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CHAPTER THIRTY-ONE

Reintroduction and the numbat recovery programme

J. A. FRIEND[1] and N. D. THOMAS[1]

Only two significant numbat populations, at Dryandra and Perup in the south-west of Western Australia, have survived the massive and widespread decline of the species. The numbat's recovery depends on the successful re-establishment of wild populations. A programme of reintroduction has been in progress since 1985, first by translocation from the wild to an area close to the source location and then to other areas within the numbat's former range. Fox control has been implemented at each site. The first reintroduction was to the eastern block (2 000 ha) of Boyagin Nature Reserve, 40 km north of Dryandra, where 35 numbats were released between 1985 and 1988. A population appears to have become established there, and numbats have now been recorded in the western block (3 000 ha), which is separated from the eastern block by 500 m of farmland. Since 1986, numbats have been translocated from the wild at Dryandra to three sites where regular baiting for foxes occurs. At a more arid site at Karroun Hill Nature Reserve (300 000 ha), rates of predation are high, due particularly to raptors and cats. The reintroductions to Tutanning Nature Reserve (2 000 ha) and the Batalling area (14 000 ha under fox control) are still in the early stages.

Key words: Numbats, Reintroduction, Fox Control, Predation, Feral Cats, Raptors.

INTRODUCTION

THE decline of the numbat *Myrmecobius fasciatus* since the introduction of European fauna and land management practices to Australia has been dramatic. One-hundred-and-fifty years ago, numbats occurred from the west coast across the southern half of the continent to western New South Wales. By the early 1980s, the species survived in only a handful of sites in bushland near the southwestern extremity of its former range (Friend 1990a). In the last 10 years, some of these small remnant populations have disappeared, and there are now only two significant surviving populations, both in Western Australia, near Narrogin at Dryandra and east of Manjimup at Perup (Fig. 1).

The biology of the numbat, a small mammal that attains an adult weight of 500–700 g, has been studied at Dryandra (Calaby 1960; Friend and Burrows 1983; Friend 1987, 1989) and at Perup (Christensen *et al.* 1984; Maisey and Bradbury 1985). Although most closely related to the carnivorous marsupials (family Dasyuridae), numbats have peculiar anatomical and behavioural traits that adapt them to a specialized diet of termites, which they extract from shallow galleries in the soil and from under dead wood on the ground. Up to four young are produced by each female in January or February after a gestation of 14 days and remain attached to her four nipples until July, when they are deposited in a nursery burrow. Weaning occurs in October, when food availability is high, and the juveniles disperse about six weeks later. Females breed in the first year, but males reach sexual maturity a year later. There is no evidence of pair fidelity, and males appear to take no part in the care of the young.

An investigation of the factors limiting numbat numbers and likely to have an impact on the conservation status of the species focused on the surviving population at Dryandra (Friend 1990a, b). This chapter outlines the role of reintroduction in the numbat recovery process and reports on the current status of the reintroduction programme.

DRYANDRA AND THE BEGINNINGS OF RECOVERY

For many years, the 28 000 ha of forest and woodland at Dryandra, 170 km south-east of Perth, has been known as the stronghold of the numbat (Fig. 2). Numbats were previously most numerous in the Western Australian wheatbelt, an area east of Perth now extensively cleared for cereal growing (Friend 1990a). Dryandra Woodland (28 000 ha) comprises 10 blocks of wooded land in the western part of the wheatbelt which was reserved for forestry purposes in the 1920s. Serventy (1954) drew attention to an increase in sightings of numbats and other marsupials at "Dryandra Forestry Settlement", and the definitive study of the numbat (Calaby 1960) was carried out at Dryandra in the mid-1950s because the animals were relatively abundant there. Apparently numbats could be reliably seen at Dryandra until the late 1970s, when the population declined dramatically (Friend 1987, 1990a). This event coincided with declines in other medium-sized native mammal species and

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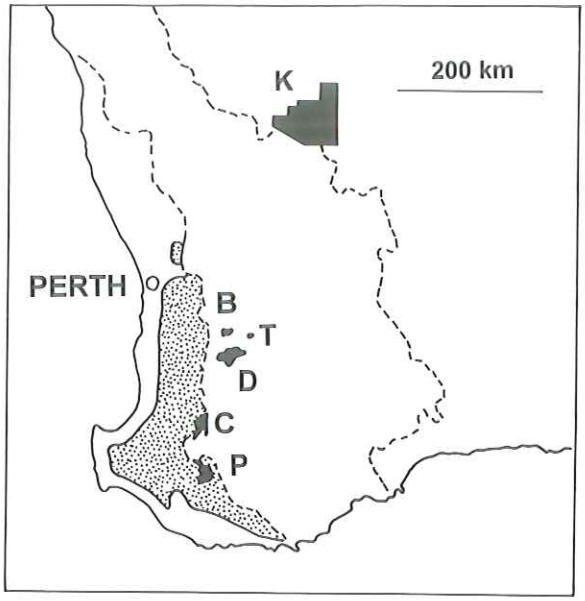

Fig. 1. The south-west of Western Australia showing places mentioned in the text. The main cereal growing area (the "wheatbelt") is bounded by dashed lines, and the stippled area shows the extent of State forest dominated by Jarrah *Eucalyptus marginata*. B — Boyagin Nature Reserve; T — Tutanning Nature Reserve; D — Dryandra Woodland; C — Batalling block; P — Perup Nature Reserve; K — Karroun Hill Nature Reserve.

an increase in numbers of the introduced Red Fox *Vulpes vulpes* in southwestern Western Australia (King *et al.* 1981). By monitoring numbat abundance in an area of 2 000 ha at Dryandra in which the number of foxes was reduced by poison baiting, as well as in an unbaited area, Friend (1990a) showed experimentally that these introduced predators were regulating the numbat population.

After the experiment, fox baiting continued at Dryandra and was extended in 1989 to encompass the two largest blocks (17 000 ha in total). The control programme uses baits consisting of 120 g (wet weight) of kangaroo meat injected with 4.5 mg of sodium monofluoroacetate (a highly toxic compound known as "1080") in aqueous solution. The meat baits are then dried to 40 per cent of original weight and stored at −20°C until needed (CALM 1990). Each month, baits are placed under bushes along perimeter roads and selected internal tracks at 100 m intervals. This procedure can be used with little risk to native animals because the vertebrate fauna of southwestern Australia have a characteristically high tolerance to 1080 (Twigg and King 1991).

The Dryandra population has continued to grow, despite the removal of 10–30 animals

Fig. 2. The lower valley slopes at Dryandra Woodland are dominated by Wandoo *Eucalyptus wandoo* with an open understorey composed mainly of Sandplain Poison *Gastrolobium microcarpum*, over a ground cover of low grasses and forbs. These areas support the highest densities of numbats. Wandoo trees are often hollowed out by the wood-eating termite *Coptotermes acinaciformis*, creating hollow logs when trees or branches fall.

annually since 1985 for reintroduction programmes. Figure 3 shows the rate at which numbats have been sighted each year during surveys from vehicles driven slowly along selected tracks (after the method of Calaby 1960). These data indicate that the numbat population at Dryandra has increased at least 50-fold since 1979, and that it is considerably larger now than it was after the documented increase of the mid-1950s. Some fox control was probably achieved in Western Australia in the 1950s and 1960s by secondary poisoning following the widespread use of 1080 to control rabbits. When myxomatosis became more effective as a rabbit control agent in the late 1960s following the introduction of a more efficient vector for the virus (the European rabbit flea), the use of 1080 declined and fox numbers increased (King *et al.* 1981). These events may explain both the increase in numbat numbers in the 1950s and the decrease in the 1970s.

The total number of numbats in the main block of Dryandra Woodland (13 000 ha) in November 1992 was calculated to be 800, by extrapolating the results of a line transect survey (Friend, unpubl. data). Approximately 54 per cent of the animals caught in November and December 1992 were adults, so the population of the main block, where most of the Dryandra numbats are found, comprised about 430 adults and 370 young. A survey is now carried out in November each year before removing any animals for translocation, to confirm that population levels have been maintained.

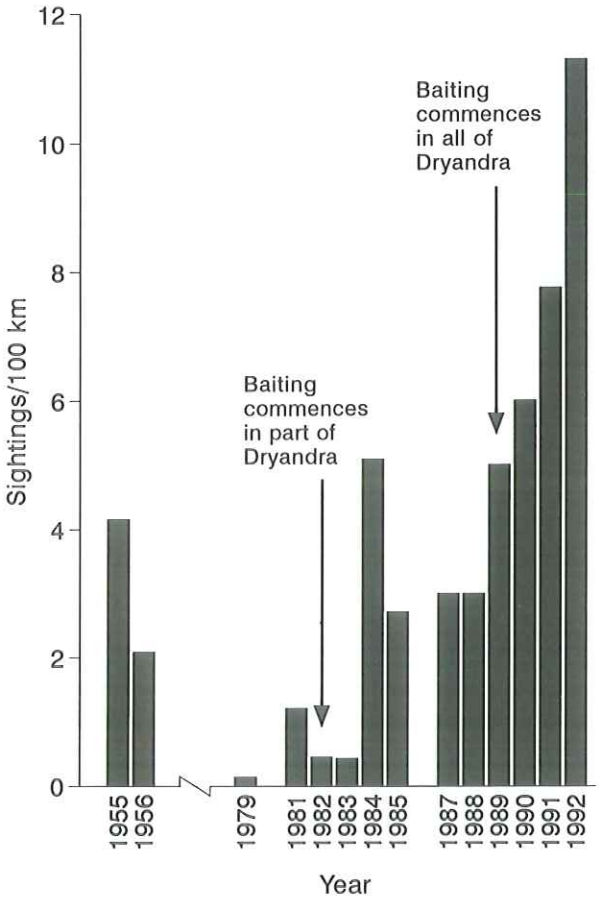

Fig. 3. Number of numbat sightings recorded per 100 km of driving surveys on roads in Dryandra Woodland. Distances driven were as follows: 1955, 385 km; 1956, 385 km; 1979, 718 km; 1981 413 km; 1982, 1 103 km; 1983, 704 km; 1984, 275 km; 1985, 590 km; 1987–88, 200 km per year; 1989–92, 400 km per year. Data for 1955–56 provided by J. Calaby.

REINTRODUCTION STRATEGY AND CHOICE OF SITES

As the survival of the numbat is now dependent on only two of its original populations, comprising a total of less than 1 500 animals (Friend 1994), establishing additional populations is essential to improve the conservation status of the species. In 1985, once the positive effect of fox control had been demonstrated, a trial reintroduction was planned. Translocation of wild animals from Dryandra was proposed to an area of similar rainfall, soils and vegetation, where numbats had recently become extinct. Fox control was to be implemented, in order to test the hypothesis that fox predation was the major factor preventing the persistence of numbat populations in such areas. If this translocation resulted in the establishment of a self-sustaining population, it would indicate that the quality of the habitat of the numbat at that site was still adequate, and that the previous extinction was due to fox predation, rather than factors affecting food supply or other habitat attributes. The next step to improve the conservation status of the species would be to conduct a series of monitored reintroductions under a regime of fox control to areas of different climate and vegetation within the numbat's former range.

Boyagin Nature Reserve (5 000 ha), 40 km north of Dryandra, satisfied the criteria for the first reintroduction site (Fig. 4). Numbats had been recorded there as recently as 1970, but had subsequently become extinct (Friend 1990a). The second site selected was Karroun Hill Nature Reserve (300 000 ha, annual rainfall about 250 mm), on the eastern edge of the Western Australian wheatbelt, where reintroduced populations could expand to the north and east into uncleared habitat on vacant Crown land and pastoral leases (Fig. 5). Numbats had previously occurred at Karroun Hill based on skeletal remains (Youngson and McKenzie 1977), and also nearby based on anecdotal accounts (Maddock 1987). A baiting regime using 1080 in meat baits was already in place around the perimeter of the reserve, to protect sheep on neighbouring farms and grazing leases from dingo predation.

Other reintroduction sites have been chosen on similar principles. Tutanning Nature Reserve (2 000 ha) approximates the minimum area able

Fig. 4. Wandoo woodland in the valley where most numbats were released at Boyagin Nature Reserve. *Eucalyptus wandoo* is dominant over an open understorey of Box Poison *Gastrolobium parviflorum* with a ground cover of low grasses and forbs.

to support a population of 50 numbats (Friend 1987). Fox control has been part of its management since 1989, and had been carried out on the reserve for research purposes since 1984, resulting in a spectacular recovery of Brush-tailed Bettongs *Bettongia penicillata*, Tammar Wallabies *Macropus eugenii* and Common Brushtail Possums *Trichosurus vulpecula* (Kinnear 1990). Numbats were present at Tutanning until the late 1970s, and although searches in 1984 found a few diggings (Connell and Friend 1985) and a sighting was reported in 1986, more recent work (see below) indicated that the population was extinct by 1990. Batalling Block, an area of State forest east of the town of Collie dominated by Jarrah *Eucalyptus marginata,* was used successfully as a reintroduction site for Brush-tailed Bettongs in 1983 (Christensen and Leftwich, unpubl. data). Fox control has been carried out there since 1990 over an area of 6 000 ha, increased to 14 000 ha in 1992. Numbats were recorded near Muja, within 20 km of Batalling Block, as recently as 1982 (Connell and Friend 1985). In choosing future reintroduction sites in the numbat recovery programme, the entire range of habitat types previously occupied by the numbat will be considered, as well as those already used.

REINTRODUCTION TO BOYAGIN NATURE RESERVE

An adult male numbat was released as a pioneer into the eastern section (2 000 ha) of Boyagin Nature Reserve in early November 1985, followed by 16 animals (three adult and five subadult males; one adult and seven subadult females) in November and December (Fig. 6). This time of year, when young numbats are dispersing from their maternal home range, was chosen as the most suitable period for translocations. It is also the beginning of a 6–8-week period before the first births of the next year, when females can be translocated without risk to dependent young. Altogether, 35 numbats (eight adult and nine subadult males, eight adult

Fig. 5. Reintroduced numbats have occupied a range of vegetation types at Karroun Hill Nature Reserve. In the foreground a low woodland is dominated by several *Acacia* species, over a seasonal ground cover mainly composed of *Helichrysum lindleyi*. In the background, York Gum *Eucalyptus loxophleba* forms a higher canopy, and provides hollows both in fallen branches and in trunks which often lean to approach the horizontal.

and 10 subadult females) were released at Boyagin between November 1985 and March 1988 (Friend 1990a).

Numbats cannot be trapped by conventional methods, so the establishment of the population was monitored in three ways. Before release, all numbats were fitted with a radio-collar (single-stage SM-1 transmitter, AVM Instruments), allowing them to be located and recaptured at intervals so that their survival and breeding status could be determined. The degree to which the population occupied available habitat in the reserve was measured by surveys for fresh numbat diggings and scats near roads at 200 m intervals. Finally, sighting surveys from vehicles carried out according to the protocol used at Dryandra were implemented in 1992, when the population had risen to a sufficiently high level.

Results from monitoring the early stages of the reintroduction were reported in Friend (1990a). All translocated numbats established home ranges within six weeks (in some cases much sooner), and over 90 per cent of translocated females produced young in the next breeding season. Six new animals were caught in 1986 and seven in 1987. Up to the end of 1989, 13 radio-collared numbats were known to have been taken by predators, judging from the damage to radio-collars and the state of remains. Four were presumed to have been taken by foxes, four by raptors and in five cases the species of predator could not be inferred from the evidence found.

Figure 7 shows the results of the survey for diggings and scats in November 1990. By this time, numbats had spread into all suitable habitat in the eastern section of the reserve. In October 1992, the search of the eastern block was limited to a series of monitoring sites, and a thorough search of the western block, where no numbats had been released, was carried out in November. These surveys indicated that all available habitat in the eastern block was still occupied, and that numbats were resident in several parts of the western block (Fig. 8).

The first vehicle-based sightings surveys at Boyagin were carried out in November 1992. The survey of the eastern block yielded seven sightings in 234 km (3.0 sightings/100 km). This compares well with sighting rates recorded at Dryandra since the introduction of fox control. No animals were sighted in 195 km of surveys in the western block, although a numbat was seen beside the road in November during non-survey driving, and there have been other sightings in the western block by Department of Conservation and Land Management staff in 1992 and 1993.

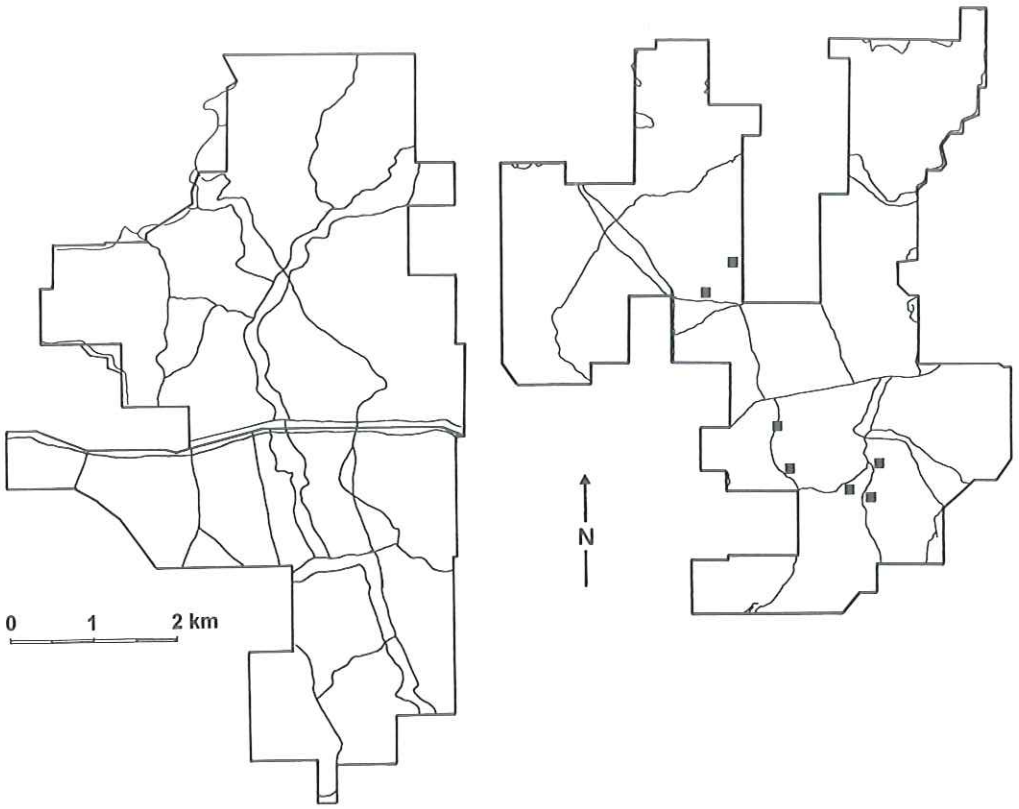

Fig. 6. Eastern and western blocks of Boyagin Nature Reserve, showing perimeter and internal roads. Sites at which numbats were released in 1985–87 are shown as dark squares.

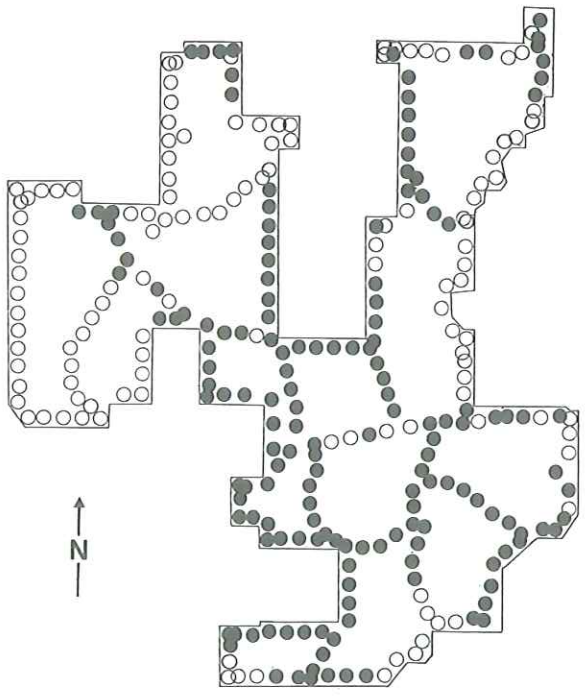

Fig. 7. Results of a survey for numbat diggings and scats in the eastern block of Boyagin Nature Reserve, October/November 1990. Dark circles denote points at which fresh numbat diggings and/or scats were found; open circles denote points at which neither were found.

No numbats were released at Boyagin between March 1988 and December 1992, yet during that time animals moved into all suitable habitat in the eastern block and colonized the western block, albeit at a low level. This indicates that the Boyagin population is now self-sustaining. Two males and a female from Dryandra were released into the western block of Boyagin in February 1993, as part of a programme of exchange of individuals to promote gene flow between isolated populations (Friend 1987).

REINTRODUCTION TO KARROUN HILL NATURE RESERVE

Compared with the Boyagin exercise, the reintroduction at Karroun Hill Nature Reserve has proved much more difficult to monitor. Road access in the reserve is very limited, and the animals are able to disperse over a much larger area. After difficulties experienced in monitoring the first release (1986), the relocation rate for radio-collars was greatly increased by the use of two-stage (AVM Instruments P2-1V) rather than one-stage transmitters, the development of a sensitive antenna system for a light aircraft, and the use in 1987 and subsequent years of a scanner (Telonics TS-1). Searches for diggings have had a very low success rate, however, because the numbats occur at low density and areas are often not reoccupied immediately after the death of a resident animal, if at all.

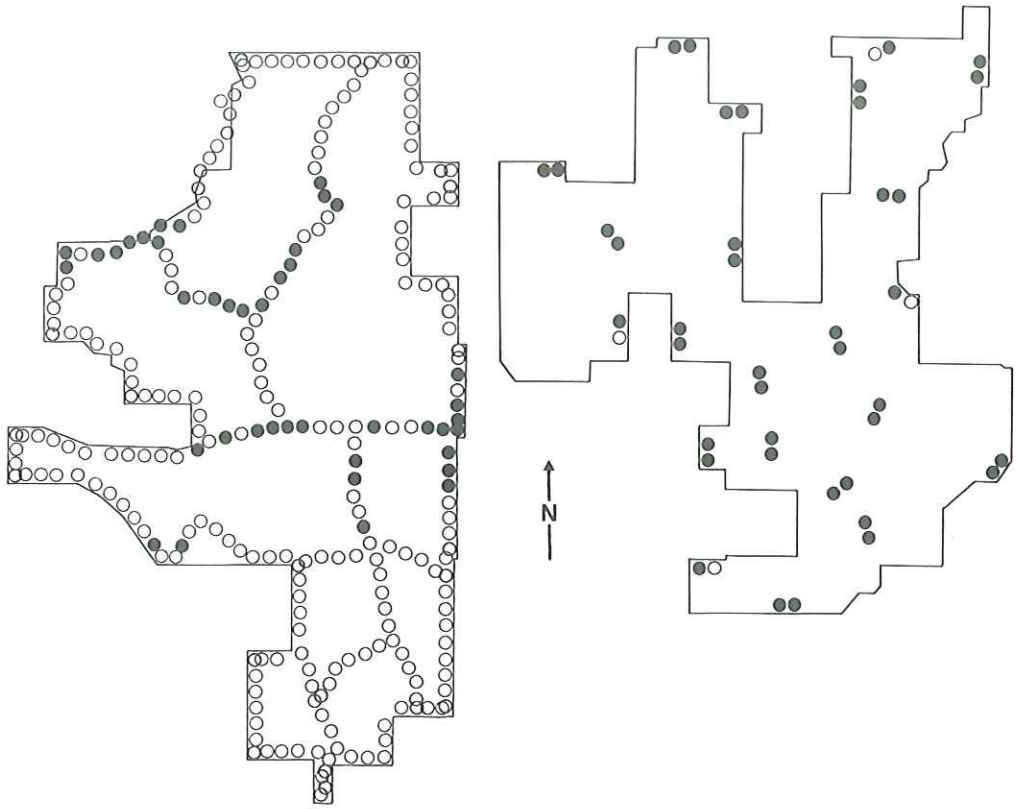

Fig. 8. Results of a survey for numbat diggings and scats in the eastern and western blocks of Boyagin Nature Reserve, October/November 1992. Dark circles denote points at which fresh numbat diggings and/or scats were found; open circles denote survey points at which neither were found. The survey of the eastern block was limited to 22 monitoring sites in suitable habitat.

The low numbat population density and the near absence of roads render sightings surveys from vehicles of little value.

The release sites used in 1987 and subsequent years have been near Karroun Hill itself, a low granite dome in the western half of the reserve. The locations at which numbats were found about one month after release in 1987 and 1988 are shown in Figures 9 and 10, respectively. In 1987, there were no numbats resident in the area at the time of the releases, and only 10 of 15 released animals were found to have stayed within 3 km of the release site. In the following year, when there were already numbats resident in the area, 13 of 14 released animals established home ranges within this area. It seems that the prior presence of numbats in an area increases the probability that newly released animals will settle nearby. Due to the small size of Boyagin Nature Reserve, this tendency had not been detected during the reintroduction there.

A total of 92 animals have been translocated from Dryandra to Karroun Hill in the period 1987–93. Thirty-four young born at Karroun Hill have been captured and fitted with transmitters, usually just before achieving independence. Ten litters are known to have been raised successfully to independence. One female is known to have raised two litters at Karroun Hill and was carrying a third when she was killed, probably by a bird of prey. This female lived for two years and seven months after translocation, achieving the greatest longevity recorded amongst the numbats translocated to this area.

There have been 50 known deaths at Karroun Hill. Forty-four have involved predation, but in only 18 cases could the predator be identified with any certainty. Of these, 10 were due to raptors, four to feral cats *Felis catus,* three to foxes and one to a dingo *Canis familiaris dingo.* None of the deaths appears to have been due to a reptile. Amongst the raptor species present at Karroun Hill, those most likely to take numbats are Brown Goshawks *Accipiter fasciatus,* Little Eagles *Hieraaetus morphnoides* and Wedge-tailed Eagles *Aquila audax*; less likely candidates include Brown Falcons *Falco berigora* and Whistling Kites *Haliastur sphenurus.* The remaining 28 predation records have not been allocated to any predator type, although given that many damaged collars show tooth marks, mammalian predators (fox, cat or dingo) must have accounted for some. Trials are being undertaken in which radio-collars are presented to captive birds of prey, cats, foxes and dingoes in an attempt to record distinctive patterns of damage made by these predators on the plastic-coated brass bands of the collars.

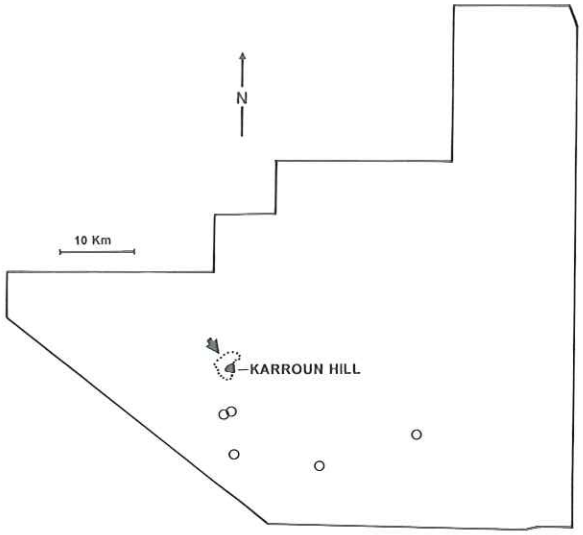

Fig. 9. Locations of 15 numbats, released at Karroun Hill Nature Reserve in November/December 1987, approximately one month after release. The release sites were located within 1 km of Karroun Hill. Ten animals remained within 3 km of their point of release (i.e., within the area marked by the dotted line and arrow). Locations of the five other animals are marked by open circles.

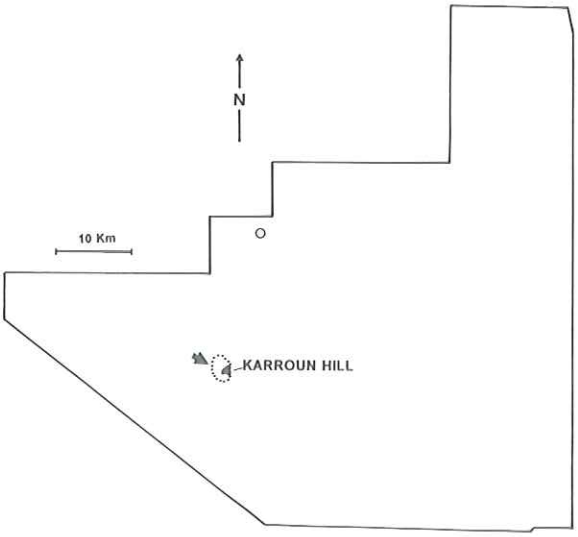

Fig. 10. Locations of 14 numbats, released at Karroun Hill Nature Reserve in November/December 1988, approximately one month after release. The release sites were located within 1 km of Karroun Hill. Thirteen animals remained within 3 km of their point of release (i.e., within the area marked by the dotted line and arrow). The location of the remaining individual is marked by an open circle.

The 44 recorded victims of predation include 28 translocated adults (30% of the animals translocated) and 16 young born at Karroun Hill (47% of the young radio-collared). Rather than reflecting the different origin of the animals, this disparity is more likely to be due to the greater vulnerability of young numbats compared with adults.

In March and September 1990 and 1991, aerial baiting using dried meat baits containing 4.5 mg of 1080 was carried out in an attempt to reduce predation by foxes, at a rate of 7.5 baits per km^2 over an area of 40 000 ha. The first instances of cat predation on numbats at Karroun Hill were recorded during the first year of aerial baiting. Cat numbers have been shown to rise after fox control at other arid and semi-arid sites in Western Australia (Christensen and Burrows 1994; Short *et al.* 1994). Although the cat population at Karroun Hill has not been monitored, it is possible that the removal of foxes and dingoes has also favoured cats in this area. Increases in cat numbers and in the rate of predation by cats following fox control have not been observed, however, in the more mesic westerly areas in Western Australia such as Dryandra, Boyagin and Batalling.

Judging from the lack of readily observed diggings, it is unlikely that a thriving numbat population has become established close to the main release site. In addition to the eight radio-collared animals, however, uncollared animals clearly exist in the reserve: two have been sighted, and a number of radio-collared females remote from all radio-collared males have produced young. The presence of cats is suspected to be hindering the establishment of a population, although raptors are also important predators. While monitoring will continue at Karroun Hill, future work will focus on means of controlling feral cats.

OTHER REINTRODUCTIONS

Three radio-collared female numbats from Dryandra were released at Tutanning Nature Reserve in November 1987 in an effort to determine whether males were still present in the reserve. Two of the females were killed by raptors in the first month, but the third was still alive and wearing a radio-collar in November 1991. She did not produce young during the four intervening breeding seasons, indicating that no male numbats survived in the reserve. More numbats were translocated from Dryandra to Tutanning Nature Reserve in 1991 (14 animals) and 1992 (seven animals), but it is too early to assess the success of this reintroduction. Fifteen numbats, including 10 fitted with radio-collars, were released at Batalling Block in December 1992. An abnormally high rate of loss of signals before the animals were moved from Dryandra indicated a high failure rate amongst the radio-collars, and the loss of our radio-tracking aircraft before the monitoring flight at Batalling meant that we were unable to search efficiently for the signals. These reintroductions will be continued.

DISCUSSION

The establishment and continued growth of the Boyagin population under a regime of fox control indicates that numbat habitat in remnant vegetation in the western part of the Western Australian wheatbelt is still intact. The success of the Karroun Hill animals in producing and raising healthy young suggests that numbat habitat in more easterly regions is also able to provide sufficient food to support populations. The absence of strong evidence that a population has become established at Karroun Hill focuses attention on the threat posed to mammal recovery efforts by the lack of a cost-efficient means of controlling feral cats. Research into methods of control using poisons and into the feasibility of biological control is now under way across Australia (Barrett *et al.*, in press). The interactions between cats, foxes and dingoes are poorly understood, however. It is possible that in some areas dingoes exert control over both foxes and feral cats.

Our experiences at Karroun Hill have also highlighted the need for an objective means of determining the predator responsible for mortality of radio-collared animals. Currently this is done by piecing together the evidence from the mortality site, the condition of any animal remains and the condition of the radio-collar, including an interpretation of the marks left on its plastic coating. Controlled trials in which captive predators are given radio-collars on food items in order to record specific marks are of some value, but some collars are left without distinctive marks in the field.

There is limited potential for other numbat reintroductions in the western wheatbelt of Western Australia, where the likelihood of success appears greatest. One possible site is on the eastern edge of the main forest block, only 6 km west of Boyagin across farmland. The large extent of the jarrah forest and its proximity to population centres and hence to management resources make it an attractive option for reintroduction sites, but the low number of historical records indicates that this environment is probably suboptimum for numbats. The Batalling reintroduction in the eastern jarrah forest will allow this to be assessed. Otherwise, most sufficiently large potential reintroduction sites are in the eastern wheatbelt, or further east in semi-arid and arid regions where feral cats may cause problems.

In addition, it is important that the reintroduction of any species should not be considered in isolation. There is a need to co-ordinate the re-establishment of threatened species so that resources are concentrated at strategic locations, where the previously recorded fauna can be reconstructed (Friend 1991). This process of co-ordination is being carried out in Western Australia through the establishment of recovery teams, and will in part determine the choice of further numbat reintroduction sites.

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