Numbats live in completely different vegetation associations in the eastern wheatbelt. At Karroun Hill, although Numbats settled in a variety of vegetation types, the best survival has occurred in York gum and gimlet woodland adjacent to dense *Acacia* thickets or tall shrubland of *Allocasuarina acutivalvis* and *Melaleuca uncinata*. The mosaic of low shrubland and mallet woodland at Dragon Rocks Nature Reserve (33 000 ha) parallels this, and in fact there are anecdotal accounts of Numbats in the mallet woodland there in the 1970s. The relatively large size of the reserve, and yet its complete encirclement by farmland preventing escape of dispersing translocated animals and young, make it ideal for re-introduction.

Numbats have been recorded in scattered locations in the jarrah forest, although it appears that it provided sub-optimal habitat and parts may not be suitable for the species. As a large uncleared area managed by CALM and where a relatively large section of the Department's resources is based, however, the main forest belt can provide advantages for Numbat conservation at low additional cost. For this reason, while the jarrah forest is not seen as the mainstay of the recovery program, a substantial effort will be made to re-establish the species there. Translocations are proposed to four sites in the main forest block. These include Batalling block near Darkan, where a translocation program has been in progress since 1992, and Julimar, at the northern end of the jarrah forest. Two other sites in the northern half of the jarrah forest, in the Swan and Central Forest Regions, will be selected for translocations. The Operation Foxglove baiting program in the northern jarrah forest will provide the resources for fox control over a number of potential Numbat translocation sites. The potential for spread into timber production areas requires that the effectiveness of current silvicultural guidelines in maintaining the availability of nest and refuge hollows through a logging operation be investigated. Likewise, the effect of prescribed burning on Numbat habitat in jarrah forest should be assessed.

Selection of re-introduction sites should evaluate the potential maximum population that can be supported, and take account of the effect that this will have on the viability of the population. The threat to small populations is twofold. Firstly, loss of genetic variability and loss of rare genes can occur when populations reach low numbers, especially when these numbers are maintained at a low level for several generations (a genetic bottleneck). Secondly, the likelihood of extinction through chance events (fire, drought, increased predator numbers, a high male-female ratio amongst one year's production of young) is higher in small populations.

A minimum effective population size of N_e=50 for short-term viability and N_e=500 for long-term viability (minimum viable population or MVP) has been suggested by Frankel and Soule (1981). An N_e of 50 (required to keep the inbreeding rate below 1%) corresponds to N=320 in Numbats (see Section 1.5). These MVPs were calculated on the basis of the predicted rate loss of genetic variability, from work on laboratory populations of fruit-flies. If 320 animals is taken as a minimum viable population on these grounds, and if it is assumed that 50 ha supports two animals and that 50% of a given area is suitable habitat, the minimum reserve size which can support a viable population in the short-term is 16 000 ha. The main block of Dryandra (13 000 ha), the smallest vegetation remnant in which a Numbat population survived the fox predations of the 1970s, is close to this size. For long-term viability, the same authors propose a minimum N_e=500, corresponding to N=3200 for Numbats and a reserve size of 160 000 ha.

These calculations of MVPs for Numbats are based on a home range size of 50 ha per individual, with overlapping male and female home ranges. This picture is based on research carried out in Dryandra before fox control was commenced. It is possible that higher population densities may be supported and more vegetation types used under a regime of fox control, but determination of home range size under fox-baiting has not been carried out. An investigation of home range size and spatial organisation in Numbats is proposed amongst the recovery actions.

The suggestion of the MVP model of Frankel and Soule (1981) is that if a population is large enough, it can be left to its own devices and will survive. These considerations of population viability are based on the assumption that there is no genetic input from outside. Clearly, Numbat populations will not survive without management, requiring fox control at the very least. Genetic management is also required, therefore, if reserves smaller than 16 000 ha are to be used, for short-term viability, or in reserves smaller than 160 000 ha for long-term viability. Nei *et al.* (1975) found that two geographically isolated populations would function as a single population with the exchange of one individual per generation. A program of exchange of individuals between Numbat populations will be designed and implemented when the results of the genetic survey of populations are known.

Given that genetic management of most populations will be necessary, the lower size limit for selection of re-introduction areas depends on the likelihood of extinction through chance events, and the ability of the managers to monitor the population, determine the cause should numbers fall to dangerously low levels, and respond.

The potential contribution to Numbat recovery from highly managed private sanctuaries is acknowledged. While some will be too small to add significantly to the total Numbat population and will require periodic exchange of individuals with other populations as proposed for small wild populations (Section 4.3.5), the publicity and education value of these populations will justify the effort needed to maintain them.

The recent decline in numbers at Dryandra

The drop in the frequency of Numbat sightings at Dryandra between November 1992 and November 1993 (Figure 3) is of concern, given the importance of the population there both for the security of the species and for the proposed translocation program. There is no doubt that a real decline in Numbat numbers occurred during 1993. It is most unlikely that the removal of animals for translocation has played a major part in the decline. On the basis of driven surveys using a line transect technique, the population of the main block of Dryandra in November 1992 was estimated at 450 adults and 350 juveniles. A total of 25 animals, half of which were juveniles, was translocated from Dryandra in November/December 1992. A similar level of removal has occurred each year since 1986, for translocation, and to provide new stock for the captive colony at Perth Zoo.

In 1994, an investigation into the causes of the decline in the Dryandra Numbat population is being carried out. This work focuses on the possibility of increased predation through rises in numbers of cats or foxes, or the possibility of disease. The baiting program, which had been reduced in mid-1993, has been returned to its original prescription. Spotlighting surveys are being conducted regularly to monitor exotic predator and nocturnal native mammal numbers and to compare these with data collected on the same survey routes by Jack Kinnear and Mike Onus of CALM in 1989-90. As two animals translocated to Yookamurra in late 1993 were found in post mortem to be infected by an acanthocephalan parasite that can cause death (S. Haigh and R. Hobbs, personal communications), a parasite survey of the population is being carried out. Numbats are being radio-collared at Dryandra as a means of monitoring their survival and determining causes of mortality. A method of broadscale control of feral cats is being developed (funded by ANCA Feral Pests Program: Algar and Friend 1994) and should be available in late 1994 for use if there are indications that cats are involved in the Numbat decline at Dryandra.

3. RECOVERY OBJECTIVE AND CRITERIA

3.1 Objective:

The Numbat's status to be downgraded from Endangered to Vulnerable (ANZECC) within 10 years by:

(i) ensuring that the species persists within its present range, and
(ii) increasing the total number of self-sustaining populations to at least nine, encompassing a wide range of habitats previously occupied by the species.
"Self-sustaining" is defined as maintaining numbers without the nett addition of individuals. Re-introduction sites will be chosen such that if Numbats colonise all available habitat, the global population will approximate 4000 individuals.

3.2 Criteria:

The criteria for successfully achieving the objectives are:

(1) At Dryandra, sighting rates of over 5 sightings/100 km on the monitoring route in November/December.

(2) At Perup-Kingston, sighting rates of over 1 sighting/100 km on the monitoring route in November/December.

(3) At Boyagin, where a self-sustaining population has already been established by translocation, sighting rates of over 4 sightings/100 km on the monitoring route in November/December.

(4) Self-sustaining populations established at six or more sites additional to the three above. Translocation programs have already been commenced to Karroun Hill NR, Tutanning NR, Batalling block in State forest and Yookamurra Sanctuary (S.A.). New sites will include Dragon Rocks NR, Julimar Conservation Park and at sites in the northern and central parts of the main jarrah forest belt.

4. RECOVERY ACTIONS

4.1 Management of existing populations

The first recovery objective is to ensure that the species persists within its existing range. This requires:

Control of exotic predators, especially foxes
Population monitoring
Habitat management research and implementation

4.1.1 Exotic predator control

Fox control will be necessary in all areas supporting Numbat populations to enhance the security of the species as well as to maximise the production of individuals to support the translocation program. Existing populations of Numbats are protected from fox predation by regular baiting at Dryandra Woodland, Perup Nature Reserve and Boyagin Nature Reserve. Fox control by distribution of dried meat baits containing 1080 is carried out by CALM Narrogin District staff in over 15 000 ha at Dryandra Woodland (monthly in the main Dryandra block and bi-monthly in Montague block), monthly over the entire 5000 ha of Boyagin NR and, in the same program, over the entire 2000 ha of Tutanning NR. At Perup, fox baiting is carried out twice a year over 30 000 ha in the Perup Nature Reserve and four times a year over 40 000 ha in and around Kingston block, east of Perup, by CALM Manjimup District staff. This

baiting program will continue as long as there is no more cost-effective method of fox control available.

The costs of fox control at Dryandra, Boyagin and Tutanning in the Narrogin District, and Perup and Kingston are shown in full here, although it benefits other threatened species including the Woylie and Chuditch, for which there are Recovery Plans being funded by ANCA Endangered Species Program. On the other hand, the cost of the northern jarrah forest baiting program, "Operation Foxglove", which will also benefit those species and the Numbat re-introduction program, is not included in the costings for this Recovery Plan.

Responsibility: CALM Narrogin and Manjimup Districts

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	28296	28296	28296	28296	28296	28296	28296	28296	28296	28296
ESP	0	0	0	0	0	0	0	0	0	0
Total cost	**28296**	**28296**	**28296**	**28296**	**28296**	**28296**	**28296**	**28296**	**28296**	**28296**

4.1.2 Monitoring of existing populations

Population monitoring by driven survey is currently carried out annually in the areas supporting self-sustaining populations at Dryandra, Boyagin and Perup-Kingston. This annual survey will continue. At Boyagin, monitoring by searching for diggings and scats is also carried out annually. Searches are carried out at 20 established monitoring sites in the eastern block and beside tracks at 200 metre intervals in the western block. When the western block is fully colonised, searches there will be reduced to 20 monitoring sites.

Initially, monitoring will be carried out by SID staff, contract technical officer (CTO) and Operations staff (OS) from the relevant CALM District , then ongoing monitoring will be taken over by District staff assisted by CTO. ESP funds are required for vehicle running costs, field allowance and CTO salary.

Responsibility: CALM SID, CALM Narrogin District, CALM Manjimup District.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	8811	8811	8811	8811	8811	8811	8811	8811	8811	8811
ESP	7041	7135.8	7234.8	7370.5	7476.5	7585.8	7697.9	7851.3	7971.7	8095.6
Total cost	15852	15947	16046	16182	16288	16397	16509	16662	16783	16907

4.1.3 Habitat management research

Management guidelines developed for Dryandra Woodland under the draft area management plan recently published (CALM 1994) recognise the needs of the Numbat, based on research into the effects of fire (Section 1.4.6) and mallet harvesting (Section 1.4.7) on Numbats in Dryandra. These guidelines include a commitment to promote the establishment of vegetation corridors between isolated blocks of Dryandra and other remnant vegetation. Appropriate management of Numbat habitat in the Perup and Kingston areas as well as in re-introduction sites in parts of the central and northern jarrah forest will be facilitated by examination of the effect on Numbats of management practices currently used in the jarrah forest. In particular, prescribed

burning and timber harvesting have the potential to affect the viability of existing and re-introduced Numbat populations.

4.1.3.1 Effectiveness of silviculture guidelines

Silviculture guidelines developed for the production areas in high rainfall and low rainfall jarrah forest also provide for the maintenance of den sites for chuditch, which broadly encompass the needs of Numbats. These guidelines require the retention of logs and stumps to provide refuge for hollow nesting fauna (CALM Silviculture Specification 5/89). The implementation of the northern jarrah forest baiting program (Operation Foxglove) will increase the potential importance of the jarrah production areas for Numbat conservation. The effectiveness of these guidelines in providing nesting sites for Numbats therefore needs to be investigated in case modifications to the guidelines are needed. This research can be carried out in logging coupes in areas occupied by Numbats in and near Kingston block, Manjimup District. The research requires the capture of at least three Numbats, to be fitted with radio-collars, in areas to be logged. Before logging, the animals will be tracked and log/burrow use documented. Immediately after logging according to the silviculture guidelines, and at six, 12 and 18 months after logging, this exercise will be repeated. This project will be carried out in 1995-1996, and will be funded by CALM.

Responsibility: CALM SID, CALM Manjimup District

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	13249	13649	0	0	0	0	0	0	0	0
ESP	0	0	0	0	0	0	0	0	0	0
Total cost	**13249**	**13649**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

4.1.3.2 Effect of hazard reduction burning in jarrah forest

In jarrah forest, Numbats depend on hollow logs for shelter, and feed on termites in the upper soil layers and under fallen wood on the forest floor. Fire also removes understorey shrubs that offer protection from predators, so it has the potential to reduce the availability of both food and shelter for Numbats. This study will be carried out in the Perup-Kingston area. By comparison between burnt and unburnt control areas, changes in termite abundance, hollow log availability and the abundance of Numbat diggings will be monitored before and immediately after fires in autumn and spring 1999 and for three years afterwards. Between five and ten Numbats will be caught and radio-collared before the fires, and monitored during and after the fire to measure mortality during the fire and mortality, breeding and changes in condition in the period afterwards. Radio-collars will be recycled from earlier studies. ESP funds will be required for travel, vehicle running and CTO salary.

Responsibility: CALM SID, CALM Manjimup District.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	0	0	0	0	9656	5206	4578	4578	0	0
ESP	0	0	0	0	17336	14890	2200	2200	0	0
Total cost	**0**	**0**	**0**	**0**	**26992**	**20096**	**6778**	**6778**	**0**	**0**

4.1.3.3 Research on Numbat home range size

Knowledge of the Numbat's ecology is quite comprehensive, and most data necessary for the implementation of this recovery plan are available. However, much of the knowledge was gathered before fox control was in operation, and estimates of home range size and potential population density, for instance, may now be very inaccurate. It is proposed to carry out radio-tracking studies in Dryandra and Perup to provide data to enable firmer estimates of potential stocking rates to be made. This action will be carried out in 1997-1998. ESP funds are required for CTO salary, travel allowance, vehicle running costs, radio collars and refurbishing.

Responsibility: CALM SID.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	0	0	9156	8999	0	0	0	0	0	0
ESP	0	0	16696	17901	0	0	0	0	0	0
Total cost	**0**	**0**	**25852**	**26900**	**0**	**0**	**0**	**0**	**0**	**0**

4.1.4 Modification and implementation of prescriptions

If necessary, modifications to fire prescriptions and timber harvesting guidelines will be prepared and implemented. The cost of this action is not possible to calculate at this stage, but it will be borne by CALM.

Responsibility: CALM SID, CALM Operations Division

4.2 Genetic survey of existing populations

Decisions regarding the source of animals for translocations should take into account the genetics of the available populations. An investigation of the genetic variability within and between the Dryandra and Perup Numbat populations by sequencing mitochondrial DNA amplified from ear tissue samples is being carried out in 1994 with ESP funding. It is proposed to resample all populations at five-yearly intervals, including re-introduced populations. The aim of this sampling will be to determine whether the genetic management is achieving its aims, that is, to maintain genetic variability within populations and within the species as a whole.

Samples will be collected from Numbats caught opportunistically during driven surveys of all established populations, carried out as part of the monitoring program. Travel and vehicle running costs will appear under monitoring of existing (4.1.2) and re-introduced populations (4.3.4).

Responsibility: CALM SID

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	0	0	0	0	2100	0	0	0	0	2100
ESP	0	0	0	0	5000	0	0	0	0	10000
Total cost	**0**	**0**	**0**	**0**	**7100**	**0**	**0**	**0**	**0**	**12100**

4.3 Translocation

Re-introduction of Numbats into parts of their former range is necessary in order to achieve sufficient numbers of individuals and populations to allow the downlisting of the species. A re-introduction program has been formulated, building on the work already started with translocations to Boyagin, Karroun Hill, Tutanning, Batalling and Yookamurra.

The re-introduction program has the following components:

- Selection of sites
- Exotic predator control at translocation sites
- Translocation
- Monitoring success of translocation
- Genetic management of populations

Programs of re-introduction to suitable sites in other States will be supported. Fifteen Numbats were released at Yookamurra Sanctuary near Sedan in South Australia in November-December 1993. At present, there are no other areas of suitable habitat outside Western Australia at which effective predator control or exclusion is being carried out. For the purposes of this plan, the re-introduction program will only involve Western Australian sites and Yookamurra, but it is envisaged that other re-introduction sites outside Western Australia will become available within the term of this plan. In that event, this translocation program may need review.

Success of a translocation of Numbats is difficult to assess in the early years. It is only when diggings can be found reliably in an area, and there is evidence of the occupied area expanding, that any assurance of the establishment of a population is provided. At a later stage, a significant rate of sightings on driven surveys may be achieved, giving added confirmation. The translocation protocol involves assessment of the success of translocations after five years.

4.3.1 Selection of re-introduction sites

A list of re-introduction sites is given under Section 4.3.3. Re-introduction sites need to be chosen, in 1995 at Dragon Rocks Nature Reserve, in 1996 in the northern jarrah forest (in addition to Julimar CP) and in 1998 in the central jarrah forest (in addition to Batalling). Site selection will be based on existing and proposed land use and habitat suitability, assessed by log and termite abundance and cover afforded by understorey vegetation. This will be carried out by the Research Scientist (RS) and the Senior Technical Officer (STO) in consultation with OS from Katanning, Jarrahdale and Harvey Districts.

Responsibility: CALM SID, CALM Katanning District, CALM Harvey District, CALM Jarrahdale District.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	2372	2372	0	2372	0	0	0	0	0	0
ESP	890	890	0	890	0	0	0	0	0	0
Total cost	**3262**	**3262**	**0**	**3262**	**0**	**0**	**0**	**0**	**0**	**0**

4.3.2 Exotic predator control

Control of foxes will be carried out at all translocation sites.

In the Numbat re-introduction area at Karroun Hill NR, fox control is being carried out by CALM Science and Information Division staff as part of research to develop a suitable predator control strategy and methodology for that area. Fox control is being carried out by aerial baiting and fox, cat and Numbat response is being monitored as part of a research program funded by ANCA Feral Pests Program (FPP Project 11). This funding will cease at the end of 1994. Methods of feral cat control in Western Australia are currently being developed under the same FPP project and will be tested at Karroun Hill in 1994.

A major program of fox control in the northern jarrah forest, "Operation Foxglove" commenced in June 1994, funded by Alcoa and CALM. Numbat re-introduction sites within the baited area will therefore need no extra resources for fox control, assuming that effective control is achieved. This baiting program will include the Batalling area currently being baited by CALM Collie District, and Julimar Conservation Park, where fox control is currently funded by ANCA under the Chuditch Recovery Plan. The costs of "Operation Foxglove" are not included in the estimates below.

ESP funds will be required for predator control on the proposed re-introduction sites outside these areas. Karroun Hill NR and Dragon Rocks NR will both require baiting from 1995 on. Fox control at Karroun Hill NR will protect the existing colony there until 1997, when a decision will be made whether or not to proceed with further translocations there. This decision will be made by CALM in the light of advice from the Recovery Team, which will review the survival of the colony at Karroun Hill and the feasibility of feral cat control in the Nature Reserve. Work planned for late 1994 under the ANCA Feral Pests Program project 11 "Methods of broadscale cat control, and fox control at a Numbat re-introduction area" will establish whether or not feral cats can be controlled at Karroun Hill by baiting. Fox control in part of Dragon Rocks Nature Reserve is currently being carried out as part of a research program on the Western Mouse (*Pseudomys occidentalis*), due to finish at the end of 1994.

Responsibility: CALM SID, CALM Merredin District, CALM Katanning District.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	1758	1758	1758	1758	1758	1758	1758	1758	1758	1758
ESP	21428	21428	21428	21428	21428	21428	21428	21428	21428	21428
Total cost	**23186**	**23186**	**23186**	**23186**	**23186**	**23186**	**23186**	**23186**	**23186**	**23186**

4.3.3 Translocation program

A tentative re-introduction program is shown below. Each release will consist of 15-20 animals. The projected population numbers that this program will achieve are shown in Appendix 1. The locations of the proposed sites are shown in Figure 5. In 1994, releases will be carried out at Batalling and Tutanning.

Area	First release	Second release	Third release
Dragon Rocks NR	1995	1996	1997
Northern jarrah forest	1996	1997	1998
Karroun Hill NR*	1997	1998	1999
Central jarrah forest	1998	1999	2000
Julimar CP	1999	2000	2001

* Translocations have already been carried out to Karroun Hill: a new series of releases in 1997-1999 will be implemented only if exotic predator control can be performed successfully.

Responsibility: CALM SID.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	5126	5126	5126	5126	5126	5126	5126	0	0	0
ESP	17781	21052	23996	24401	24716	22390	18424	0	0	0
Total cost	**22907**	**26178**	**29122**	**29527**	**29842**	**27516**	**23550**	**0**	**0**	**0**

4.3.4 Monitoring re-introduced populations

The re-introduced populations will be monitored intensively in the initial stages (approximately five years) as detailed in Section 2.4, then by driven survey only. During the first five years driven surveys will be conducted annually, then subsequently every second year. ESP funds will be required for CTO salary, travel, vehicle running, refurbishment of radio-collars and consumables.

Responsibility: CALM SID.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	9467	9467	9467	9467	9467	9467	10252	10252	10252	10252
ESP	20637	24526	30728	31383	32198	30314	37663	37028	35394	34532
Total cost	**30104**	**33993**	**40195**	**40850**	**41665**	**39781**	**47915**	**47280**	**45646**	**44784**

4.3.5 Genetic management of populations

Maintenance of genetic variability in existing and re-introduced populations will rely on movement of animals between populations. A program of artificial transfer of individuals will be designed and implemented when the results of the investigation of the Dryandra and Perup populations are known. Animals will be transferred during the translocation and monitoring actions and so will impose no additional costs on the program.

Responsibility: CALM SID.

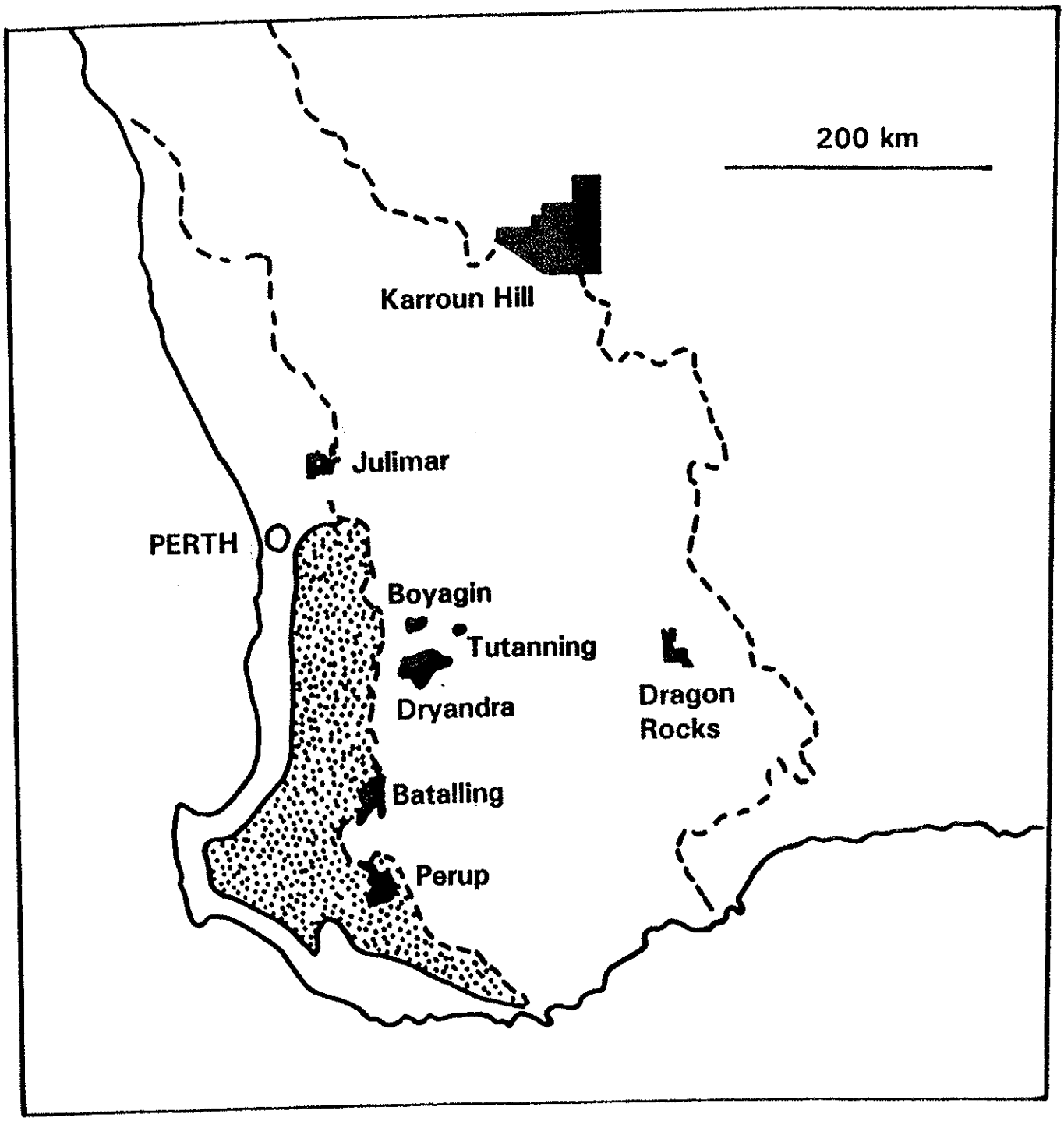

Figure 5. Locations of surviving Numbat populations and proposed re-introduction sites (shown in black). The dashed lines enclose the most heavily cleared agricultural area (termed "the wheatbelt"); the stippled area is the portion of the main forest block dominated by jarrah or wandoo.

4.4 Health monitoring

Parasites and disease can threaten the viability of re-introductions, as shown in several other projects, such as the Black-footed Ferret and Whooping Crane recovery programs in North America. A Numbat transferred from Dryandra to Yookamurra died from complications caused by infection by an acanthocephalan species (a parasitic worm). Another Numbat killed by a raptor at Yookamurra was found to be infected by the same parasite species. The health monitoring program will be based on collection of blood and faecal samples prior to and after translocation. ESP funds will be required for analysis of samples for haematology, blood biochemistry, serology, faecal parasites and bacteriology. The number of samples analysed each year will increase with the number of populations.

Responsibility: CALM SID.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
ESP	1500	1500	2100	2100	2100	3000	3000	3600	3600	3600
Total cost	**3600**	**3600**	**4200**	**4200**	**4200**	**5100**	**5100**	**5700**	**5700**	**5700**

4.5 Captive breeding

In the event that the wild populations cannot provide sufficient animals for the translocation program (1995-2001), a healthy and genetically viable captive breeding program will be of great value to recovery in the wild. The captive breeding colony at Perth Zoo also has the potential to make a great contribution to the Numbat recovery effort by forming a valuable resource for raising public awareness of the plight of the Numbat and work involved in its recovery. Due to its attractive appearance and its diurnal nature, the Numbat is a very appealing species for display, and it is anticipated that a number of Australian zoos will be prepared to house Numbats for display and to participate in the captive breeding program. Endangered Species Program funds will not be required to support these programs.

Responsibility: Perth Zoo.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	0	0	0	0	0	0	0	0	0	0
ESP	0	0	0	0	0	0	0	0	0	0
Perth Zoo	60000	60000	60000	60000	60000	60000	60000	0	0	0
Total cost	**60000**	**60000**	**60000**	**60000**	**60000**	**60000**	**60000**	**0**	**0**	**0**

4.6 Public awareness and support

The recovery of the Numbat is dependent on a relatively large number of re-introductions, and the difficulty of monitoring requires a high expenditure of funds and personnel. Public support is essential to maintain the funding necessary to complete these actions, and assistance from interested members of the public could be utilised in some of the management and monitoring actions. The Numbat is a very

high profile species, and has attracted much public interest, particularly in Western Australia but also in South Australia, where a Numbat Action Group has been formed, through the Threatened Species Network.

4.6.1 Education and publicity

The Department of Conservation and Land Management, in co-operation with other relevant organisations, will formulate and implement an education strategy to increase public awareness of the Numbat and efforts being made to improve its conservation status. This will be coupled with encouragement for community groups to support and become involved in recovery actions.

Responsibility: CALM SID, CALM Corporate Relations Division, Numbat Recovery Team.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	2825	2825	2825	2825	2825	2825	2825	2825	2825	2825
ESP	1000	0	0	1000	0	0	1000	0	0	0
Total cost	**3825**	**2825**	**2825**	**3825**	**2825**	**2825**	**3825**	**2825**	**2825**	**2825**

4.6.2 Grants and sponsorships

Funds to achieve the actions listed in this recovery plan will be sought from the public sector through sources such as the Endangered Species Program, and from the private sector through approaches to industry, foundations and trusts.

Responsibility: Numbat Recovery Team, CALM Sponsorship Co-ordinator.

Cost:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CALM	1470	1470	1470	1470	1470	1470	1470	1470	1470	1470
ESP	0	0	0	0	0	0	0	0	0	0
Total cost	**1470**	**1470**	**1470**	**1470**	**1470**	**1470**	**1470**	**1470**	**1470**	**1470**

5. IMPLEMENTATION SCHEDULE

a: CALM contribution; b: ESP funds required;
d: Perth Zoo contribution; c: Total cost.

Task # 3.*	Task description	Priority	Feasibility	Responsible party		Cost estimate ($000s/year) 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
1	**Management of existing populations**															
1.1	Exotic predator control	1	95%	Narrogin/ Manjimup Districts	a	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	283.0
					b											0
					c	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	283.0
1.2	Monitoring of existing populations	1	100%	SID/ Narrogin/ Manjimup Districts	a	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	88.0
					b	7.0	7.1	7.2	7.4	7.5	7.6	7.7	7.9	8.0	8.1	75.0
					c	15.8	15.9	16.0	16.2	16.3	16.4	16.5	16.7	16.8	16.9	163.0
1.3	Habitat management research															
1.3.1	Effectiveness of silviculture guidelines	2	85%	SID/ Manjimup	a	13.2	13.6									26.9
					c	13.2	13.6									26.9
1.3.2	Effect of hazard reduction burning	2	90%	SID/ Manjimup District	a					9.7	5.2	4.6	4.6			24.0
					b					17.3	14.9	2.2	2.2			36.6
					c					27.0	20.1	6.8	6.8			60.6
1.3.3	Research on Numbat home range size	2	100%	SID	a			9.2	9.0							18.2
					b			16.7	17.9							34.6
					c			25.9	26.9							52.8
1.4	Implementation of prescriptions	2	100%	Operations Div./SID	c											0
2	**Genetic survey**	2	100%	SID	a					2.1					2.1	4.2
					b					5.0					10.0	15.0
					c					7.1					12.1	19.2

5. IMPLEMENTATION SCHEDULE (cont'd)

Task # 3.*	Task description	Priority	Feasibility	Responsible party		Cost estimate ($000s/year) 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
3	**Translocation**															
3.1	Selection of sites	1	100%	SID/Harvey	a	2.4	2.4		2.4							7.1
				Katanning/	b	0.9	0.9		0.9							2.7
				Jarrahdale/	c	3.3	3.3		3.3							9.8
3.2	Exotic predator control	1	95%	SID/	a	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	17.6
				Katanning/	b	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	214.3
				Envir. Prot.	c	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	231.9
3.3	Translocation program	1	80%	SID	a	5.1	5.1	5.1	5.1	5.1	5.1	5.1				35.9
					b	17.8	21.1	24.0	24.4	24.7	22.4	18.4				152.8
					c	22.9	26.2	29.1	29.5	29.8	27.5	23.5				188.6
3.4	Monitoring of new populations	1	95%	SID	a	9.5	9.5	9.5	9.5	9.5	9.5	10.3	10.3	10.3	10.3	97.8
					b	20.6	24.5	30.7	31.4	32.2	30.3	37.3	37.0	35.4	34.5	314.4
					c	30.1	34.0	40.2	40.9	41.7	39.8	48.0	47.3	45.7	44.8	412.2
3.5	Genetic management	2	95%	SID	c											0
4	**Health monitoring**	2	100%	SID	a	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	210.0
					b	1.5	1.5	2.1	2.1	2.1	3.0	3.0	3.6	3.6	3.6	26.1
					c	3.6	3.6	4.2	4.2	4.2	5.1	5.1	5.7	5.7	5.7	47.1
5	**Captive breeding**	1	90%	Perth Zoo/	d	60.0	60.0	60.0	60.0	60.0	60.0	60.0				420.0
				Other zoos?	c	60.0	60.0	60.0	60.0	60.0	60.0	60.0				420.0

5. IMPLEMENTATION SCHEDULE (cont'd)

Task # 3.*	Task description	Priority	Feasibility	Responsible party		Cost estimate ($000s/year) 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
6	**Public awareness, support**															
6.1	Education and publicity	2	100%	SID/	a	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	28.3
				Corp. Relns	b	1.0			1.0			1.0				3.0
					c	3.8	2.8	2.8	3.8	2.8	2.8	3.8	2.8	2.8	2.8	31.3
6.2	Grants and sponsorship	2	85%	SID/	a	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15.0
				Spons.Coor.	c	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15.0
	Total annual cost of Numbat Recovery			**CALM**		75.6	75.9	69.0	71.2	71.7	65.1	65.3	60.0	55.5	57.6	666.9
				Perth Zoo		60.0	60.0	60.0	60.0	60.0	60.0	60.0	0	0	0	420.0
				ESP		70.2	76.5	102.2	106.5	110.2	99.6	91.4	72.2	68.4	77.7	874.9
				Total		205.8	212.4	231.2	237.7	241.9	224.7	216.7	132.2	123.9	135.3	1961.8

N.B. Due to rounding of subtotals and totals to $000s, some totals do not equal the sum of the subtotals. Precise costings are given in the budgets contained in the text.

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APPENDIX

POTENTIAL NUMBAT POPULATION NUMBERS AT PROPOSED SITES

Numbers are estimated from the area baited, on the assumption that one adult occupies about 50 hectares, and using the observation that male and female home ranges overlap and an estimation of the proportion of each area comprising suitable habitat.

	Area baited/monitored	Potential numbers (adults)
Surviving populations:		
Dryandra Woodland *	20000 ha	600
Perup-Kingston area *	70000 ha	1000
Current re-introduction sites:		
Boyagin NR *	5000 ha	200
Karroun Hill NR	100000 ha	1000
Tutanning NR	2000 ha	50
Batalling area SF	16000 ha	300
Proposed re-introduction sites:		
Julimar Conservation Park	29000 ha	500
Another northern jarrah forest site	30000 ha	500
Another central jarrah forest site	30000 ha	500
Dragon Rocks NR	33000 ha	650
Fenced sanctuaries:		
Yookamurra	1113 ha	30
Total		**5330**

* currently self-sustaining populations