THE DISTRIBUTION, RELATIVE ABUNDANCE, AND HABITAT PREFERENCES OF RARE MACROPODS AND BANDICOOTS ON BARROW, BOODIE, BERNIER AND DORRE ISLANDS.

Jeff Short
Bruce Turner
Christopher Majors

CSIRO, Division of Wildlife and Ecology
LMB No. 4, P.O. MIDLAND. W.A., 6056.

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Final report for the 2 year consultancy program entitled
"Feasibility of Reintroducing the Burrowing Bettong *B. lesueur* to Mainland Western Australia Phase 1".
to
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Jeff Short
Bruce Turner
Christopher Majors

CSIRO, Division of Wildlife and Ecology
LMB No. 4, P.O. MIDLAND. W.A., 6056.

SUMMARY

Three islands off the coast of Western Australia - Barrow, Bernier and Dorre - provide a refuge for six species of rare bettong, hare-wallaby, and bandicoot. Three species have been absent from the Australian mainland for over 30 years; three have only remnant populations remaining on the mainland. Hence their protection and management on these islands is of critical importance to the overall survival of each species. This study provides the first systematic surveys of their abundance and distribution on Barrow, Bernier, and Dorre Islands. In addition, we provide the results of a survey for bettongs on Boodie Island, a small island off the southern tip of Barrow Island.

The surveys employed a mixture of spotlighting and trapping. Techniques were standard across islands. A total of 200 km of transect were spotlighted on foot across the four islands and cage traps were laid for a total of 2,116 trap nights.

The mammal fauna of Barrow Island includes the burrowing bettong, the golden bandicoot, the spectacled hare-wallaby and an endemic sub-species of the euro. Spectacled hare-wallabies are most abundant with a population estimated by line transect methodology of 10,000 at a density of c. 42 km^{-2}, followed in order of decreasing abundance by bandicoot (c. 9,000; 38 km^{-2}), bettong (c. 3,400; 14 km^{-2}), and euro (c. 1800; 8 km^{-2}). All occur widely across the island. Euro tend to be concentrated to the west in the more rugged parts of the island and on floodout flats where grasses other than *Triodia* grow. Spectacled hare-wallabies were recorded on 96% of 50 spotlight transects indicating a broad distribution across the island. Golden bandicoots were infrequently recorded by spotlight but were caught on all trapping grids at between 8 and 28 per 48 trap nights indicating that they are both abundant and widespread. Bettongs were recorded on 36% of the 50 spotlight transects, and caught on 15 of 24 trapping grids at between 0 and 7 individuals per grid.

Hence they were at considerably lower densities than either the hare-wallabies or bandicoots. The combination of spotlighting, trapping, sightings in the headlights of vehicles, and the location of their warrens revealed that there were few locations on the island that they did not utilize.

Bernier and Dorre Islands contains populations of the burrowing bettong, the banded hare-wallaby, the rufous hare-wallaby, and the western barred bandicoot. The banded hare-wallaby is the most abundant species on both islands (c. 4,100 on Dorre; 3,300 on Bernier). They are dependent on the shelter afforded by low spreading shrubs of *Ficus platypoda*, *Heterodendrum oleifolium*, *Acacia coriacea*, *A. ligulata*, and *Diplolaena dampiera*. They occur mainly on the dunes that form the spine of Dorre Island and the travertine of its west coast. On Bernier Island they occur in the north where dense thickets of *Acacia coriacea*, *A. ligulata*, *H. oleifolium* and *D. dampiera*, and a tall heath of *Abutilon exoneum* and *Scaevola crassifolia* are best developed.

The rufous hare-wallaby occurs throughout both island in most habitats, but is most abundant in the south of each. It has a population of *c.* 2,400 on Bernier and 1,700 on Dorre. It burrows extensively on the inland sandplain and in the dunes.

The burrowing bettong occurs widely on both islands. On Dorre it was at highest densities around the margin of the island, and at White Beach and immediately to its south. It has a population of c. 1,000. Trapping results on Dorre indicated that bettongs favour coastal dune and *Triodia* habitats to heath and travertine/heath. The bettongs on Bernier appeared to be at roughly equivalent density as on Dorre but with a lower total population size (c. 600) because of the smaller island size. They were widely distributed. Trapping results revealed no preferences for particular habitat types. Spotlighting results suggested that bettongs favoured the coastal margins. Over 30% of sightings on both islands were around the coastal fringe despite this making up less than

20% of habitat along the transects. Bettong warrens were located under the rock capping of the coastal cliffs on both islands.

Western barred bandicoots had a population of c. 1600 on the Dorre and 600 on Bernier. We caught and sighted too few to make any generalisations about their habitat preferences.

Trapping and spotlighting on Boodie Island, immediately to the south of Barrow, suggested that bettongs are no longer present on this island. It is likely that poisoning to rid the island of *Rattus rattus* has eliminated bettongs also.

An analysis of trends in abundance and condition of bettongs with respect to habitat variables on Barrow Island indicated that bettongs showed no response to the major environmental gradients on the island. One gradient was the cline from coastal locations showing high habitat diversity, greater soil depth, greater vegetation height and cover, and a predominance of vegetation types other than *Triodia wiseana* to upland locations in the interior of the island where there was little habitat diversity, soil was shallow, and the vegetation was dominated by *Triodia wiseana* with scattered clumps of *Ficus platypoda*. The second major gradient was that created by the oilfield operation. Areas within the oilfield tend to have a higher plant diversity because earthworks to create and maintain well sites, roads and borrow pits removes climax vegetation of *Triodia* allowing early successional plants (native shrubs and forbs) to establish.

Bettong were frequently sighted at night in open habitats created by the oilfield operation (roads, seismic lines, borrow pits, well sites). This may reflect their greater visibility in these habitats and their use of seismic lines as pathways through dense *Triodia* rather than a preference for disturbed habitats.

The bettong on Barrow Island lives in large warrens of many burrows (range : 4-91; mean: 25) which occur sparsely across the island at a density of c. 0.5 km^{-2}. They occur on well drained sites, often on ridge lines, where cap rock provides insulation and structural support. A detailed profile of bettong warrens is provided which enumerates number of active entrances, depth of cap rock, slope of site, distance to ocean, altitude, aspect, and the occurrence of trees and shrubs on the warren. Warrens showed a slight concentration within 1 km of the coast.

The major oil and gas field, concentrated in 100 km^2 of the 233 km^2 area of the island, appears to have had no deleterious effect on the populations of any of the species surveyed. There was no significant difference in either sightings of bettongs or of number of warrens between areas where oilfield activities were concentrated and areas where they were not. The oilfield operator, West Australian Petroleum Pty. Ltd., has been successful in excluding exotic animals from the island. These constitute the major threat to the survival of Barrow's rare fauna.

We have provided a static picture of the distribution and abundance of the medium-sized mammals on Barrow, Dorre, and Bernier Islands. Drought and plenty, successional stage after fire, and competitive interactions between species (e.g. banded vs rufous hare-wallaby, bettong vs bandicoot) may alter the relative abundances of these species over time. It is possible that some rare combination of these events may push an island population of one or more species to extinction. This can only be guarded against by monitoring at critical times and/or the establishment of other island or mainland populations of these species.

The major threat to the continued survival of all species on these islands is the introduction of exotic predators - the cat or fox. The extinction of bettongs and hare-wallabies on Dirk Hartog, and hare-wallabies and bandicoots on islands in the Monte Bello group after the introduction of the cat, suggests a strong causal role by the cat in island extinctions.

PREFACE

The objectives of this consultancy are:

1. Complete preparation of habitat maps for Barrow, Bernier and Dorre Islands.
2. Review potential applicability of aerial photography and satellite data for monitoring vegetation data on the islands.
3. Complete analysis of line transect estimates of Burrowing Bettong density on the surveyed islands.
4. Survey the distribution and abundance of Burrowing Bettong warrens on Barrow Island.
5. Investigate in detail the habitat requirements of Burrowing Bettongs, principally on Barrow Island.
6. Continue to collect abundance data for other species of macropodoids on the islands as opportunity allows.

This report is an amalgamation and expansion of two previous reports to ANPWS (Short, Turner, and Cale 1988, Short and Turner 1989a).

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CHAPTER 1

INTRODUCTION

The rare fauna of Barrow, Bernier and Dorre Islands.

Barrow, Bernier and Dorre Islands (Fig. 1.1) collectively represent one of the most valuable collections of rare mammals anywhere in Australia. Their combined fauna includes the burrowing bettong *Bettongia lesueur*, the banded hare-wallaby *Lagostrophus fasciatus*, the rufous hare-wallaby *Lagorchestes hirsutus*, the spectacled hare-wallaby *L. conspicillatus*, the Barrow Island euro *Macropus robustus isabellinus*, and the western barred and golden bandicoots *Perameles bougainville* and *Isoodon auratus*.

The bettong, the banded and rufous hare-wallabies, and the western barred bandicoot are listed in the IUCN Red Data Book as rare. They are at risk because of their continental extinctions and because their remaining populations are small and localised.

The burrowing bettong

The burrowing bettong is one of 9 species of rat-kangaroos of the Family Potoroidae within the Superfamily Macropodoidea. It is distinctive among the macropods as being the only species to construct and live in warrens.

The rat-kangaroos represent a conservative branch of the evolutionary line that led to modern kangaroos. All remaining members are small in size (< 4 kg), and are generally omnivores. They dig for much of their food: underground fungi, roots, tubers and invertebrates but also feed on fruit.

The bettongs tend to inhabit drier ranges than other species within their family (e.g. potoroos and the musky rat kangaroo). However the three species of bettong collectively inhabitated all of Australia other than the tropical north, south-western Queensland and south-western Tasmania.

The bettongs, along with other medium-sized mammals, have suffered greatly since European settlement. All species of bettongs have suffered major contractions in range. Now the burrowing bettong (Fig. 1.2) and the eastern bettong *B. gaimardi* are confined only to islands, while the brush-tailed bettong *B. penicillata* survives in relatively fox-free refugia in south-western Australia and in north-eastern Australia.

The bettongs, including *B. lesueur*, were recognized by distinctive names in Aboriginal dialects. The former distribution of bettongs can be mapped by plotting those locations where Aborigines had a distinctive name for rat-kangaroos (Figure 1.3). Names which refer specifically to the burrowing bettong are underlined. Hence the burrowing bettong was variously known as a boodee, a jalva, a tchungoo, a booming and a mal-la, and a moondo-bil-bi. Burbidge *et al.* (1988) lists many other names used for *B. lesueur* in the deserts of Western Australia.

The type specimen of the burrowing bettong was collected on Dirk Hartog Island in 1817 by de Freycinet on the French ship l'Uranie and subsequently described by Quoy and Gaimard in 1824.

The reduction in range of the burrowing bettong appears to have commenced in south-eastern Australia and progressed westwards and northwards (Fig. 1.4). The last museum record of this species in New South Wales is from Tyndarie, near Bourke in 1879. The record for the Murray-Darling junction in 1892 given by Marlow (1958) cannot now be substantiated (L. Gibson, pers. com.). The burrowing bettong had apparently disappeared from much of southern South Australia by about 1910, from the pastoral zone of this state by the 1930s, and from desert ranges in the north-west of the state by the 1950s (Finlayson 1961).

The last record of its occurrence in the pastoral areas of Western Australia is from Rawlinna in 1928 (Australian Museum records). The species persisted in the wheat belt of Western Australia until the 1940s (Kitchener and Vicker 1981); in the southern deserts till the late 1940s; and the Gibson Desert until the early 1960s (Burbidge *et al*. 1988).

The burrowing bettong is now confined to three islands off the coast of Western Australia: Barrow, Bernier and Dorre (Fig. 1.1). It is reported to be extinct on Dirk Hartog Island (Burbidge and George 1978). It is no longer present on Boodie Island (see Chapter 4).

The hare-wallabies

The banded hare-wallaby now survives only on Bernier and Dorre Islands. It was formerly widespread in the south-west of Western Australia (Fig. 1.5), but no specimens have been collected there since 1906. It was dependent on thick scrub for shelter. Gilbert (in Gould 1863) reported that it was only found "in densely thick scrubs, on flats and on the edges of swamps, where the small brush *Melalueca* grows so thickly, that it is almost impossible for a man to force his way through; its runs being under this, the animal escapes even the quick eye of a native. The only possible means of obtaining it is by having a number of natives to clear the spot, and two or three with dogs and guns to watch for it." Gilbert took "three days of severe toil" to secure a single specimen. At this location it occurred with the tammar (*M. eugeni*).

Peron and Lesueur found it "among the impenetrable low thickets of *Mimosa*" on Dirk Hartogs and neighbouring islands in 1801, but found none on the mainland (Gould 1863).

Shortridge (1909) collected 22 specimens of this species from "thick prickly scrub" in the Pingelly (Woyaline Wells) area of the south-west in 1906. Two of these specimens are held by the Western Australian Museum (Kitchener and Vicker 1981). These are the only mainland specimens of this species held by Australian museums.

It is likely that this species has been adversely affected by the clearance of native vegetation for agriculture in south-western Australia.

The rufous hare-wallaby now survives only on Bernier and Dorre Islands and as a small population in the Tanami Desert (**c.** 20 individuals). It was formerly widespread through a large area of central and Western Australia (Fig. 1.5). It apparently disappeared from the south-western and western margins of its range by early this century (Shortridge 1909, Glauert 1933). Museum records indicate that it remained widespread until the 1930s: specimens were taken on the Canning Stock Route in north-western Australia in 1930 and 1931, and from the Musgrave Ranges in north-western South Australia and the McEwin Hills north-east of Lake Disappointment in the Northern Territory in 1933. Burbidge *et al.*(1988) have presented evidence for its survival in the northern deserts of Western Australia until 20-30 years ago.

The rufous hare-wallaby was known as a woo-rup by the Aborigines of the south-west (Gould 1863), and as the maala in central Australia (Finlayson 1935). The early colonists of the south-west knew it as the whistler (Shortridge 1909); those of the deserts as the spinifex rat. "When running, and particularly when hunted, it utters a singular note, resembling the syllable *ting* rather quickly repeated. It constructs a burrow, open at both ends, with a seat at the side of the entrance, from which it plunges into the burrow the instant it is alarmed. It feeds on the open country adjacent to the thickets, where there is a low thick scrub about two feet high" (Gould 1863).

The spectacled hare-wallaby is the only hare-wallaby to have maintained viable populations on mainland Australia. It is reported to be relatively common in Queensland although it is regarded as rare and scattered in Western Australia (Burbidge and Johnson 1983). Its distribution is essentially tropical (Fig. 1.5). The only mainland records in the Western Australian museum for this species are from the Pilbara (Abydos, Jimblebar, Woodstock and Carlindi) from 1958 to 1960 (Kitchener and Vicker 1981). Aboriginal informants suggest that it still occurs along the southern edge of the Kimberley and in the Pilbara (Burbidge *et al*. 1988).

The euro

The euro is abundant throughout mainland Australia but the sub-species on Barrow Island is of particular theoretical interest. Barrow is the smallest island off the Australian coast on which a population of one of the larger macropods survives. Hence it is likely that its population size may be close to the lower limit required to survive in isolation.

The Barrow Island subspecies is considerably smaller than the mainland form. The largest of 7 males and 2 females collected by Butler (1964) on Barrow Island was 20.0 and 8.3 kg respectively. Mainland animals grow to 46.5 and 25 kg for male and female respectively (Poole 1983).

The bandicoots

The western barred bandicoot is one of four species of long-nosed bandicoots of the genus *Perameles* These differ from other bandicoots in having a longer head, ears and limbs, a delicate build, and softer fur.

It formerly occurred in semi-arid areas from Port Hedland in north-western Western Australia to the Liverpool Plains in New South Wales (Fig. 1.6). The last record of its occurrence in the pastoral zone is from Ooldea in South Australia in 1922 (Kitchener and Vicker 1981). It was last reported on mainland Western Australia along the Canning Stock Route in the northern Gibson Desert in the 1940s (Kitchener and Vicker 1981). This is well north of the range reported for this species by Burbidge (1983).

Gould (1863) reported that it "inhabits the whole line of coast of the Swan river colony, but, so far as I can learn, is not found to the westward of the Darling range of hills", suggesting that it may never have been common away from the coast. Shortridge (1909) collected two specimens from Pingelly (Woyaline Wells) and Kojonup (Darton) in the south-west. He regarded them as being "not plentiful", although reported by Aboriginal informants to be fairly numerous in the Salt River district between Kellerberrin and Brookton. Glauert (1933) considered the mainland form to be extinct.

The golden bandicoot is one of three species collectively known as the short-nosed bandicoots. One (*I. obesulus*) has a predominately southern distribution (south-western and south-eastern Australia, and Tasmania), one (*I. macrourus*) a tropical and east coast distribution (Kimberley to Sydney), and the third (*I. auratus*) has a distribution which formerly took in the Kimberley, the Top End and the northern arid zone (Fig. 1.6).

The short-nosed bandicoots are characterised by their short heads, robust build and harsh, almost spiny hair. *Isoodon auratus* is the smallest of the three species with a body weight to 670 g reported from the Kimberley, compared to weights of 850 g for *I. obesulus* and 2,100 g for *I. macrourus* (Braithwaite 1983, Gordon 1983, McKenzie 1983). They spend the day in nests concealed within dense vegetation, made of flattened heaps of sticks and debris with no obvious entrance. They are known to dig burrows in sandy soil during hot weather.

I. auratus is nocturnal and forages for termites, ants, centipedes, moths, insect larvae, small reptiles, roots and tubers (McKenzie 1983). It digs small conical pits in search of food.

I. macrourus and *I. obesulus* are common to abundant over most of their ranges. In contrast, *I. auratus* has suffered a major range contraction. It now has only sparse, scattered populations in the Kimberley in addition to the Barrow, Middle, and Augusta Island populations. It was formerly widely distributed in central Australia (Fig 1.6) until the 1930s, occurring as far south as the Rawlinson Ranges. The most recent museum record for central Australia is from the Granites in the Northern Territory in 1952.

The surveys reported herein provide the first systematic information on the abundance and distribution of the suite of rare species present on Barrow, Boodie, Bernier, and Dorre Islands. The surveys of these four islands sample the total known populations of the burrowing bettong, the banded hare-wallaby, and the western barred bandicoot, and two of only three discrete populations of the rufous hare-wallaby. In addition, we provide much valuable information on the distribution of species within each island. Hence this study provides an invaluable base-line data set for the on-going management of the mammal populations of these islands.

Conservation status

The loss of many of these species from the mainland and from several off-shore island refugia in the last 90 years illustrates their vulnerability. The burrowing bettong and banded hare-wallaby are now absent on Dirk Hartog Island (Burbidge and George 1978), probably due to predation from introduced cats. Similarly, the golden bandicoot and the spectacled hare-wallaby were eliminated from the Monte Bello group by introduced cats: the golden bandicoot prior to 1912; the spectacled hare-wallaby between 1912 and 1950 (Burbidge 1971).

Their effective conservation requires

(i) a knowledge of their status in their remaining refugia;

(ii) an understanding of the likely reasons for their extinction on the mainland and on off-shore islands. This understanding is fundamental to any attempt to translocate species to the mainland or to other islands.

(iii) a knowledge of what active management, if any, is required to maintain them on these island refugia.

(iv) an assessment of whether translocation to other islands or to the mainland is either feasible or desirable. This requires a knowledge of whether removal of animals from the source population is likely to have a deleterious effect, and an assessment of the likely success and cost/benefit of such a management action.

This report primarily addresses (i) above.

Fig. 1.1 The central-western coast of Western Australia showing the location of islands mentioned in the text.

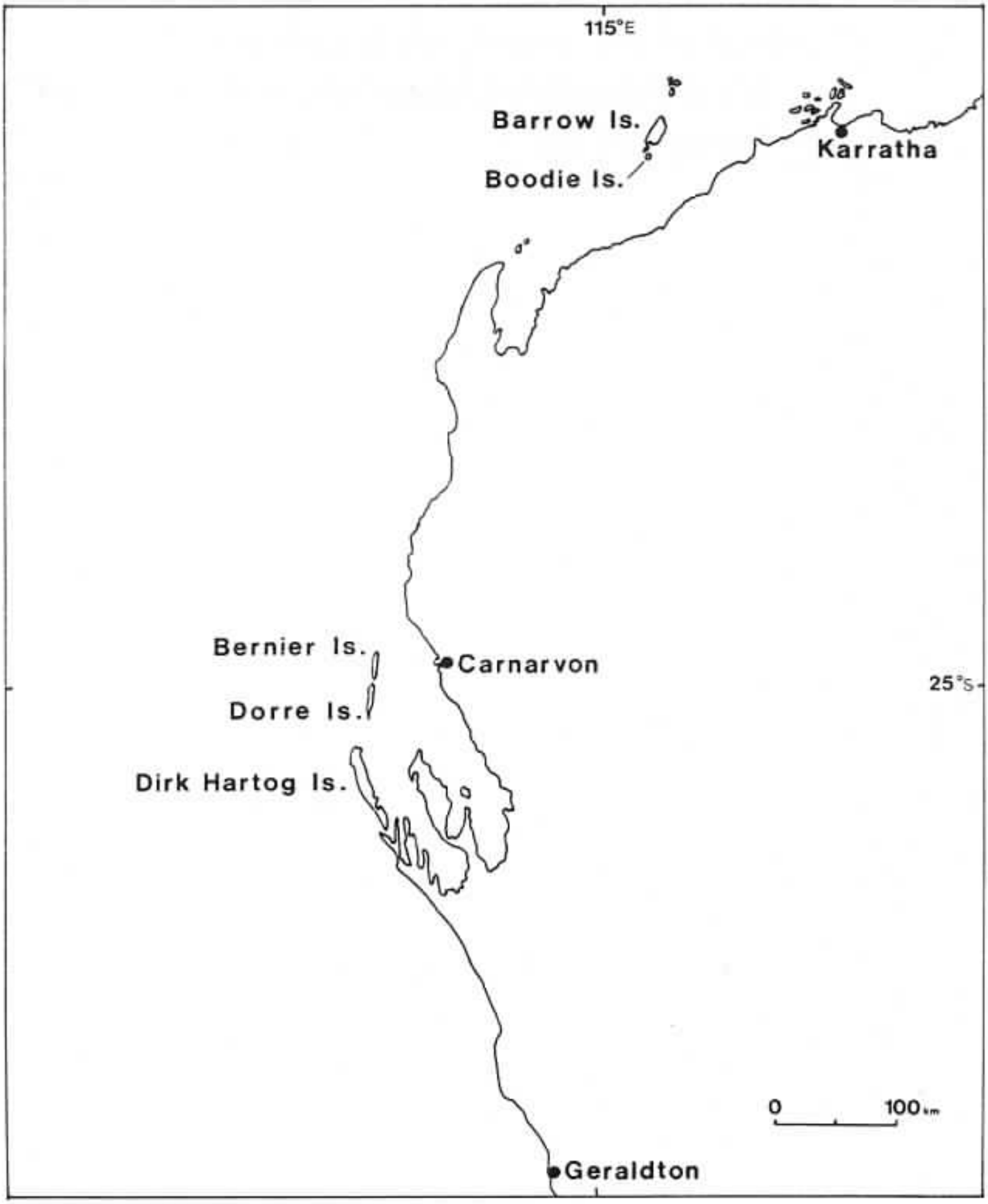

115°E
Barrow Is.
Boodie Is.
Karratha
Bernier Is.
Carnarvon
Dorre Is.
Dirk Hartog Is.
25°S
0
100km
Geraldton

Fig. 1.2 The former (lightly shaded) and present (arrowed and heavily shaded) ranges of a) the burrowing bettong (*Bettongia lesueur*), b) the brushtail bettong (*B penicillata*) and c) the Eastern bettong (*B. gaimardi*).

Source: Finlayson (1958), Strahan (1983),

Burbidge et al (1988).

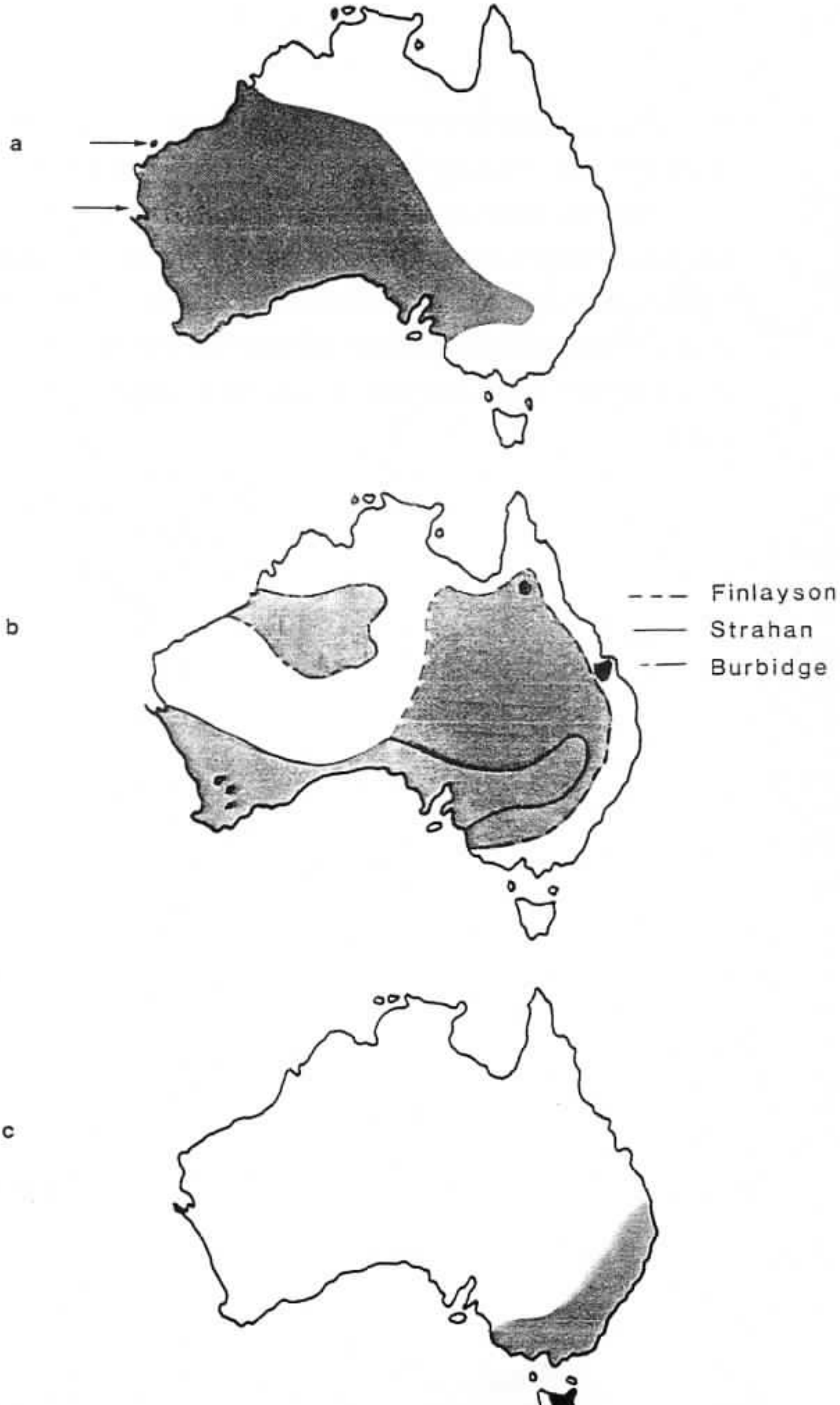
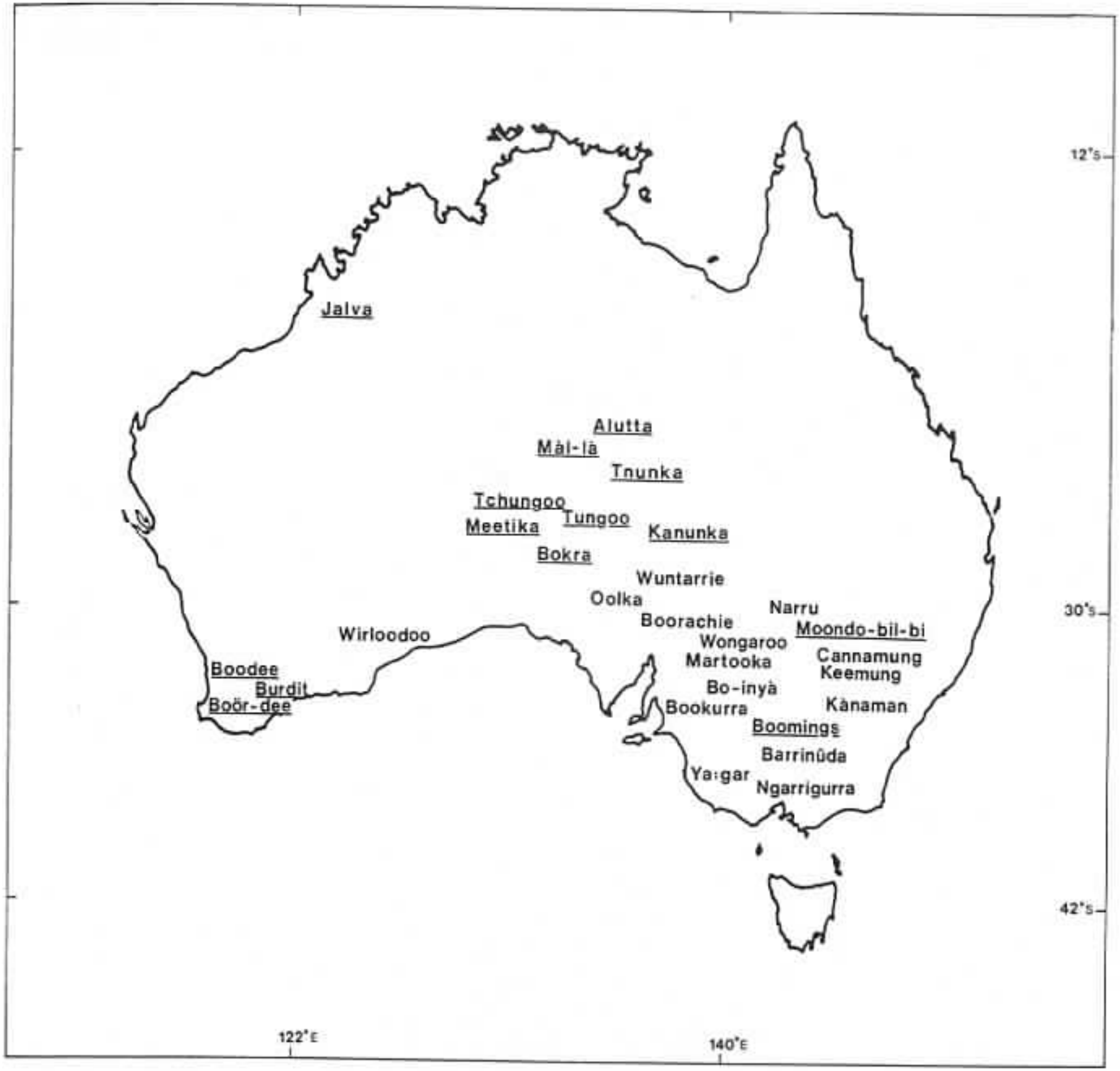

a
b
Finlayson
Strahan
Burbidge
c

Fig 1.3 The geographic distribution of Aboriginal names for the burrowing bettong (underlined) and rat-kangaroos in general. Only names within the former range of the burrowng bettong are given. Note that both 'mal-la' and 'bil-bi' were used for this species. These are now in general use as names for the rufous hare-wallaby *Lagorchestes hirsutus* and the bilby *Macrotis lagotis*. Sources: Dahl (1926), Oldfield Thomas (1906), Gould (1863), Scarlett (1969), Harris-Browne (1897), Finlayson (1961), Harper (1945), Wood-Jones (1923), Lydekker (1894), and Curr (1886).



12°S
30°S
42°S
122°E
140°E
Jalva
Alutta
Màl-là
Tnunka
Tchungoo
Tungoo
Meetika
Kanunka
Bokra
Wuntarrie
Oolka
Narru
Boorachie
Moondo-bil-bi
Wirloodoo
Wongaroo
Martooka
Cannamung
Keemung
Boodee
Burdit
Boör-dee
Bo-inyà
Bookurra
Kànaman
Boomings
Barrinûda
Ya:gar
Ngarrigurra

Fig. 1.4 Museum and historical records for *Bettongia lesueur*. Dates shown are the most recent for that area.

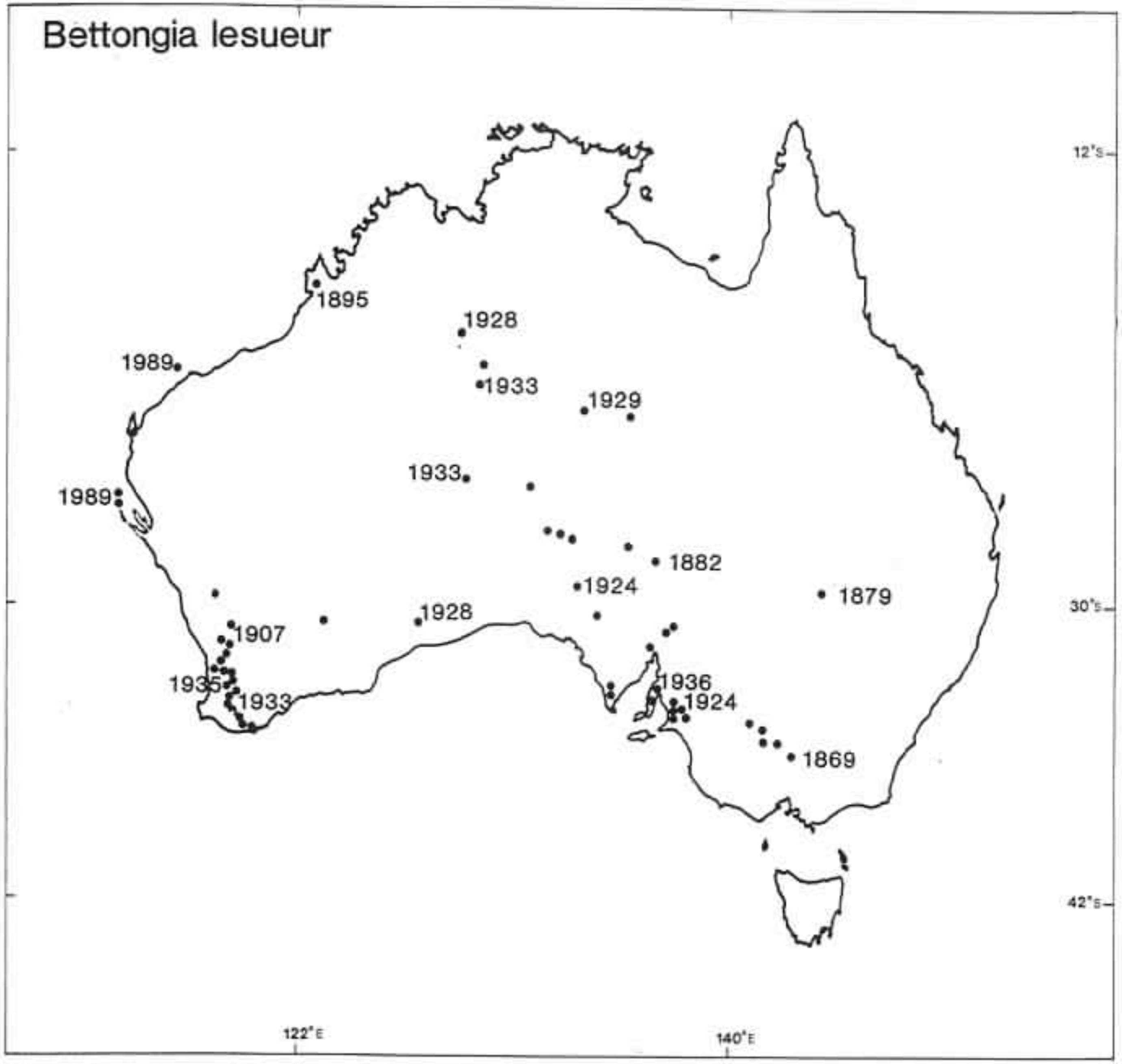

Bettongia lesueur
1895
1928
1989
1933
1929
1933
1989
1882
1924
1879
1928
1907
1935
1933
1936
1924
1869
12°S
30°S
42°S
122°E
140°E

Fig 1.5 The former (lightly shaded) and present distributions (heavily shaded or arrowed) of

a) banded hare-wallaby (*Lagostrophus fasciatus*)

b) rufous hare-wallaby (*Lagorchestes hirsutus*)

c) spectacled hare-wallaby (*Lagorchestes conspicillatus*)

Source: Strahan (1983)

a

b

c

Fig 1.6 The former (lightly shaded) and present distributions (heavily shaded or arrowed) of:

a) the golden bandicoot (*Isoodon auratus*)

b) the western barred bandicoot (*Perameles bougainville*)

Source: Strahan (1983)

a

b

CHAPTER 2

BARROW, DORRE AND BERNIER ISLANDS - THEIR ENVIRONMENT AND VEGETATION

(1) Barrow Island

Barrow Island lies off the north-west coast of Western Australia at latitude 20°S. It is 1300 km north of Perth and approximately 60 km off the coast. It is a limestone island of approximately 233 km^2. It experiences a monsoonal northern climate (Gentilli 1972) moderated by its oceanic position. Mean annual rainfall is approximately 200 mm, with most falling in February-March and May-June.

Barrow is separated from the mainland by shallow seas to a depth of 12 m (Buckley 1983). This suggests that it may have been last joined to the mainland between 7,500 and 8,000 years B.P. (Thom and Chappell 1978).

The island is both an A class fauna and flora reserve and a producing oilfield. It was gazetted as a A class reserve in 1910 by the Western Australian government - a status that can only be revoked by an Act of Parliament.

Early exploration of Barrow Island by WAPET geologists in the 1950s suggested that it was an anticline that might hold oil. Drilling in 1964 yielded both oil and gas. Intensive drilling followed. By 1987 over 221 million barrels of oil and 900,000 barrels of LPG and natural gas had been produced. The oil lease covers the entire island but the major oilfield infrastructure occupies about 100 km^2 of the 233 km^2 of the island. In 1987 there were approximately 700 wells, 10 separator stations, 1000 km of pipeline, several hundred kilometers of road and an infrastructure of workshops, warehouses, tankfarms, administrative buildings, and accommodation.

Measures taken to protect the wildlife of Barrow Island include a total ban on introduced plants and animals, domestic animals, and firearms, and immediate restoration of areas when use is finalised (Butler 1987). Oil loading facilities constructed well off-shore prevent rodents from colonising the island from tankers. In addition an annual research grant is provided to support studies of the environment.

Habitats

Butler (1970) recognised the following habitats on Barrow Island:

(i) fore-dunes of aeolian white sand,

(ii) red sand dunes, inland of the fore-dunes,

(iii) limestone ridges, the zone of greatest areal extent on Barrow,

(iv) clay pans, localised run-on areas covered with grasses other than *Triodia* or *Spinifex*.

(v) creek-beds, and

(vi) mangrove thickets.

This classification was refined by Buckley (1983). He divided Barrow into 9 major habitat types:

(i) limestone uplands dominated by *Triodia wiseana*;

(ii) intermittent watercourses dominated by *T. angusta*;

(iii) areas where *T. pungens*, *T. wiseana* and *T. angusta* form a mosaic;

(iv) coastal sand assemblages which include strandline, white aeolian foredunes, and inland red dunes;

(v) coastal rock assemblages, largely exposed cliffs or headlands sometimes covered with blown sand. These areas often have a flora of *T. wiseana*, *Sarcostemma australe* or *Frankenia pauciflora*.

(vi) mangroves;

(vii) floodout flats with diverse assemblages of grass and forbs;

(viii) saltflats - limited areas near mouths of intermittent watercourses having a vegetation of halophytes and succulents (e.g. *Halosarcia* spp., *Sclerolaena*, *Neobassia*, *Threlkeldia*, and *Frankenia*);

(ix) disturbed areas such as borrow pits, well sites and road verges. These have a characteristic suite of native species: *Diplopeltis eriocarpa*, *Trichodesma zeylanicum*, *Cymbopogon* spp., *Heliotropium undulatum*, *Adriana tomentosa*, *Tephrosia rosea*, *Cassia notabilis*, *Pterigeron bubakii*, and *Petalostylis labicheoides*.

These are mapped in Figure 2.1. It can be seen from this figure that about 70% of Barrow Island is limestone upland with a vegetation of *Triodia wiseana*. Oilfield infrastructure is mapped in Figure 2.2. Most development (wells, roads, etc.) are in the southern half of the limestone upland. Habitat and level of oil-field development form the basis of the stratification of sampling described in the next chapter.

(2) Boodie Island

Boodie is a small island of c. 4.7 km^2 off the southern tip of Barrow Island. It was named after the discovery of burrowing bettongs there in 1973. It is listed as one of the four islands of mainland Australia to have remnant colonies of this species (Burbidge 1983). It is uninhabited with no current human use or visitation. Several oil wells have been drilled on the island but are not currently in use.

The vegetation map (Fig. 2.3) is modified from one produced by R. Buckley for West Australian Petroleum Pty Ltd. It was drawn from 1:15,000 vertical colour air photographs (August 1980) supplemented by ground-truthing.

The major landform and vegetation types on Boodie Island are:

(i) dunes of aeolian white sand sparsely covered with *Spinifex longifolius* and *Ipomea pes-caprae*. This habitat makes up about 80% of the island.

(ii) an area of red sand with *Acacia coriacea*.

(iii) an area of limestone rock with shallow soils with *Triodia angusta*, *Ficus platypoda* and *Sarcostemma australe*.

(3) Bernier and Dorre Islands

Bernier and Dorre Islands are uninhabited islands in Shark Bay 50 and 60 km west and south-west of Carnarvon respectively. Dorre, the southernmost island is 26 km north of Dirk Hartog Island. They are Class A nature reserves set aside primarily for the preservation of their mammalian fauna. Bernier is 25 km long, up to 2.5 km wide, and has an area of 31 km^2. Dorre is 30 km long, up to 3.6 km wide, and has an area of 52 km^2.

Both are elongated masses of Pleistocene Coastal Limestone. They are underlain with red, quartzose sandstone. Their recent geological history has been described by Ride *et al*. (1962):

"The bathymetry of the present Shark Bay clearly shows that Bernier and Dorre would have been connected with Dirk Hartog, the Peron Peninsula, and the mainland when the sea level was 10 fathoms below present. This would place the date of separation at approximately 8,000 years before Present (Churchill 1959).

The channel between Bernier and Dorre is clearly no more than a breach in a formerly continuous dune, and it has about two fathoms of water in it. The islands may have been isolated from each other at the time when sea level was two fathoms below that at present and before the period of the ten foot eustatic high level. If this is so they may have been separate for as long as 6,000 years (dates of changes in sea level from Churchill 1960).

However, the opening of the channel may be considerably more recent since the breach may have been made at a time when sea level was higher that it is at present and, during the subsequent fall, successively planated down by wave action to its present depth of about two fathoms which Logan says is wave base. Separation could thus have taken place between 5,000 and 3,000 years ago."

Both islands are flat plateaux girdled by cliffs on all sides. Bernier has many large unconsolidated dunes in the southern third of the island, crossing the island in an almost north-south direction. There is a narrow margin of travertine which extends the length of the western cliffs. Inland from this are a series of north-south trending consolidated dunes. The centre of the island is a plain with a vegetation of heath. Low dunes of limited extent fringe the eastern cliffs. Dorre has a series of dunes which run down the western margin of the island north of White Beach, and down the centre of the island to the south. Poorly consolidated dunes occur at White Beach and at Disaster Cove. Dorre has a similar inland plain to Bernier but the vegetation of the plain is dominated by *Triodia* hummock grassland.

The western Shark Bay area has a dry warm mediterranean climate (Beard 1976). There is a strong rainfall gradient across Shark Bay with Dirk Hartog Island receiving an annual average rainfall of 313 mm and Denham receiving 235 mm. Annual evaporation between 2,000 and 2,200 mm (Butcher et al. 1984). Approximately 80% of rain falls from May to August.

Landform and Vegetation

The landforms and vegetation of Bernier and Dorre Islands were described (but not mapped) by Royce in Ride *et al*. (1962). He divided the island into four categories based on landform: travertine crust, sandhills, open steppe, and tall scrub. We have attempted to map broad landform and vegetation types on Bernier Island from colour photographs (1:20,000) and on Dorre Island from black and white aerial photographs (1:40,000). Both were taken in 1977. Our mapping was aided by walking 28 east-west transects across Bernier in July/August 1989 and 24 across Dorre in October 1988 (Fig. 2.4). The four northernmost lines on Dorre (at 1.5 - 3 km south of northern tip) were not surveyed for vegetation. Detailed notes on the vegetation of each transect are avaailable from the authors (Dorre: Cale and Short; Bernier: Majors and Short).

Bernier and Dorre Islands can be broadly divided into 4 major landforms: sandplain, consolidated dunes, unconsolidated dunes, and travertine (Table 2.1 and 2.2 and Figs 2.5 and 2.6). Sandplain is the major landform by area on both islands but the vegetation on it varies greatly between islands. On Dorre Island the sandplain north of White Beach has a dense low cover of *Triodia plurinervata* with emergent shrubs of *Alyogyne cuneifomis* near White Beach, *Melaleuca cardiophylla* near Castle Point and extensive clumps of *Eucalyptus dongarensis* in the north near Quoin Bluff. To the south of White Beach the sandplain is covered with a low heath of *Scaevola crassifolia* and *Thryptomene micrantha*. On Bernier the sandplain has a sparse ankle-high cover of *T. micrantha* and *Phebalium* sp. in the south. It becomes taller in the north of the island with an overstorey to 1 m of *Abutilon exonemum* and *Scaevola crassifolia*. *Triodia* occurs throughout the sandplain but either as a co-dominant with, for example, *T. micrantha* or in localised monospecific patches.

A series of roughly parallel dunes run down the west coast of Dorre Island between the sandplain to the east and a narrow strip of travertine along the cliff top to the west. To the south of White Beach the dunes occupy the centre of the island. They have a vegetation of tall scrub to 2 m tall made up of *Heterodendrum oleifolium*, *Acacia coriacea*, *Ficus platypoda*, *Santalum spicatum*, *Pimelea microcephala*, and *Diplolaena dampieri*.

Comparable habitat on Bernier Island is characterised by less cover in some areas, more extensive unvegetated blowouts and a lack of *Ficus platypoda* in their species complement.

Unconsolidated dunes are extensive on Bernier, presumably due to a large population of goats that grazed the island up until 1984. Most of the bare dunes occur to the south of Red Cliff Point. In the south they are being colonised by *Spinifex longifolius*, normally a coastal fringe plant. Elsewhere *Pileanthus limacis* is the major coloniser.

Poorly consolidated dunes of beach sand occur at White Beach and Disaster Cove on Dorre Island, and on the east coast of Bernier, particularly from just south of Boulder Point north to Hospital Landing. They are dominated by *P. limacis*, often with *Olearia axillaris*, *Beaufortia dampieri*, *T. micrantha*, *Atriplex paludosa*, and *Carpobrotus equilaterus*.

The travertine is a narrow strip of rock with a cover of skeletal soil on the cliff margin on the western side of the islands. Occasionally it occurs as large outcrops on the east coast such as at Quoin Bluff on Dorre Island. It has a vegetation of low very-open heath dominated by *T. micrantha*, *Frankenia pauciflora*, *C. equilaterus* and, in some areas *Scaevola crassifolia* and *Westringia rigida*. Often a dense scrub of *Diplolaena dampieri* occurs on deeper soils between the travertine and the first dune. On Dorre *Ficus platypoda*, *Sarcostemma australe*, *Acacia coriacea*, *H. oleifolium* also occurred in this situation.

Table 2.1 Landforms and vegetation of Dorre Island.

Landform	Vegetation type and structure	Species composition	Distribution on island
Sandplain	1. *Triodia* hummock grassland (< 0.5 m high)	*Triodia plurinervata*, *Thryptomene micrantha* with low scattered *Acacia bivenosa*; *Alyogyne cuneiformis* is common emergent in south, *Melaleuca cardiophylla* in centre, & *Eucalyptus dongarensis*, *Exocarpus aphylla*, & *Hibiscus* sp. in north.	Major habitat by area on island; occurs from White Beach to north.
	2. heath (< 0.5 m high)	*Scaevola crassifolia*, *T. micrantha*, *Frankenia pauciflora*, *Olearia axillaris* with scattered emergents of *Eremophila leucophylla*, *Atriplex paludosa*, and *Pimelea microcephala*.	Occurs to south of White Beach.
Consolidated dunes	3. tall scrub (< 2 m high)	*Acacia coriacea*, *A.* sp., *Heterodendrum oleifolium*, *Ficus platypoda*, *Santalum spicatum*, *Pimelea microcephala*, *Diplolaena dampieri*.	Extensive along western side of island north of White Beach, crosses island south of White Beach in a north-south direction, denser and taller in swales.
Unconsolidated or poorly consolidated dunes	4. coastal dunes crest vegetation < 0.5 m, swale vegetation < 1.5 m	*T. micrantha*, *Pileanthus limacis*, *O. axillaris* *A. paludosa*, *Carpobrotus rosii*, foredunes with *Spinifex longifolius*, *Acanthocarpus preissi* and *Rhagodia obovata*.	Limited areas at White Beach and at Disaster Cove where cliffs are absent from coast and dunes extend inland from beach.
Travertine	5. low very open heath (< 0.5 m high)	*T. micrantha*, *Frankenia pauciflora*, *C. rosii*, with *Scaevola globulifera*, *S. crassifolia* & *Westringia rigida*	Narrow fringe generally < 100 m wide along cliff top of west coast, also on Quoin Bluff on east coast.
	6. tall scrub (1-3 m high)	*A. coriacea*, *H. oleifolium*, *S. spicatum*, with occasional *F. platypoda*, *Sarcostemma australe*, and *D. dampiera*	Screens on perimeter of travertine or in isolated deeper soil pockets on travertine.

Table 2.2 Landforms and vegetation of Bernier Island.

Landform	Vegetation type and structure	Species composition	Distribution on island
Sandplain	1. *Triodia* hummock grassland (< 0.5 m high)	*Triodia plurinervata* with scattered emergents of *Pimelea microcephala*, *Rhagodia obovata*, and *Atriplex paludosa*	Very limited in extent compared to Dorre; also occurs in dune swales near Red Cliff Point.
	2. heath 2a. open heath	*Thryptomene micrantha*, *Phebalium* sp. often appearing dead but with green tips to stem; large but localised patches of the grass *Eulalia fulva*.	Abundant south of Boulder Point
	2b. open tall heath	Dominated either by *Scaevola crassifolia* or by *Abutilon exoneum*.	Common in complex mosaic of species associations on inland plain north of Boulder Point.
Consolidated dunes	3. tall scrub	*Diplolaena dampiera*, *Acacia coriacea* with *P. microcephala*, *R. obovata*, *Alyogyne cuneiformis* and understorey of *Acanthocarpus preissi*, *Stylobasium spathulatum*, *Myoporum acuminatum*, *Solanum orbiculatum*, *Ptilotus villosiflorus*, *A. paludosa*, and *Threlkeldia diffusa*.	No *Ficus platypoda* present in contrast to Dorre Island.
Unconsolidated or poorly consolidated dunes	4a. coastal dunes	*T. micrantha*, *Pileanthus limacis*	
	4b. bare dunes (< 10% cover)	Either (i) *P. limacis*, *Olearia axillaris*, and *Beaufortia dampieri*. (ii) *Spinifex longifolius* colonising recently bare dunes.	Extensive particularly in eroded areas at Hospital Landing. Extensive to south of Red Cliff Point, probably due to goat browsing.
Travertine	5. low very-open heath	*Frankenia pauciflora*, *Carpobrotus rosii*, *Westringia rigida*, *Scaevola crassifolia*	Strip often < 100 m wide along top of cliff on west coast.
	6. scrub (often dense)	*D. dampiera*	On deeper soils between travertine and inland dunes.

Fig. 2.1 The vegetation of Barrow Island.

Source: Buckley (1983).

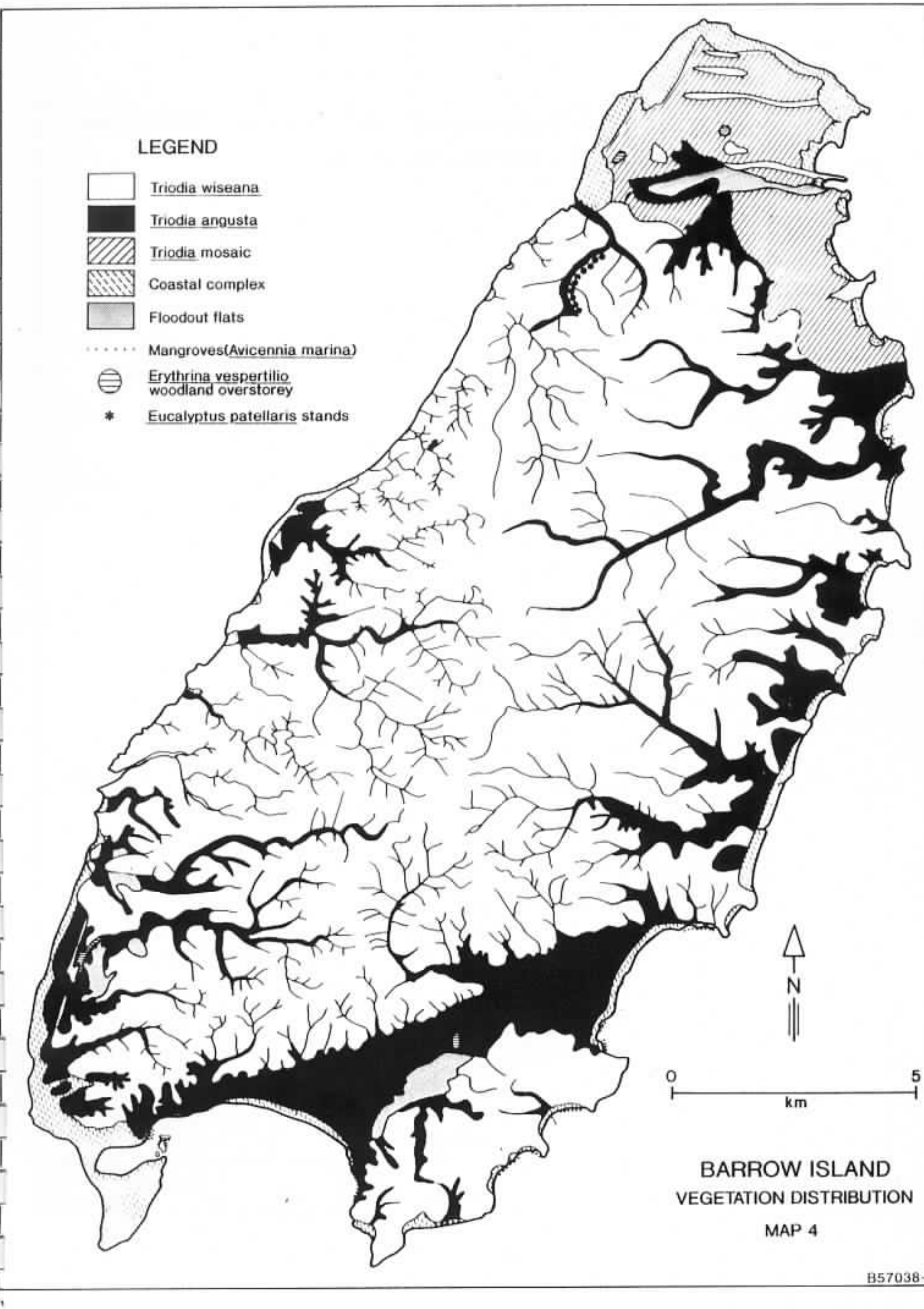

LEGEND
Triodia wiseana
Triodia angusta
Triodia mosaic
Coastal complex
Floodout flats
Mangroves(Avicennia marina)
Erythrina vespertilio woodland overstorey
Eucalyptus patellaris stands
N
0
5
km
BARROW ISLAND
VEGETATION DISTRIBUTION
MAP 4
B57038

Fig. 2.2 Barrow Island showing roads, wells and infrastructure of the oilfield.

Source: West Australian Petroleum Pty Ltd.

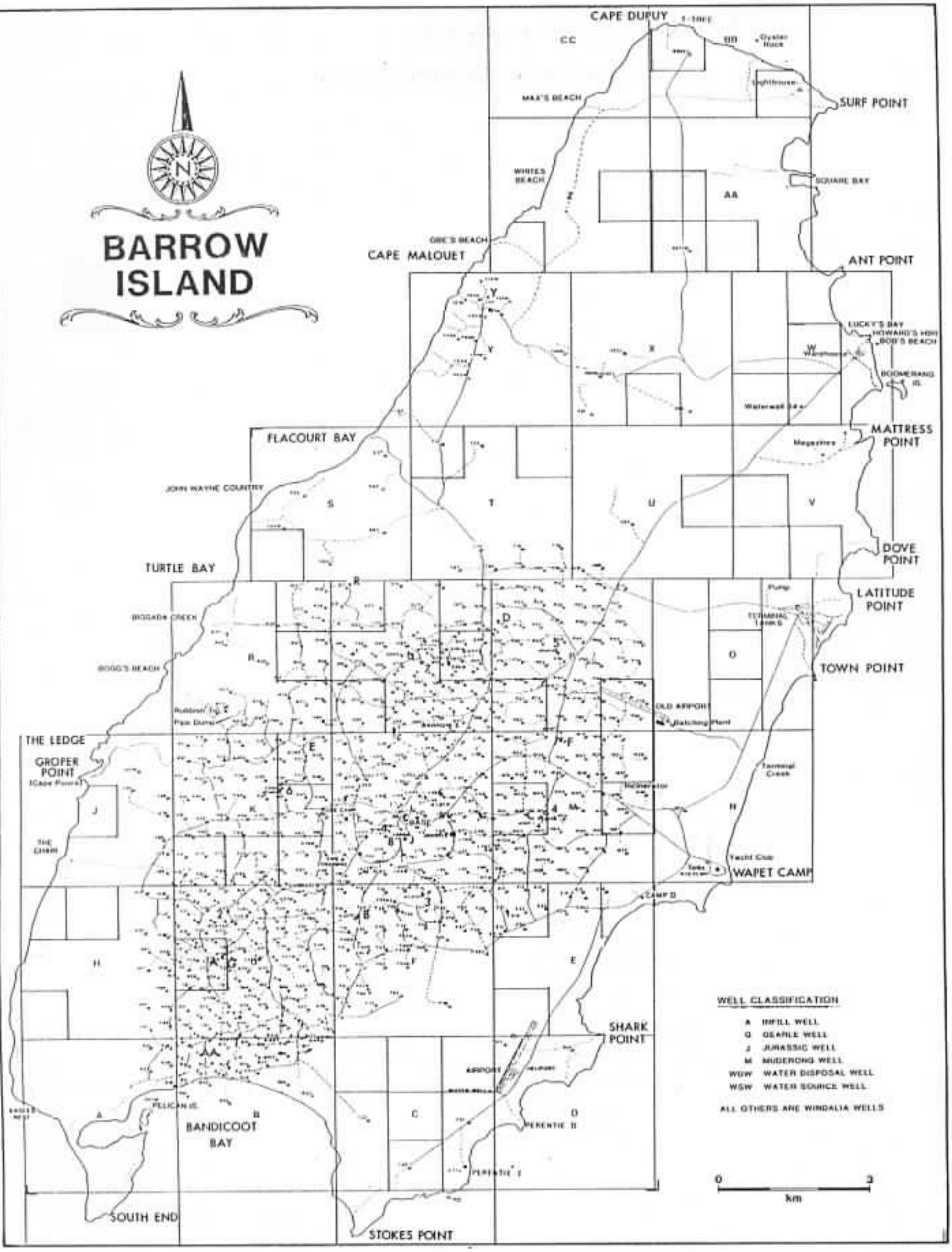

BARROW ISLAND
N
CAPE DUPUY
CC
BB
MAX'S BEACH
SURF POINT
WHITES BEACH
SQUARE BAY
AA
CAPE MALOUET
ANT POINT
Y
X
W
LUCKY'S BAY
BOB'S BEACH
BOOMERANG IS.
FLACOURT BAY
MATTRESS POINT
JOHN WAYNE COUNTRY
S
T
U
V
DOVE POINT
TURTLE BAY
R
LATITUDE POINT
BIGGADA CREEK
D
O
TOWN POINT
BOGG'S BEACH
OLD AIRPORT
THE LEDGE
GROPER POINT
J
K
N
WAPET CAMP
H
E
SHARK POINT
AIRPORT
A
PELICAN IS.
B
BANDICOOT BAY
C
D
PERENTIE II
PERENTIE I
SOUTH END
STOKES POINT
WELL CLASSIFICATION
A INFILL WELL
G GEARLE WELL
J JURASSIC WELL
M MUDERONG WELL
WDW WATER DISPOSAL WELL
WSW WATER SOURCE WELL
ALL OTHERS ARE WINDALIA WELLS
0
3
km

Fig. 2.3 The vegetation of Boodie Island.

Source: West Australian Petroleum Pty Ltd.

BOODIE ISLAND

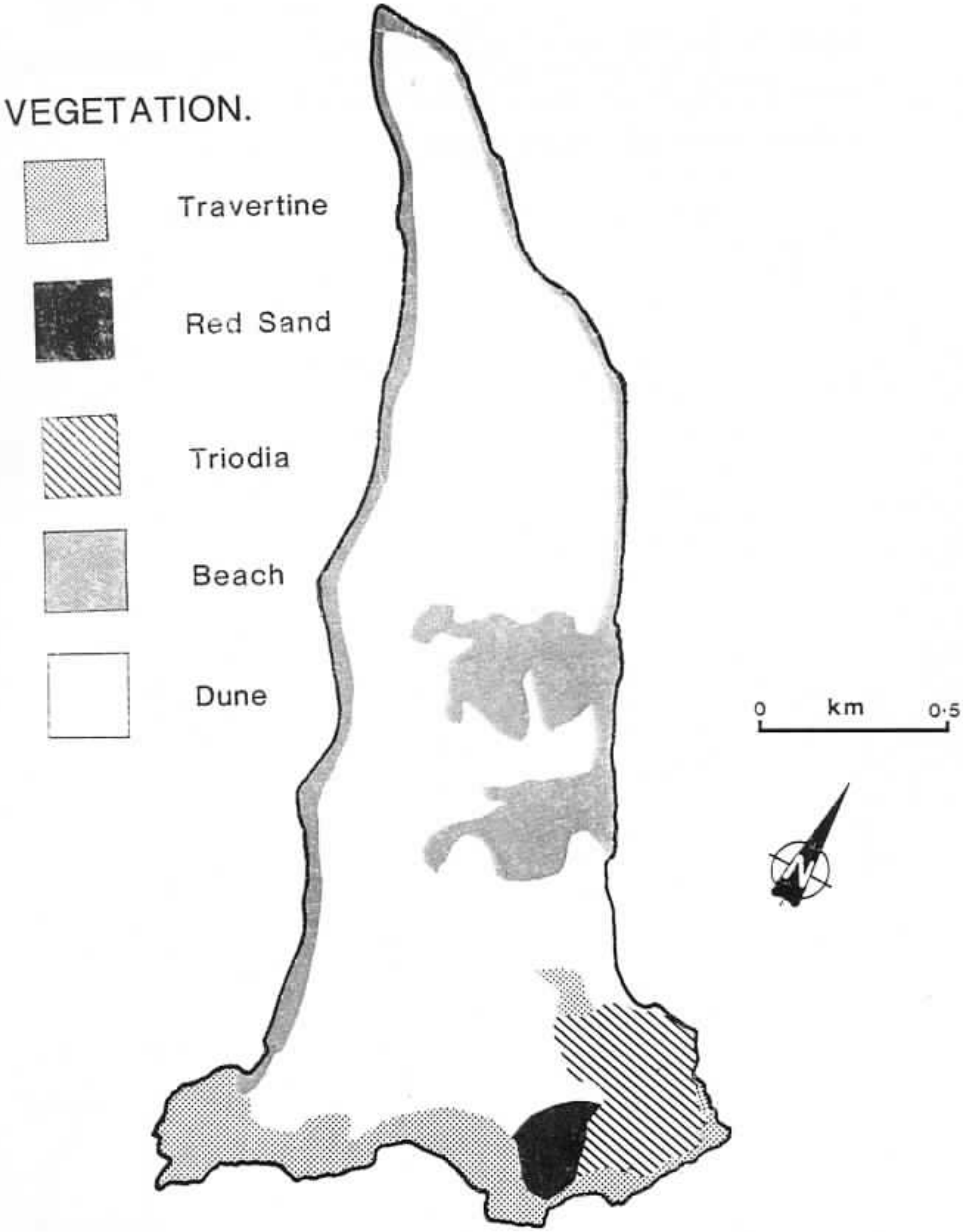


Fig. 2.4 Dorre and Bernier Islands showing transects used for vegetation notes and spotlighting surveys. The blocks of four transects were located randomly. Transects within blocks are 0.5 km apart.

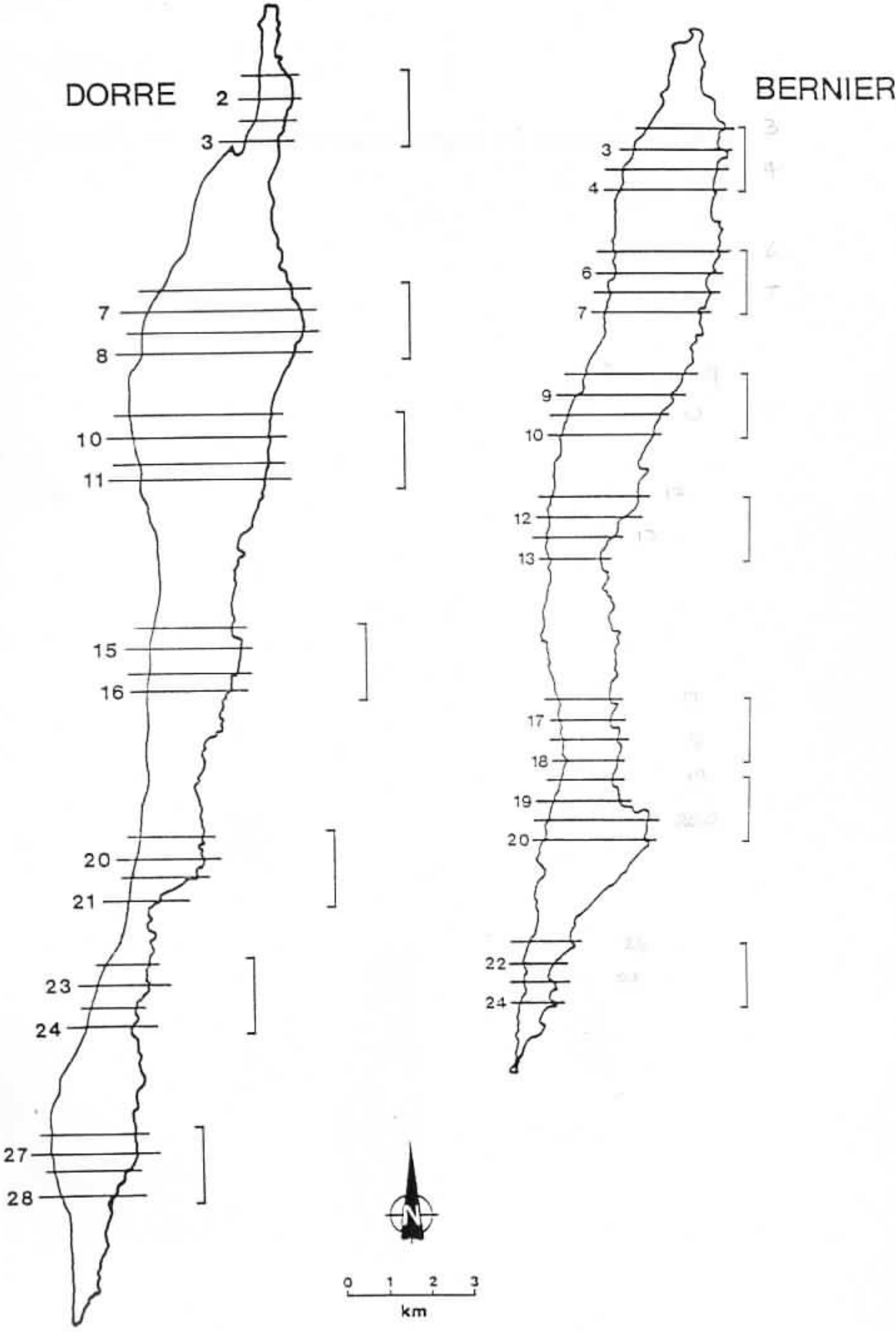

DORRE
2
3
7
8
10
11
15
16
20
21
23
24
27
28
BERNIER
3
4
6
7
9
10
12
13
17
18
19
20
22
24
N
0 1 2 3
km

Fig. 2.5 The landforms and vegetation of Dorre Island.

DORRE ISLAND

Landform and Vegetation

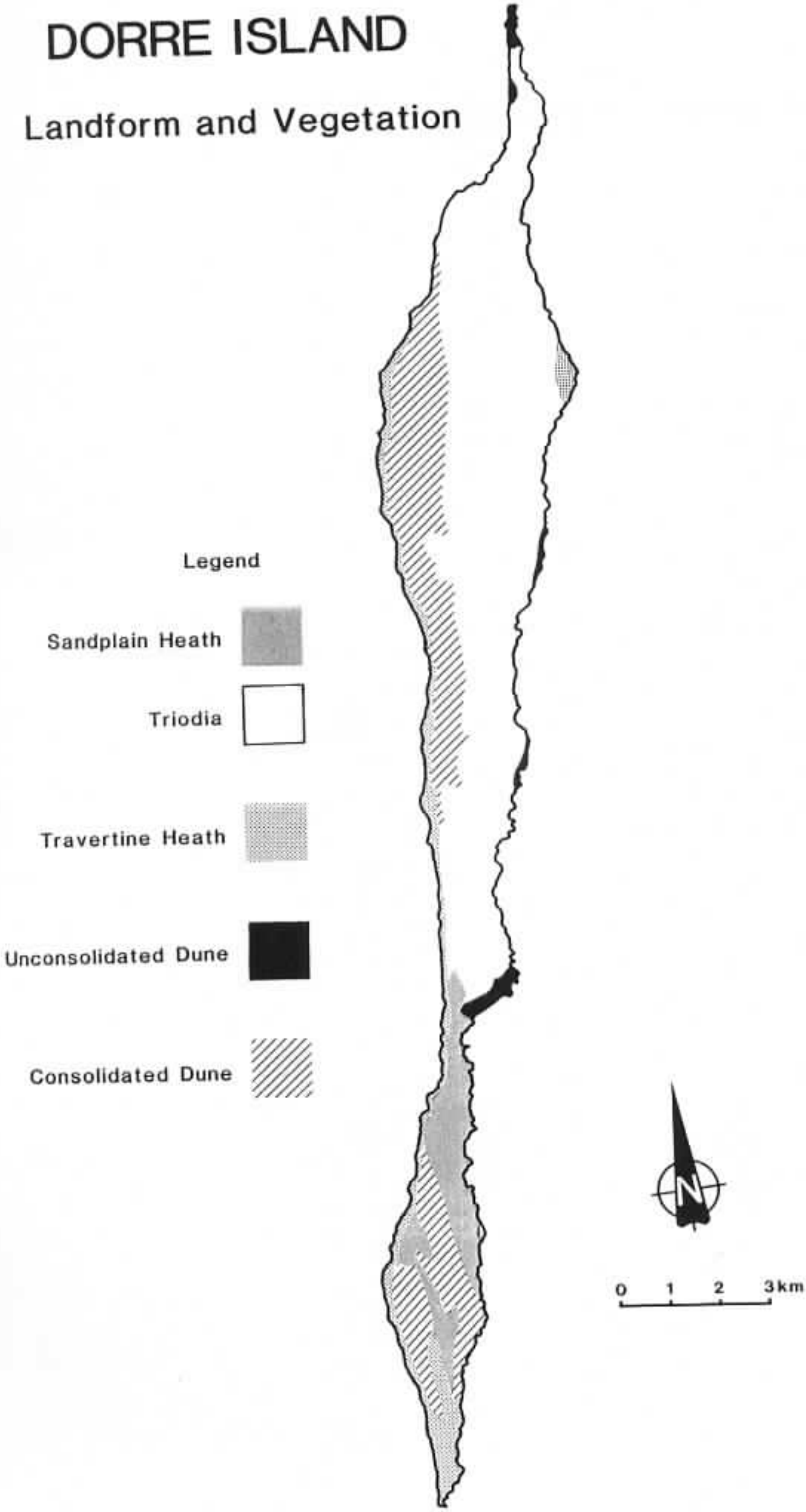
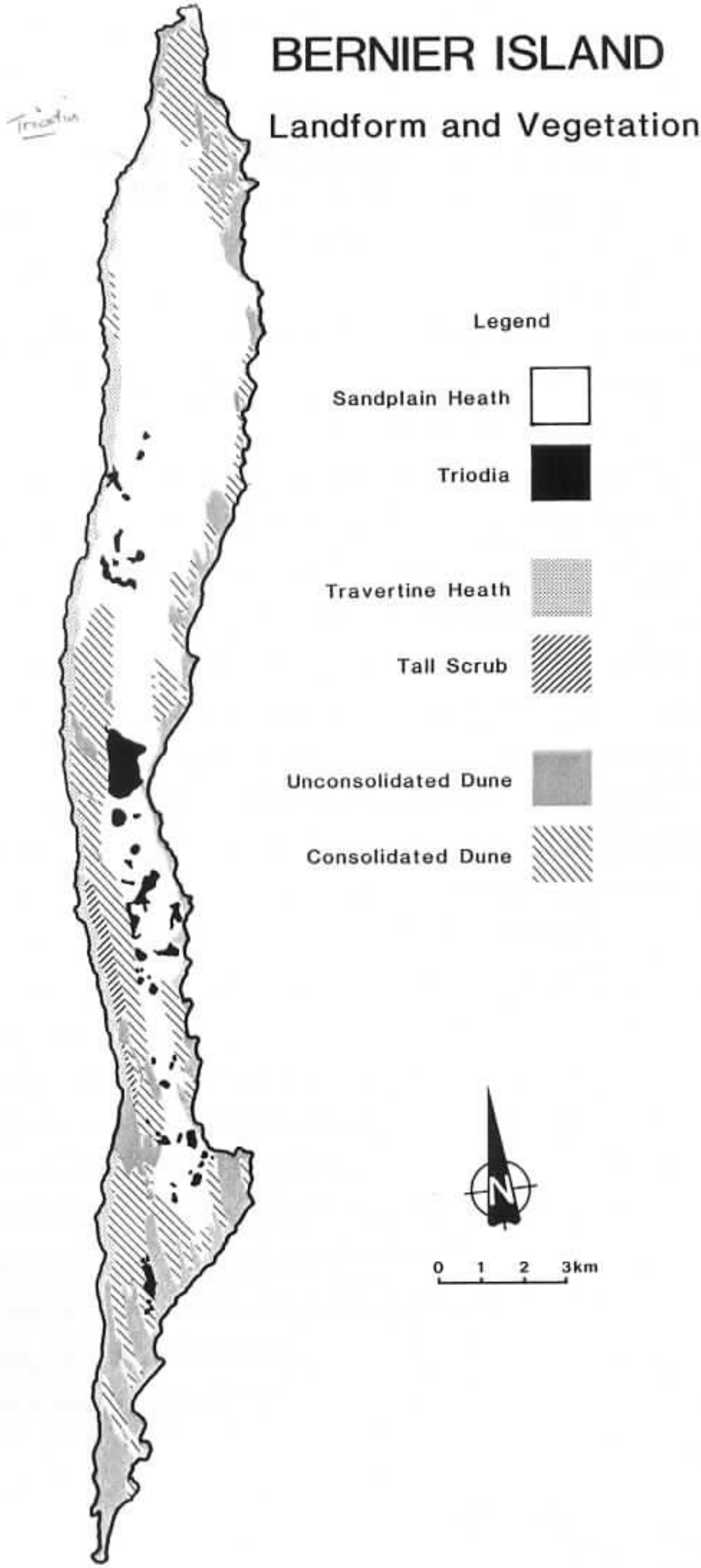


Fig. 2.6 The landforms and vegetation of Bernier Island.

BERNIER ISLAND

Landform and Vegetation



CHAPTER 3

DISTRIBUTION AND ABUNDANCE OF RARE FAUNA

Methods

(i) Barrow Island

The distribution and abundance of bettongs, hare-wallabies, euros and bandicoots were assessed by spotlight surveys along line transects placed by restricted random sample. Fifty 1 km^2 blocks were chosen randomly within three major habitat strata (*Triodia wiseana* disturbed, *T. wiseana* undisturbed, other habitats) on Barrow Island (see Figs. 2.1 and 2.2 for vegetation and oilfield infrastructure on Barrow). The number of blocks assigned to each strata was proportional to the area of each strata (20:20:10). Blocks were spotlighted in August 1988 at new moon. Two north-south transects, each 1 km in length, were spotlighted in each block to give a total of 98 km of transect. The beginning, middle, and end of each transect had been marked prior to spotlighting by survey stakes bearing colour-coded reflectors. The distribution of the 50 blocks on Barrow is given in Figure 3.1. An additional 46 km of spotlighting was done while moving between lines. Data collected during this 46 km were used in the construction of sightability curves for each species but not used in the calculation of density.

The spotlight data for bettongs, hare-wallabies, euros, and bandicoots were analysed using the programme LINETRAN. Estimates have been derived using the Fourier series.

In addition to the spotlighting, the abundance of bettongs were assessed by trapping on 24 grids of 12 traps each for 4 nights. These grids were located at the midpoint of 24 of the 50 blocks of 1 km^2 used for spotlighting (Fig 3.2). The methodology of this trapping programme is described in greater detail in Short and Turner (1989b).

(ii) Boodie Island

We carried out spotlight counts on 6 east-west lines across Boodie Island at 0.5 km intervals over four nights (30/3/89 - 2/4/89) at new moon. We put in 96 trap nights (2 grids of 12 cage traps for 4 nights). The location of spotlight lines and trapping grids are shown in Fig. 3.3.

(iii) Bernier and Dorre Islands

The distribution and relative abundance of bettongs, hare-wallabies, and bandicoots on Bernier and Dorre Islands were assessed in the same way as on Barrow Island (i.e. spotlight survey along line transects). Seven groups of 4 lines were spotlighted on each island (46 km on Bernier, 51 km on Dorre) at new moon. The position of each group of lines was determined randomly, with lines within groups being 0.5 km apart. All lines ran E-W across the grain of the island (Fig. 2.4). The position of each line was marked by reflective tape placed in daylight prior to the spotlight survey.

The results from both islands were combined for the LINETRAN analysis because of small sample sizes. The results for each island were then derived from the combined total using the relative areas of each island and the number of animals recorded per kilometre of survey on each island.

In addition eight grids of twelve traps (48 trap nights per grid) sampled bettongs in four different habitats on each island (2 grids per habitat). Grids were in the vicinity of White Beach on Dorre Island (Fig. 3.4) and Red Cliff Point on Bernier Island (Fig. 3.5).

Results

Spotlighting

Sightability histograms for bettongs, hare-wallabies, bandicoots and euros are given in Figs. 3.6 - 3.9. Average sighting distances to spotlighted animals varied from 8 m for bandicoots on Bernier and Dorre Islands to 45 m for euros on Barrow Island (Table 3.1) The number of animals sighted per kilometre of spotlight survey varied from 0 for bettongs on Boodie Island to 1.84 for hare-wallabies on Barrow. Estimates of density and population size for each species are given in Table 3.1. Population estimates vary from a low of 0 for bettongs on Boodie Island to a maximum of c. 10,000 for spectacled hare-wallabies on Barrow Island. Table 3.2 shows the approximate numbers of each species on Bernier and Dorre Islands.

Results for bandicoots, particularly for golden bandicoots must be regarded as considerable underestimates. Bandicoots evaded being sighted by hiding under the nearest Triodia clump. They frequently failed to flush even when we walked within 1 m of them. This behaviour violates the basic assumption of line transect methodology - that all animals on the survey line are seen.

Trapping results

Trapping results are detailed in Table 3.3. Bettongs were a minor component of trapped animals on Barrow Island making up only 7.6% of all captures. Golden bandicoots were the most frequent species to be caught (77.1%), followed in decreasing order by possums (14.1%), bettongs and hare-wallabies (1.2%). Trap size almost certainly limited captures of hare-wallabies.

Overall trap success on Barrow Island (including recaptures) was 56% in January and 71% in June. The higher success rate in June may have been due, in part, to the greater number of juvenile bandicoots present at that time. Overall trap success was lower on Bernier and Dorre Islands (27 and 42%) compared to that on Barrow Island. On both Bernier and Dorre Islands bettongs were the most common species sampled by the traps making up 70% of trapped animals.

A comparison of relative densities of bettongs on Barrow Island versus that on Bernier and Dorre Islands using trapping data yeilds a result greatly different to that indicated by spotlighting. If frequency of capture is transformed to estimated density of catches per trap (Caughley 1977: 20)then the comparative results suggest that bettongs are circa five times more abundant on Bernier and Dorre Islands than on Barrow Island. This contrasts with the results of Table 3.1 where the density index (number per km of spotlighting) suggests that densities on Bernier and Dorre Islands are roughly double that on Barrow Island. Absolute estimates of density (number km^{-2}) show an even smaller difference between Bernier and Dorre Islands and Barrow Island (approximately 18%), because the average sighting distances are less on Bernier and Dorre (13m) compared to Barrow (20m).

If home range size of bandicoots is assumed to be approximately that of the trapping grids (c. 5 ha) then the results from trapping suggest minimum population densities of 280 km^{-2} for golden bandicoots on Barrow Island and 50 km^{-2} for western barred bandicoots on Dorre and Bernier Islands (Short and Turner 1989b). These results are considerably greater than that obtained from spotlighting (Fig. 3.1), confirming the suspicion mentioned earlier that the behaviour of bandicoots violated the basic assumption of line transect methodology.

Discussion

Burrowing bettong, banded hare-wallaby, and western barred bandicoot are found only on the islands we have surveyed. Hence Tables 3.1 and 3.2 provide an estimate of their total population size. There are approximately 5,000 bettongs on three islands, and 7,000 banded hare-wallabies and 2,000 western barred bandicoots on two islands. The estimated 4,000 rufous hare-wallabies on Bernier and Dorre Islands represent the most numerous and secure populations of this species.

Two species have island populations of under 1000 individuals (Table 3.2): the western barred bandicoot and the bettong on Bernier Island. This is due in part to the small size of the island (31 km^2).

Densities of bandicoots on Barrow Island tended to be considerably higher than on Bernier or Dorre; densities of bettongs somewhat less, and hare-wallabies considerably less if the density of spectacled hare-wallabies on Barrow are compared to the combined densities of rufous and banded hare-wallabies on Bernier and Dorre. However, island populations were much larger for all speces on Barrow because of it's greater area. The spectacled hare-wallaby is the most abundant animal on Barrow with a population of c. 10,000 individuals; the euro is least abundant with c. 1,800 individuals. The population estimates for Barrow Island are compared with the guestimates of an experienced naturalist who is familiar with the island and its fauna in Table 3.4.

Banded hare-wallabies are abundant on both Bernier and Dorre. On Dorre they are concentrated along the inland dunes that run the length of the island and along the travertine of the west coast. They shelter below the wind-swept divaricating shrubs of these habitats: *Ficus platypoda*, *Acacia coriacea*, *Diplolaena dampieri*, and *Heterodendrum oleifolium*. They are abundant on the northern half of Bernier where dense thickets of *Acacia* *ligulata*, *A. coriacea*, and *H. oleifolium* occur. Interestingly, they are rare in such locations as White Beach on Dorre Island and Red Cliff Point on Bernier Island because of their preference for thickets and dense cover. This may largely explain the different ratios of banded to rufous hare-wallabies collected on Bernier and Dorre Islands over the years. The differences may reflect simply the localities in which collections were made rather than major shifts in the ratio of the two species over time due to interspecific competition as suggested by Ride *et al.* (1962: p. 88).

We have explored this possibility by examining the skulls collected on Bernier and Dorre Islands since 1899 (Table 3.5). The 1959 collection by Ride *et al.* (1962) on Bernier Island shows the most extreme ratio of banded to rufous hare-wallabies. They could collect few rufous hare-wallabies despite much effort, and thus concluded that this species must be at extremely low numbers compared to times when other collections had been made (e.g. Shortridge's 1906 collection on Bernier Island and Lipfert's 1910 collection on Dorre Island in which rufous hare-wallabies outnumbered banded hare-wallabies). Table 3.5 suggests that banded hare-wallabies are much more numerous relative to rufous hare-wallabies on Bernier Island. Table 3.6 indicates how the ratios can change between different locations on the one island. Banded hare-wallabies are abundant on the northern end of Bernier Island whereas rufous hare-wallabies are the dominant species in the south.

Bettongs appear to be extinct on Boodie Island as we neither saw nor caught any nor did we see any evidence of their tracks. This island had a population of Rattus rattus that may have been introduced to the island between 1860 and 1900 when the area was used by pearl fishermen for careening their vessels. The Western Australian Department of

Conservation and Land Management (CALM) placed poison on the island (oat grain impregnated with the anticoagulant Pindone) in May 1985 in an attempt to eliminate Rattus. This formed part of a generally successful campaign by CALM to rid off-shore islands of rabbits, rats, goats and foxes (Morris 1989).

Grain was placed in upturned buckets with small Vs cut in the side to allow rats in but to prevent bettongs feeding on the grain. It seems likely that bettongs were poisoned, from eating grain scratched out of the buckets by rats. Bettongs may also have been poisoned by feeding on the carcasses of rats.

We put in 350 trap nights with Elliot traps in addition to the 96 trap nights with cage traps but did not catch any small mammals. Hence it is likely that the attempt to eradicate Rattus was successful.

Table 3.1. Relative and absolute abundance of bandicoots and macropods on Barrow, Boodie, Bernier and Dorre Islands. Densities estimated by Fourier analysis of line transect data.

Island and Species	ASD (m)	TL (km)	No./km	No./km^2 ± S.E.	Population
Barrow Island (233 km^2)				1.9	
Bettongia lesueur	20	98.0	0.21	14.4±2.2	3,400
Lagorchestes conspicillatus	25	98.0	1.84	41.8±1.72	9,700
Macropus robustus isabellinus	45	98.0	0.44	7.9±0.9	1,800
Isoodon auratus	12	98.0	0.35	38.0±16.4	8,900
Boodie Island (4.7 km^2)					
Bettongia lesueur	-	4.4	0.00	0.0	0
Bernier and Dorre Islands (93.2 km^2) 98 km^2				4.9	1666
Bettongia lesueur	13	98.2	0.38	17.0±3.8	1,580
Lagorchestes hirsutus	15	98.2	0.75	44.0±13.7	4,100
Lagostrophus fasciatus	12	98.2	1.13	79.9±0.5	7,400
Perameles bougainville	8	98.2	0.17	23.9±14.9	2,200 23

ASD - average sighting distance, TL - transect length.

Table 3.2 The relative abundance of bettongs, hare-wallabies and bandicoots on Bernier and Dorre Islands.

Species and Island	N	(*)	No./km	% of total both islands	Population
B. lesueur					
Bernier	18	(3)	0.39	39	600
Dorre	19	(18)	0.37	61	1000
Lagorchestes hirsutus					
Bernier	50	(6)	1.09	58	2400
Dorre	24	(8)	0.47	42	1700
Lagostrophus fasciatus					
Bernier	60	(1)	1.30	44	3300
Dorre	51	(9)	0.99	56	4100
Perameles bougainville					
Bernier	6	(0)	0.13	27	600
Dorre	11	(4)	0.21	73	1600

* number sighted while walking along the coast between transects.

Table 3.3 Trapping results for Barrow, Boodie, Dorre, and Bernier Islands.

Island	Trap nights	Date	Captures (recaptures) Bettongs	Bandicoots	Possums	H-wallabies	Total captures	Trap success (%)
Barrow	576	Jan. 1989	14(1)	170(97)	27(6)	6(0)	217(104)	55.7
	576	June 1989	24(8)	218(103)	44(14)	0(0)	286(125)	71.3
Boodie	96	April 1989	0(0)	0(0)	0(0)	0(0)	0(0)	0.0
Dorre	384	Oct. 1988	72(65)	22(-)	-	3(0)	97(65)	42.2
Bernier	384	Aug. 1989	42(30)	23(5)	-	1(0)	66(35)	26.3

Table 3.4. Population estimates of the larger mammals on Barrow Island

	Butler (1970)	This report
Isoodon auratus	1000+	8900
Bettongia lesueur	400+	3400
Lagorchestes conspicillatus	800+	9700
Macropus robustus	200+	1800

Table 3.5. Collections of specimens of bettongs and hare-wallabies from Bernier and Dorre Islands. Data from Kitchener and Vicker (1981), Ride et al. (1962), and from our collections.

Year	Collector	Total of 3 species	Ratio Bettongs:H-W	Ratio Banded:Rufous
DORRE				
1899	Tunney	8	4:4	2:2
1910	Lipfert	17	4:13	6:7
1959	Ride	23	12:11	8:3
1969	Prince & Evans	12	4:8	3:5
1974-75	Prince & Martin	12	6:6	5:1
1988	Short	22	11:11	7:4
BERNIER				
1906	Shortridge	34	9:25	8:17
1910	Lipfert	21	6:15	8:7
1959	Ride	35	12:23	21:2
1963	Ride	99	12:77	68:9
1969	Prince & Evans	39	5:34	17:17*
1989	Short	51	13:38	28:10

* 20 of 34 animals collected at Redcliff Point (see Table 3.5).

Table 3.6. Collections of specimens of bettongs and hare-wallabies from Bernier Islands. Data from Kitchener and Vicker (1981) and from our collections.

	Bet. les.	*Lag. fasc.*	*Lag. hirs.*
NORTH (includes Wedge Point)			
1959	12	21	2
1974-75	0	6	0
1989	5	12	1
SOUTH (includes Red Cliff Point and Cape Couture)			
1974-5	5	11	16
1989	7	6	8

Fig. 3.1 The distribution of the 50 random blocks of 1 km^2 on Barrow Island. Twenty blocks are in limestone uplands with a vegetation of *Triodia wiseana* in an area of high oilfield activity (dark stipple), 20 are in the same habitat in areas of low oilfield activity (cross-hatched), and the remaining 10 are in other habitats: watercourses with *Triodia angusta*, *Triodia* mosaic, coastal dunes and rock, and floodout flats (light stipple).

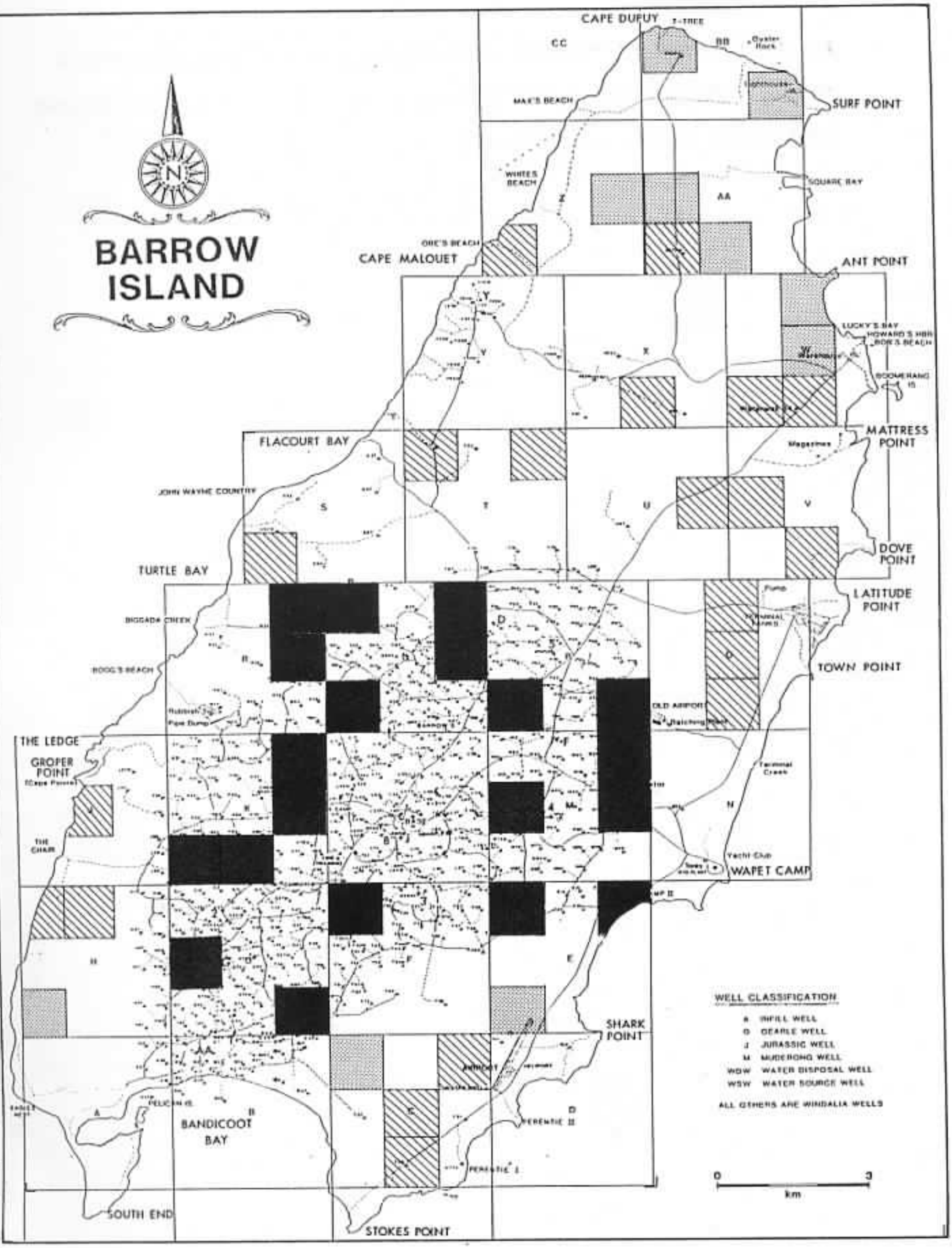

BARROW ISLAND
N
CAPE DUPUY
CC
BB
MAX'S BEACH
SURF POINT
WHITES BEACH
SQUARE BAY
AA
ORC'S BEACH
CAPE MALOUET
ANT POINT
Y
X
W
LUCKY'S BAY
HOWARD'S HBR
BOOMERANG IS
MATTRESS POINT
FLACOURT BAY
JOHN WAYNE COUNTRY
S
T
U
V
DOVE POINT
TURTLE BAY
LATITUDE POINT
BIGGADA CREEK
R
D
Q
TOWN POINT
BOOG'S BEACH
OLD AIRPORT
THE LEDGE
GROPER POINT
(Cape Poivre)
N
THE CHAIR
Yacht Club
WAPET CAMP
H
E
SHARK POINT
WELL CLASSIFICATION
INFILL WELL
DEARLE WELL
J JURASSIC WELL
M MUDERONG WELL
WDW WATER DISPOSAL WELL
WSW WATER SOURCE WELL
ALL OTHERS ARE WINDALIA WELLS
A
BANDICOOT BAY
C
D
0
3
km
SOUTH END
STOKES POINT

Fig. 3.2 Location of 24 blocks in which trapping grids of 12 traps were set for 4 nights. Traps were placed at the geographic centre of each block. The 24 blocks were divided equally between 6 treatments.

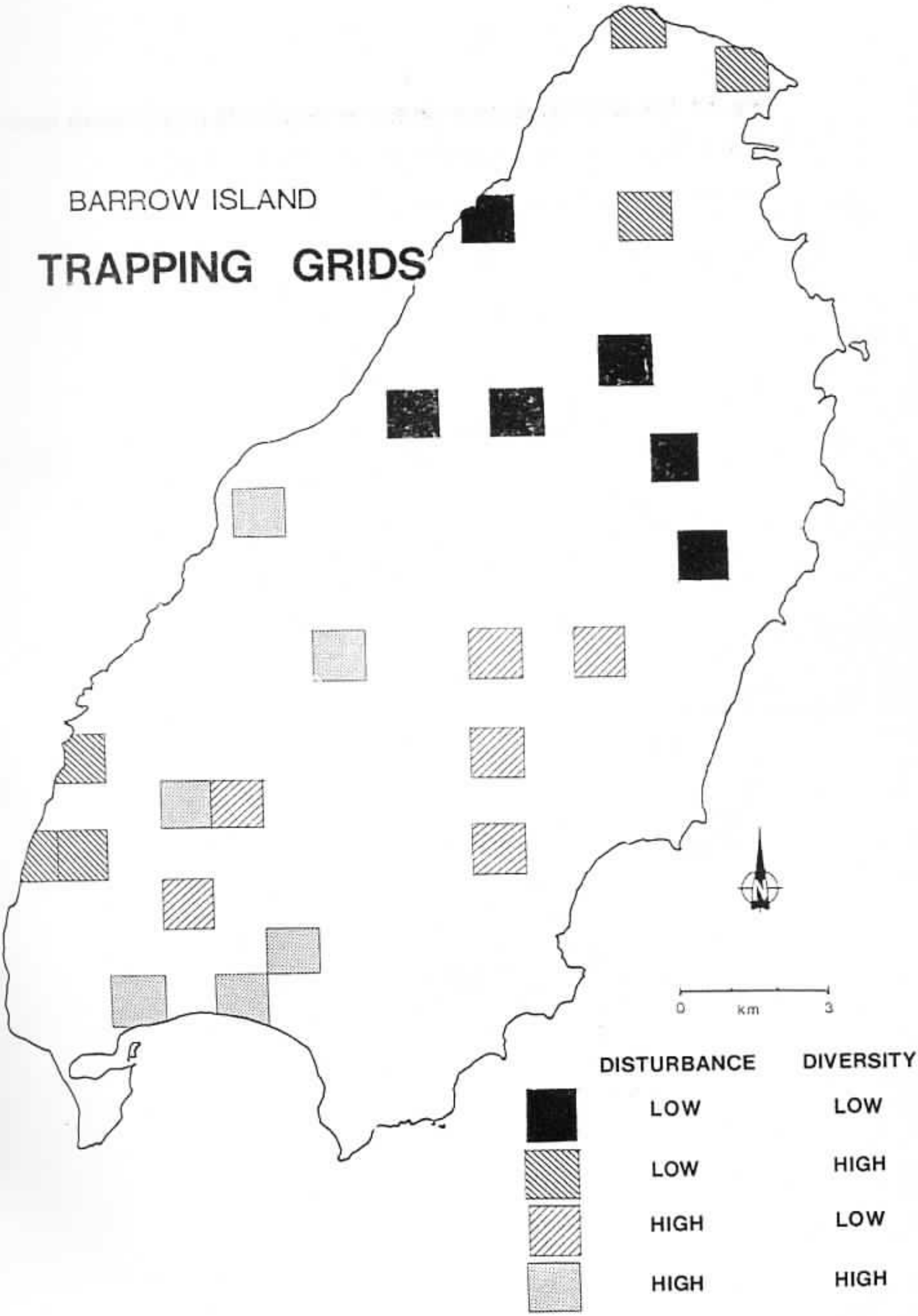

BARROW ISLAND
TRAPPING GRIDS
0 km 3
DISTURBANCE DIVERSITY
LOW LOW
LOW HIGH
HIGH LOW
HIGH HIGH

Fig. 3.3 The location of spotlight survey lines and trapping grids on Boodie Island

BOODIE ISLAND

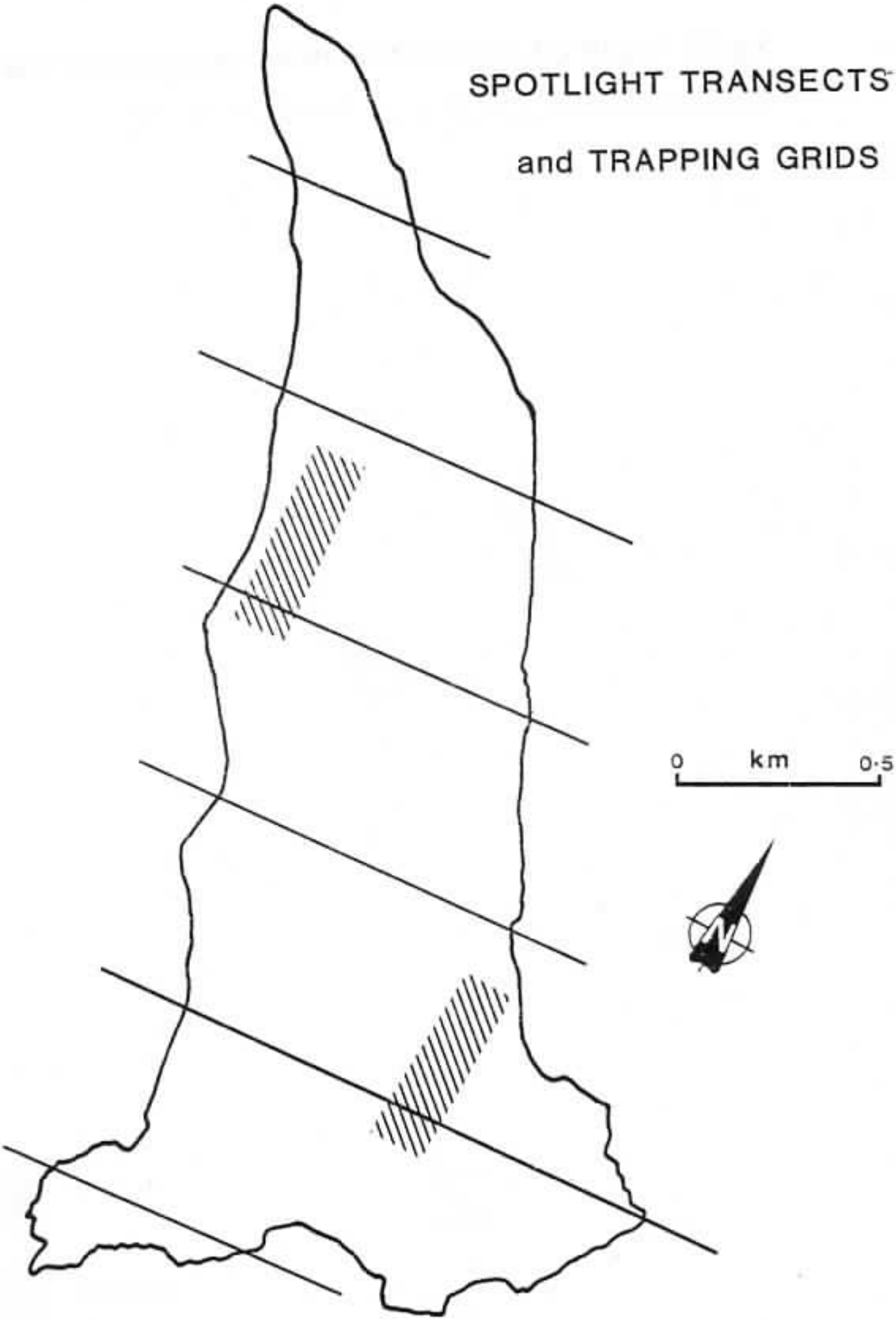
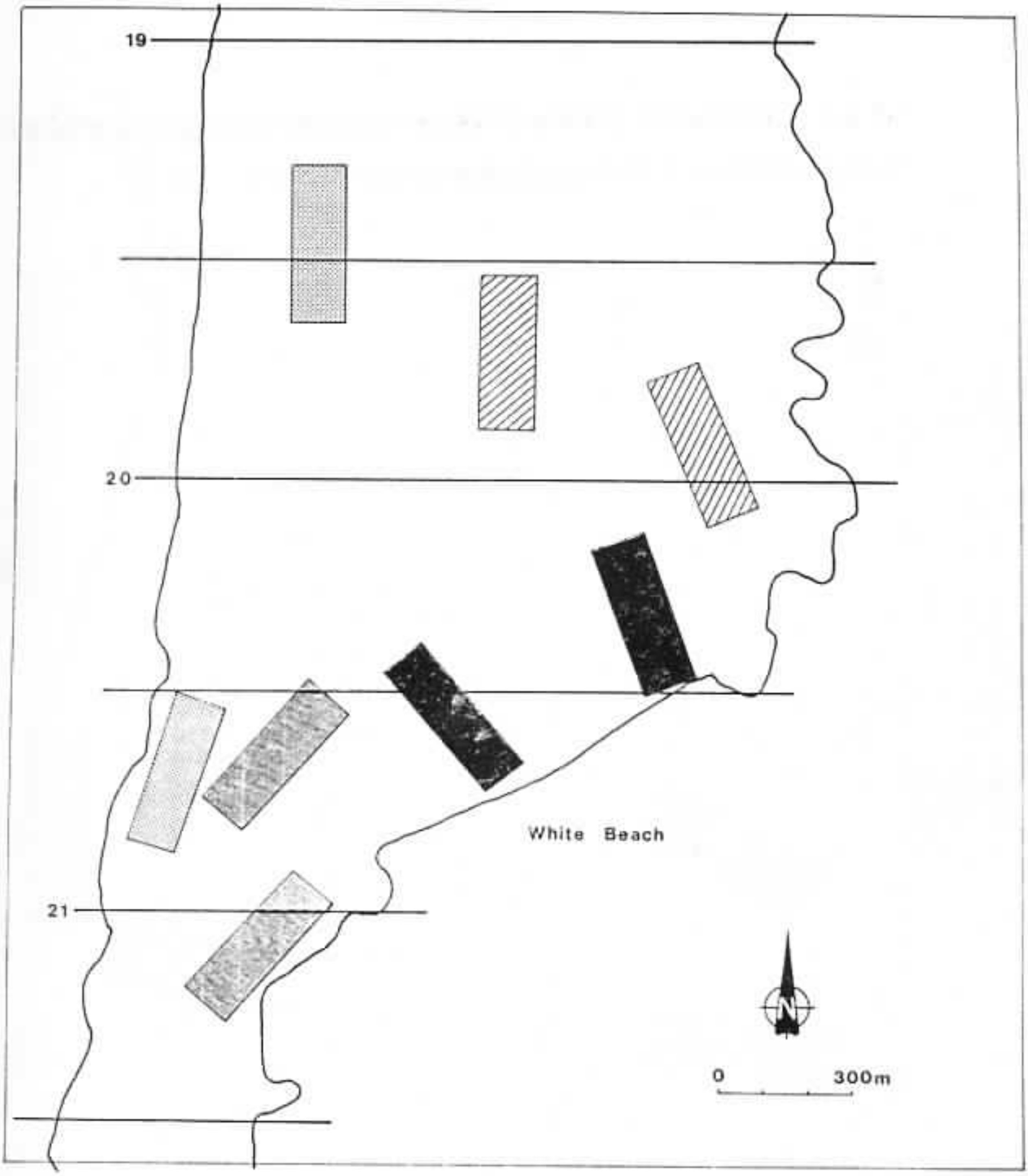


Fig. 3.4 The White Beach area of Dorre Island showing trapping grids and spotlight transects. Trapping grids were in four habitats.



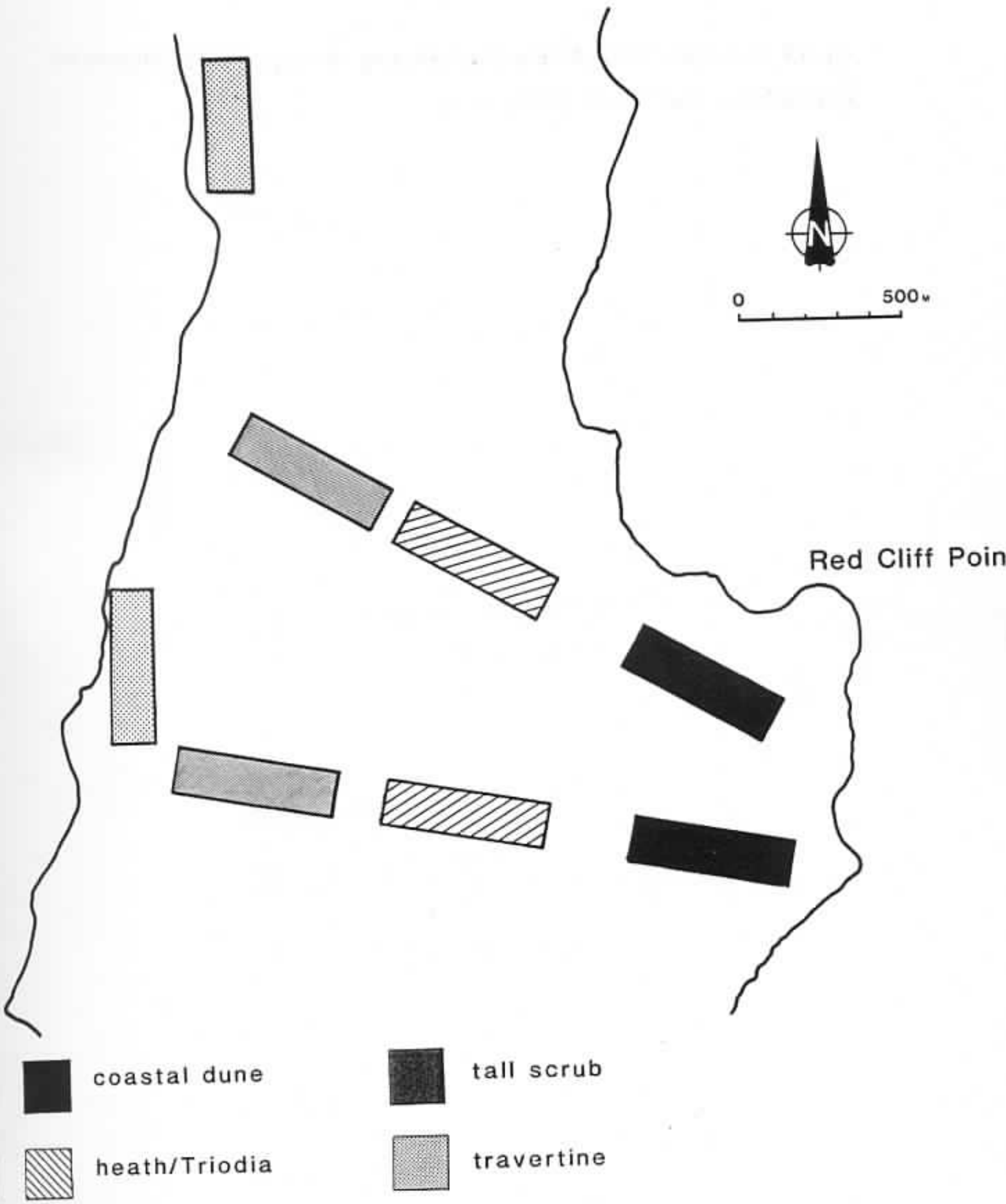
coastal dune

travertine/heath

Triodia

heath

Fig. 3.5 The Red Cliff Point area of Bernier Island showing trapping grids and spotlight transects. Trapping grids were in four habitats.



Red Cliff Poin
0
500 m
coastal dune
tall scrub
heath/Triodia
travertine

Fig. 3.6 Sightability histograms for the burrowing bettong (*Bettongia lesueur*) on Barrow, Dorre, and Bernier Islands.

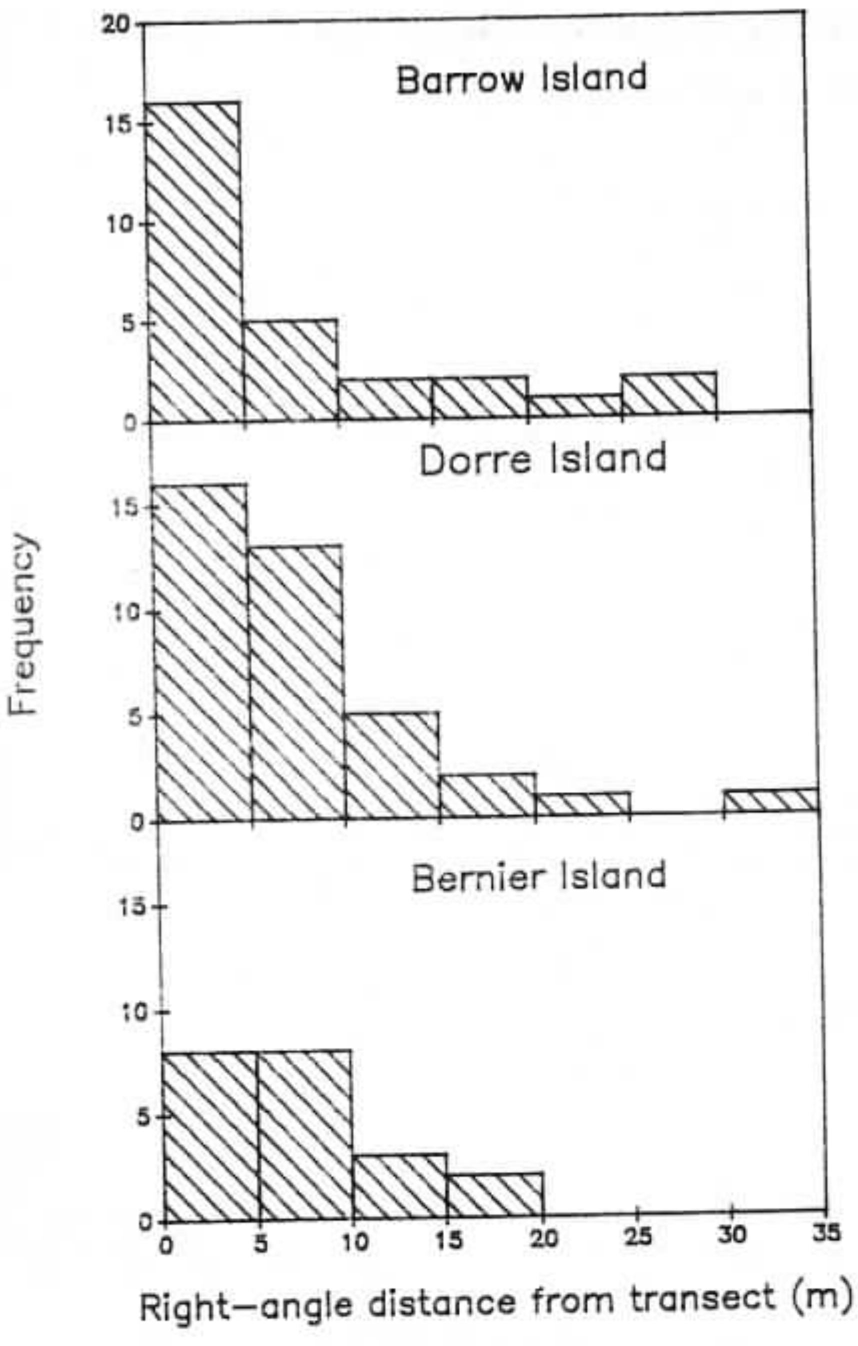
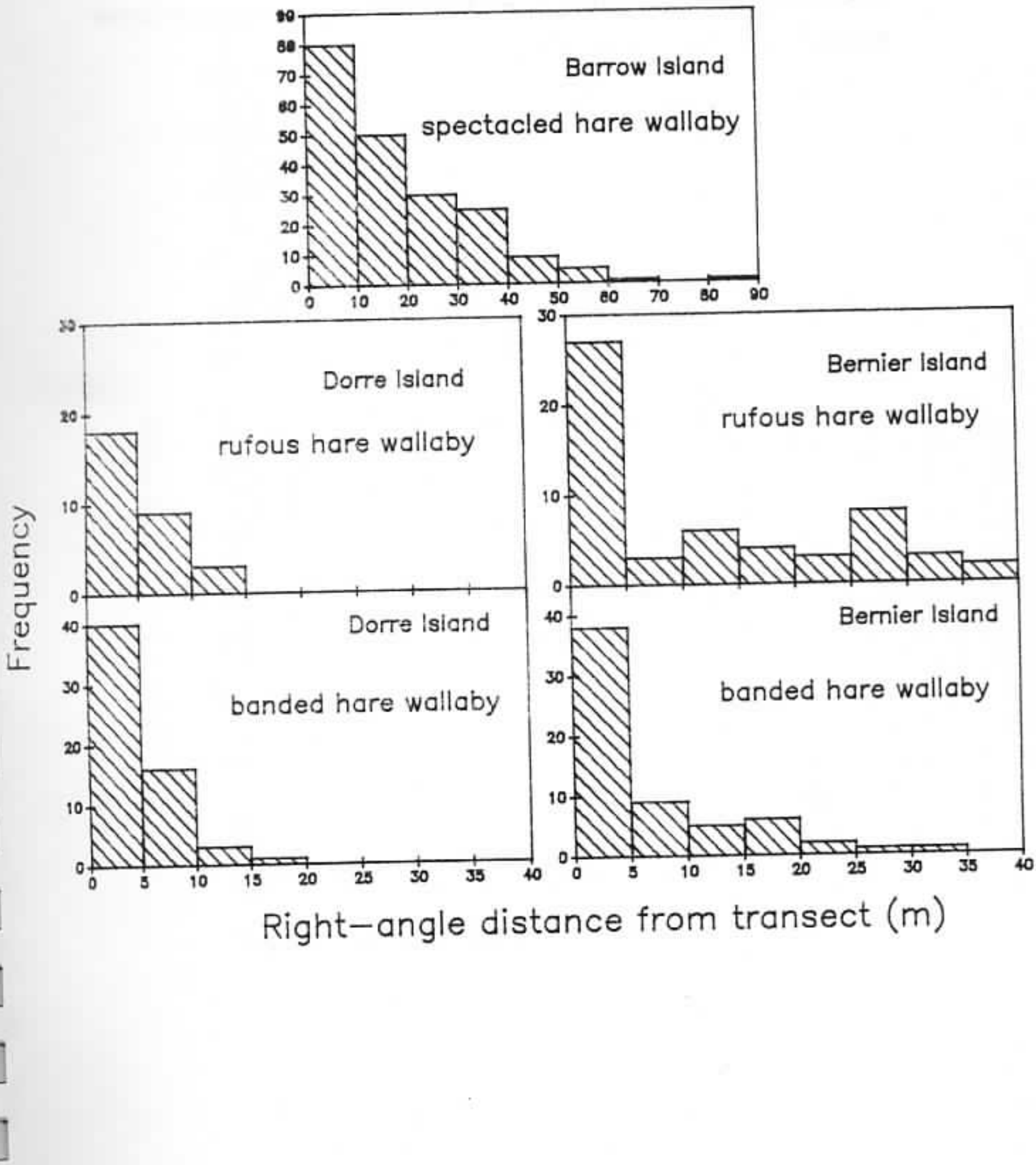
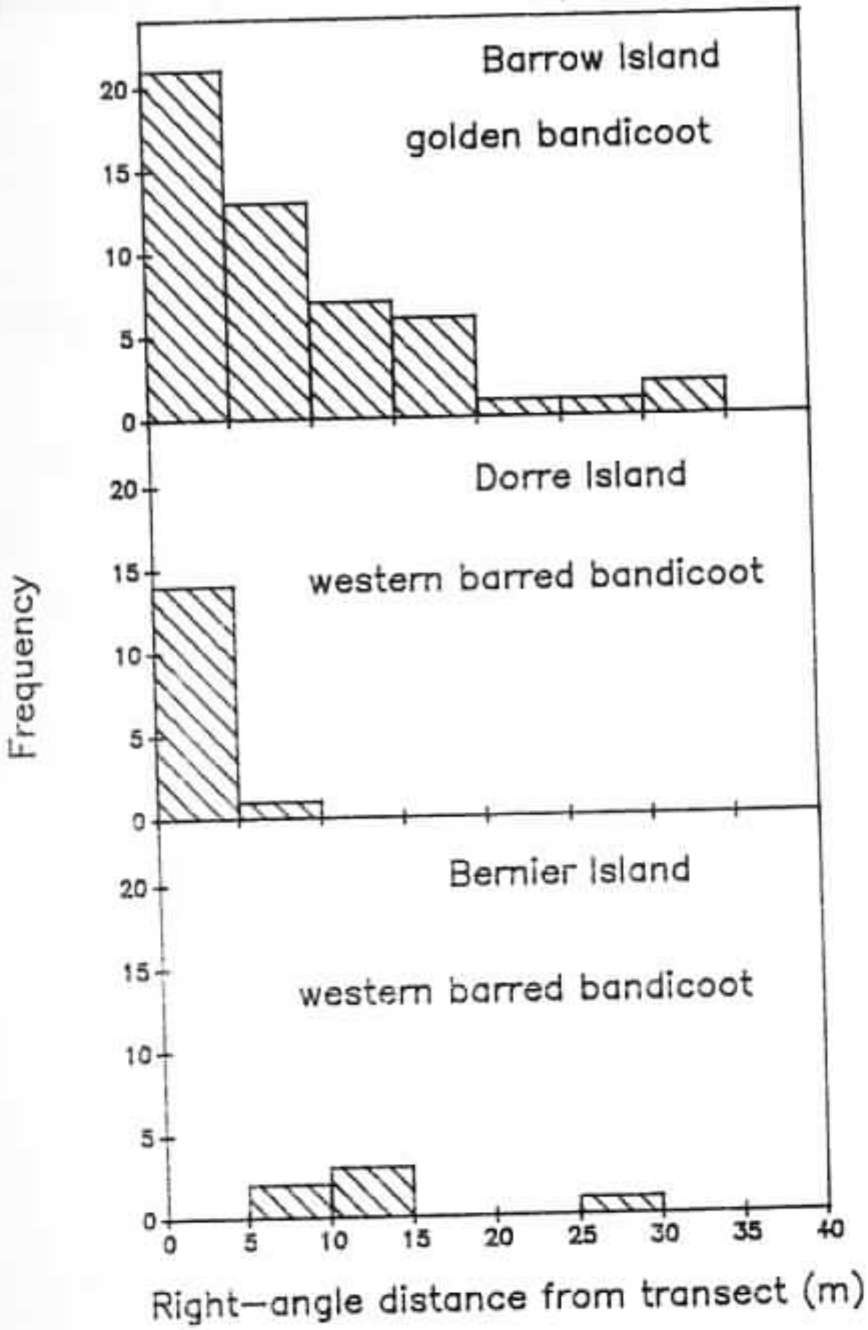

Barrow Island
Dorre Island
Bernier Island
Frequency
0
5
10
15
20
25
30
35
Right–angle distance from transect (m)

Fig. 3.7 Sightability histograms for hare-wallabies on Barrow, Dorre, and Bernier Islands.



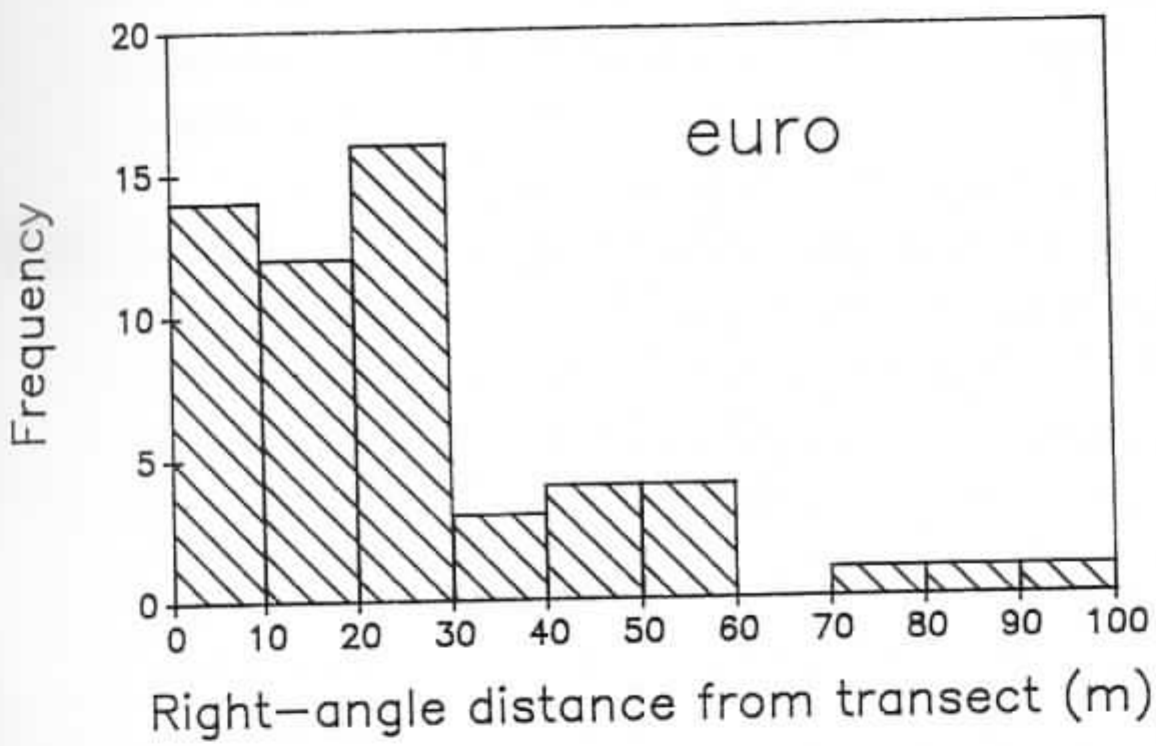
Barrow Island
spectacled hare wallaby
Dorre Island
rufous hare wallaby
Bernier Island
rufous hare wallaby
Dorre Island
banded hare wallaby
Bernier Island
banded hare wallaby
Frequency
Right-angle distance from transect (m)

Fig. 3.8 Sightability histograms for bandicoots on Barrow, Dorre, and Bernier Islands.



Barrow Island
golden bandicoot
Dorre Island
western barred bandicoot
Bernier Island
western barred bandicoot
Frequency
0
5
10
15
20
25
30
35
40
Right–angle distance from transect (m)

Fig. 3.9 Sightability histogram for the euro (*Macropus robustus isabellinus*) on Barrow Island.



euro
Frequency
0
5
10
15
20
0
10
20
30
40
50
60
70
80
90
100
Right-angle distance from transect (m)

CHAPTER 4

HABITAT PREFERENCES OF BETTONGS

This chapter describes the distribution of bettongs with respect to habitat and accounts for that distribution in terms of environmental parameters.

The distribution of bettongs was assessed from their sightings on spotlight traverses on Barrow, Bernier, and Dorre Islands, from road sightings and road kills on Barrow Island, from data on the distribution of their warrens on Barrow Island, and finally from trapping programmes in the vicinity of White Beach on Dorre Island, Red Cliff Point on Bernier Island, and from 24 locations spread across Barrow Island.

Barrow Island

(1) The distribution of bettongs with respect to habitat

Spotlighting results

Figure 4.1 maps both the sightings of bettongs on the 144 km of spotlight survey and sightings in the headlights of the vehicle while driving at night. Sightings of bettongs on spotlight surveys are given as numbers per kilometre. Interpretation is limited by the low number of sightings (e.g 27/144 km of spotlight survey). The distribution of sightings at night from the vehicle in part refects roads that we used most frequently. However it tends to fill in many gaps between our 50 surveyed blocks.

Table 4.1 shows the relative occurrence of bettongs as observed in the spotlight surveys by habitat. Thirty seven percent of sightings were in disturbed areas of one sort of another - borrow pits, seismic lines, well sites, burnt areas, or roads. This may reflect greater visibility in disturbed areas, an actual preference for disturbed areas, or the use of disturbed areas, such as seismic lines, as pathways for movement by night. If these sightings are redistributed to the other major habitats then most sightings were in limestone uplands (~60%) or in drainage lines (30%); the two most common habitats. Eleven percent of sightings were recorded in beach and dune habitats although these habitats made up <3% of habitat along survey lines. Similarly bettongs were almost twice as abundant along drainage lines (30% of sightings) as might be expected from the relative abundance of this habitat. Hence disturbed areas, beach, dune and drainage lines would appear to be favoured habitat.

There was no significant difference in abundance of bettongs between the three major habitat types (*Triodia wiseana* + oilfield, *Triodia wiseana* - oilfield, other habitats: *T. angusta*, *T. mosaic*, floodout flats and coastal complex) (Table 4.2). The overall impression from this result is that bettongs are widely and evenly dispersed across Barrow Island with a slight bias towards coastal fringe and disturbed areas.

Trapping results

A number of habitat variables were measured at each of 24 trapping grids (12 traps in an area of c. 5 ha). Three measures of bettong abundance are available for each of these grids:

- density of catches of bettongs per trap (Caughley 1977: 20) in 48 trap nights (12 traps for 4 nights) on 24 grids (BETDEN).

- number of bettongs seen per kilometre of spotlight transect in each block of 1 km^2 (BETSPOT). Only 24 of the 50 random blocks which were surveyed are included in this analysis. These are the 24 blocks that had trapping grids.

- the number of active entrances of the warren or warrens located in each block of 1 km^2 (WARRENENT). Again only data from 24 of the 50 surveyed blocks are used.

Unfortunately these three measures of the abundance of bettongs show no significant correlation with each other or with condition of bettongs. This is due partly to the low numbers of bettongs seen on spotlight transects (mean = 0.54 per block) and trapped (38 in 1152 trap nights or a mean of 1.6 per trapping grid).

A number of environmental variables were measured at each trap site:

- the mean depth of soil (cm) per trapping grid (SOILDPTH). This was assessed by digging 12 holes (one per trap site on each grid) to the maximum depth possible with 10 standard "digs" with a long-handled trowel.

- the average height (cm) of Triodia (VEGHT)as measured at one random location per trap site (12 per trap grid). Height was measured to the top of the leaves where seed-heads were present.

- the average cover of vegetation (VEGCOV) as assessed at 24 random locations per grid (2 per trap site). Vegetation cover was estimated as a percentage in 0.25 m^2 quadrats.

- species richness, the mean number of plant species per 0.25 m^2 quadrat (SPRICH) as assessed at 24 random locations per grid (2 per trap site).

- the Shannon - Wiener index of diversity of vegetation types calculated for the 1 km^2 block in which each trapping grid was located (HABDIV).

- the distance from the ocean of each trapping grid (DISTOCN).

- the altitude (m) of each trapping grid (ALT).

- the approximate area (%) of the 1 km^2 block in which the trapping grid is located occupied by Triodia angusta (TRANG). This species is dominant in the dry watercourses.

- the approximate area (%) of the 1 km^2 block in which the trapping grid is located that is occupied by Triodia mosaic, floodout flats and coastal complex (OTHERVEG).

- an index of disturbance calculated as the sum of the number of roads, pipelines, seismic lines, and wells within or running through the 5 ha trapping grid (DISTURB).

- the average distance (m) of each trap to the nearest Ficus clump (FICUS).

The mean and range of each variable is given for each trapping grid in Table 4.3. The data contained within these variables can be largely summarised by two principal components (Table 4.4). Component 1 (Fig. 4.2) is a composite of variables that are correlated with the altitudinal gradient of the island from sea level to 60 m ASL. These variables include altitude (ALT), distance from ocean (DISTOCN), vegetation cover (VEGCOV), soil depth (SOILDPTH), the area of the 1 km^2 block dominated by *Triodia angusta* (TRANG), and the habitat diversity (HABDIV) of the 1 km^2 block. At one extreme, areas in the centre of the island tend to have high altitude, large distance from ocean, little soil depth, low vegetation cover, low habitat diversity, little T. angusta or "other" vegetation, and small mean distances to Ficus platypoda, the dominant tree in upland areas. Coastal areas have the opposite of all these parameters.

The second component is a measure of disturbance. It separates blocks where there is a high disturbance index and high richness of plant species within each of the 24 quadrats sampled at each trapping grid from those that have low values of these variables.

The density of bettongs does not appear to respond to either of these gradients (Figure 4.3). The trapping grids where bettongs had above average condition (Fig. 4.4) tend to score high on the second component, suggesting that they are favoured by disturbance with its accompanying greater species richness of plants on trapping grids.

A step-up multiple regression with bettong density (BETDEN) as the independent variable, and selected habitat variables as dependent variables was not significant. The variable that explained most variation in bettong density was distance to closest known warren. The closer to a known warren the greater the likelihood of catching a bettong. However, even with this variable included, the regression equation accounted for only 31% of the variance.

This result reinforces that obtained from spotlighting. Bettongs are generalists occurring everywhere on Barrow Island at low densities. The one factor that might limit their occurrence in some localities is the absence of suitable warren sites. Distance to closest known warren was significantly different ($F_{1,22} = 8.1$, $P < 0.01$) between the five trapping grids where no bettongs were caught or sighted within the block ($x = 1.03$ km) and the 19 grids with evidence of bettong presence ($x = 2.04$ km). The home range size of bettongs on Barrow is approximately 1.5 km^2 (Short and Turner 1989b). Hence areas beyond 1.5 km from the nearest warren are likely to receive little utilisation.

Habitat variables which most effectively predicted the condition of bettongs in a step-up multiple regression were SPRICH (+ve), TRANG (-ve), and FICUS (+ve). Condition was highest in areas with a high species richness of plants, a low area of *Triodia angusta*, and greater distance from *Ficus*. The equation accounted for 37% of the variance.

(2) Bettong warrens

Distribution of warrens.

Sightings of animals at night give data on the habitats in which bettongs forage. Equally important for a burrowing animal is the availability of suitable sites for burrows. We measured the distribution of warrens with respect to habitat and estimated the abundance of these warrens on Barrow. We searched 50 x 1 km blocks to locate 25 warrens (= 0.50 km^{-2}). The two searchers covered approximately 9 km per block. Searching was concentrated on, but by no means confined to, major and minor ridge lines. Warrens are mapped in Fig. 4.5. An additional 15 warrens were located either by local knowledge, the following of radio-collared animals, or by serendipity. The number of active entrances of each warren is beside its location.

Warrens were generally on well-drained sites (often on or near the crests of ridges), usually located in cap rock, and often associated with figs *Ficus platypoda*. Ridge crests are *Triodia wiseana* habitat but often the area immediately around the warren (the spoil) was covered with *T. angusta*.

The number of warrens and the number of burrow entrances did not differ significantly between the three habitats: *Triodia wiseana* disturbed, *T. wiseana* undisturbed and other (floodout flats, *Triodia* mosaic, and coastal dunes). However, the two largest warren systems (91 and 67 active entrances) were in *T. wiseana* undisturbed habitat, hence the mean number of active entrances per block searched was three times higher in this habitat ($x = 17.4$) than it was in the other two ($x = 5.6$ in *T. wiseana* disturbed, $x = 5.3$ in 'other').

Warrens are distributed widely throughout the island but showed a slight concentration within 1 km of the coast, particular down the east coast. The distribution of warrens per 1 km^2 block closely followed a Poisson distribution (Fig. 4.6a; $X^2 = 1.61$, no significant departure) indicating that warrens were essentially located at random across the island. Bettong sightings on spotlight transects similarly suggested a random distribution (Fig. 4.6b; $X^2 = 3.5$, no significant departure).

Warrens occurred on slopes facing most directions (Fig. 4.7) except east. We know of no biological reasons for this apparent absence from east-facing slopes. Warrens occurred very close to the coast and in the very interior of the island, and from sea level up to 40-50 m above sea level (Fig. 4.8a). We compared the distances from the coast and altitudes of warrens with those from the mid-points of the 31 blocks without warrens (a subset of the 50 randomly chosen blocks). There was no significant departure from that expected from the random blocks for altitude of warren ($X^2 = 5.9$, d.f. = 4, n.s.), but more warrens were located within 0-1 km from the coast than expected ($X^2 = 11.7$, d.f. = 4, $P < 0.05$).

The number of active entrances varied from 4 to 91. The modal frequency class for the number of entrances was 10-20 (Fig. 4.9a). Only 5 of 40 warrens (12.5%) had >40 entrances.

Warrens were always associated with cap rock. Often they were in areas of collapse - where there were numerous solution tubes through the cap rock and where water flowing under the cap rock had removed the underlying soil. The collapse of sections of cap rock allowed bettongs to burrow in under the face of the collapsed rock. The cap rock provided structural support for the warrens and presumably provided insulation from extremes of temperature. The cap rock, as measured at burrow entrances, was 20-70 cm thick with a modal value of 30-40 cm (Fig. 4.9b).

Warrens were generally on slopes of ~ 3½ (Fig. 4.9c). This included ridge tops and the crests of minor ridges. Warrens were located from the top of the catena (ridge tops) to about two thirds of the way down to the valley floor. However, all were in areas where there would be minimal run-off from areas above the warren.

Ficus was present on 50% of the warrens. A variety of other tree and shrub species occurred on the warrens either singly or as part of a group of 2-3 species (Fig. 4.10). Only 18% of warrens had no tree or shrub species growing on them.

There was considerable similarity in the appearance of most warrens but several were atypical. One was in a large cave on a rocky headland overlooking the sea. The cave was 100 m long by 20 m wide with small entrances at either side shielded by figs. Burrow entrances were in the floor of the cave. About half were framed by rock, half were dug in the fine talc-textured soil of the floor without obvious rock support. Another warren was in amongst boulders at the cave entrance in the rim of a large circular area of collapsed rock. Trees of *Mallotus nesophilus* shielded the cave entrance. Another warren of 4 burrow entrances was in the floor of a dry creek bed in sand-dune country on the west coast. The bettongs had burrowed under a large shelf of cap rock that protruded into the creek bed.

No warrens were found in dune habitats or drainage lines in the absence of rock. Hence bettongs on Barrow do not appear to burrow as they did along the Avon River in south-west Western Australia (Gilbert in Gould 1863), or in the sand dunes of Roebuck Bay (Dahl 1926). However, several authors describe the typical warren system that we encountered on Barrow: Giles (1889), Terry (1929 in Parker 1973), Finlayson (1958:243) and Ride and Tyndale-Biscoe (1962).

The population within warrens

We have trapped on 4 warrens ranging from small (5 entrances) to large (68 entrances). Cumulative capture rates are presented in Fig. 4.11a. Unfortunately, it takes in excess of 8 nights of trapping (~ 20 traps per night per warren) to capture most animals using the warren. Two warrens for which we have most data suggest populations of about 20 individuals for warrens 35 and 52. These had 19 and 25 entrances respectively.

A.A. Burbidge and W.H. Butler observed bettongs leaving a warren of 67 entrances at dusk on Barrow Island in February 1981. They counted 32 bettongs leaving the warren. Harris-Browne (1897) observed aborigines take as many as 20 bettongs from warrens in South Australia. Hence it seems likely that there are between 20 and 40 bettongs in an average warren.

All warrens had a group of possums resident in the warren. Warren 35a (5 entrances), although obviously dug by bettongs, contained only possums. We guess that there may be competition for warrens between possums and bettongs. It may be that the bettong population of a warren may need to reach a critical size to allow them to survive within the warren without it being commandeered by possums.

The composition of the bettong community of each warren (by size and sex) is given in Fig. 4.12. Note that the communities are dominated by adult animals. Males are apparently more abundant but are much more readily trapped than are females.

The composition by size and sex of all animals trapped on Barrow, Dorre and Bernier is given in Fig. 4.13. Note the considerable size differences between bettongs from the three islands. The modal weight class for Barrow Island is 700-850 g, while that for Bernier Island is 1150 - 1300 g and for Dorre Island is 1450 - 1600 g.

Abundance of warrens and population estimate of bettongs derived from warren density and number of bettongs per warren.

We estimate that there are approximately 120 warrens on Barrow of which we know the location of about 40 (Table 4.5). A crude estimate of population size derived from the estimate of the number of warrens and approximate number of bettongs per warren is c. 3,000. This compares with that of 3,400 in Table 4.1. derived from the spotlight surveys.

Dorre Island

Figure 4.14 shows the relative densities of bettongs along the length of the island. Sightings are grouped per block of 4 survey lines and expressed as number of sightings per kilometre of transect. Only bettongs sighted while we walked the survey lines are included. Densities are highest around White Beach and immediately to its south.

Table 4.6 compares their frequency of occurrence of bettongs in particular habitats with the relative abundance of those habitats along the transect. Thirty two percent of bettongs sighted on spotlight transects were on coastal dunes. This habitat - beach, foredune, and rocky foreshore - made up only 5% of the habitat along the spotlight traverses. No bettongs were sighted actually on the beach. Just over 30% were sighted in *Triodia* steppe; 10% were sighted in heath (dominated by *Scaevola crassifolia*, *Frankenia pauciflora*, *Carpobotus equilaterus*, *Thryptomene micrantha*).

Results from the trapping programme (Table 4.7) indicated that bettongs were abundant in the coastal dunes at White Beach and in *Triodia* immediately north of White Beach, but apparently shunned the heath and travertine heath to the west and south of the Beach. There was a significant interaction between species (bettongs and bandicoots) and habitat. Either bettongs and bandicoots have different habitat preferences (bettongs = *Triodia* and dunes, bandicoots = heath), or there is some form of agonistic reaction between the two resulting in one being excluded from the habitat which is preferred by both. Butler's (1970) comments on the agonistic relationship between bettongs and possums on Barrow suggest that such a relationship may be possible between bettongs and bandicoots on Dorre.

These results suggest that bettongs occur along the entire length of the island and in all habitats. However, the coastal fringes and the area around White Beach, in particular, are areas of high concentration.

There are a number of features that distinguish White Beach from other parts of the island. White Beach has the most extensive area of coastal dunes on the island. These dunes have a flora which is quite different from those that run the length of the island (see Chapter 2). White Beach and the narrow isthmus immediately to its south are a transitional zone between the non-dune habitats to the north which are dominated by *Triodia* and similar areas to the south dominated by shrubs such as *Scaevola crassifolia*, *Frankenia pauciflora*, *Thryptomene micrantha* and *Beyeria cyanescens*. Also, being the narrowest part of the island (barring the southern and northern tips) the area is dominated by coastal margins. It is likely also that the narrow isthmus and the dunes of White Beach have formed a barrier to the spread of wildfire. This certainly happened in 1973 when a fire, which started near the northern tip of the island (between Disaster Cove and Smith Point) burnt downwind for two-thirds of the island, finally burning out at White Beach (R.I.T. Prince, pers. comm.). Hence, fire histories to the north and south of the isthmus are different. All contribute to the overall diversity of the vegetation of the area.

The mean height of vegetation in which bettongs were sighted on Barrow Island was substantially greater (45 cm) than on Dorre Island (33 cm). There were no differences in percentage cover of vegetation (Table 4.8). This, in part, reflects differences in vegetation communities between the islands, but probably also reflects the time since the last major fire (1961 on Barrow; 1973 on Dorre).

Bernier Island

Figure 4.15 shows the relative densities of bettongs along the length of the island. Bettongs occur relatively evenly along the island apart from on the southern tip. Here the dominant habitat was dense patches of *Spinifex longifolius* colonising bare dunes. This species is a coastal fringe plant elsewhere on the island. However here it occurs above the cliffs across the full width of the island. It is likely that these dunes would have been bare 10 years ago when goats were still abundant on the island. Density indices (0 - 0.61 km^2) on Bernier are in the same approximate range as on Dorre (0 - 0.85 km^2).

Table 4.9 indicates that bettongs on Bernier favour beach and foredune habitat as on Dorre.

Overall trap success of bettongs were less on Bernier (27%) than on Dorre (42%), but the differences in captures per grid was not significant ($F_{1,15} = 1.9$). The trap results were far less clear cut on Bernier compared to Dorre (Table 4.10) with larger differences between replicate grids than for grids placed in different habitats. Bettongs appear to use all four habitats. There was no apparent interaction with bandicoots as occurred on Dorre.

The difference in number of bettongs caught between the two travertine grids can be explained by relative proximity to a warren. After completing the trapping we discovered a warren under the caprock of the coastal cliff 30 m from the edge of grid 2. Hence bettongs leaving this warren to forage in the interior of the island would have had to pass across the grid. In contrast the cliff near the other travertine grid was sheer and provided no opportunity for burrowing.

Bettong warrens

There are many single (occasionally double entrance) burrows on the inland plains of Bernier and Dorre Islands (see Table 5.6 of Short *et al.* 1988).

These burrows were attributed to bettongs by us and by Ride *et al.* (1962: Plate 27 and Fig. 2). We now believe that these burrows are dug by rufous hare-wallabies. Bettongs will make opportunistic use of these burrows but mostly dig under the rock capping of cliffs and under boulders on the travertine. Ride *et al.* (1962) described this latter type of warren as located "under the blocks of fallen aeolinate and, where the cliff was little more than a bank, under the travertine crust".

Table 4.1. Sightings of bettongs on spotlight transects by habitat on Barrow Island (n=27). The classification of habitat is based on the location of the animal when observed.

Habitat	Percentage of sightings		Relative abundance of habitat along survey lines (%)
Beach	3.7	(3.7)*	1.0
Dune	7.4	(7.4)	1.9
Limestone upland	37.0	(59.3)	73.1
Drainage line	14.8	(29.6)	15.8
Floodout flat	0.0	(0.0)	0.8
Disturbed area	37.0	(-)	

* Sightings in disturbed areas redistributed to other major habitats according to the habitat in which disturbed feature was located; $X^2 = 8.2$, d.f. = 2, significant departure from expected; nb. beach, dune, and floodout flats combined for analysis because of low numbers.

Table 4.2. Mean number of animals seen per block in three different habitats on Barrow Island: <u>Triodia wiseana</u> with oilfield development, <u>Triodia wiseana</u> without oilfield development, and other habitats (<u>Triodia</u> mosaic, floodout flats, coastal complex).

Species	*T. wiseana* + oilfield	*T. wiseana* - oilfield	Other	F ratio
L. conspicillatus	3.15	4.35	3.10	2.01 (n.s.)
M. robustus	1.20	0.70	0.30	2.68 (n.s.)
B. lesueur	0.70	0.35	0.70	0.99 (n.s.)
I. auratus	0.60	0.85	0.80	0.30 (n.s.)

$F_{2,47}(0.05) = 3.18$

Table 4.3. Summary statistics of 11 habitat variables measured at 24 trap sites on Barrow Island.

Variable:	SOILDPTH	VEGHT	VEGCOV
Sample size	24	24	24
Average	11.925	26.4667	43.4833
Median	8.8	25.25	44.85
Standard error	1.29943	2.06432	2.36978
Minimum	4.8	11.2	25.3
Maximum	24.8	56.6	63.2
Range	20	45.4	37.9

Variable:	SPRICH	HABDIV	DISTOCN
Sample size	24	24	24
Average	1.15542	0.900417	1.94167
Median	1.105	0.71	1.8
Standard error	0.0539155	0.131867	0.276751
Minimum	0.67	0.09	0.2
Maximum	1.83	2.04	4.9
Range	1.16	1.95	4.7

Variable:	ALT	TRANG	OTHERVEG
Sample size	24	24	24
Average	20.5833	15.4167	12.1417
Median	19	9.75	0
Standard error	2.24166	3.10296	4.50498
Minimum	5	0	0
Maximum	45	61	92
Range	40	61	92

Variable:	FICUS	DISTURB	DISTWARREN
Sample size	24	24	24
Average	343.725	3.95833	1.2375
Median	63.5	3	1.245
Standard error	88.8252	0.668871	0.164643
Minimum	15	0	0.15
Maximum	1000	11	2.71
Range	985	11	2.56

Table 4.4 The results of the principal components analysis of 11 habitat variables measured at trapping grids on Barrow Island.

Component	Percent of Variance	Cumulative percentage
1	47.4	47.4
2	16.0	63.4
3	8.8	72.2
4	8.1	80.4
5	6.0	86.4
6	4.7	91.0

Table 4.5 Estimate of the number of warrens and bettongs on Barrow Island.

Number of blocks searched	50	
Number of warrens found	25	
Number inactive	5	(20%)
Number known to be missed	3	(11%)
Average number of entrances	25	
Modal number of entrances	10-20	
Density of warrens (km^{-2})	0.50	
Estimated number of warrens	120	
Approximate number of bettongs per warren entrance	c. 1	
Population estimate from warrens	c. 3000	

Table 4.6. Sightings of bettongs while walking spotlight transects on Dorre Island classified by habitat (n=19).

Habitat	Percentage of sightings	Percentage occurrence of habitat along transects
Beach/foredune/ rocky foreshore	31.6	5.0
Triodia	31.6	46.4
Heath	10.5	8.5
Consolidated dune	15.8	21.7
Travertine	10.5	18.3

Not enough sightings for X^2 analysis.

Table 4.7. Habitat use by bettongs and bandicoots on Dorre Island - the number of animals caught in replicate grids of 12 traps over 48 trap nights in Triodia, coastal dune, travertine, and heath.

	Species			
	Bettongs		Bandicoots	
	Grid 1	Grid 2	Grid 1	Grid 2
Habitat				
Triodia	19	10	2	0
Coastal dune	17	12	1	6
Travertine/Heath	2	4	3	1
Heath	4	3	7	2

ANOVA of above data - 2 species x 4 habitats x 2 replicates.

	F
Habitats	4.13
Species	16.79
H x S	5.9*

$F_{3,8}$ (0.05) = 4.07   *P<0.05

Table 4.8. Mean height and percentage cover of vegetation in which bettongs were sighted on spotlight surveys at Barrow and Dorre Islands.

	Barrow	Dorre	F
Mean height	45.2+30.7	33.2+12.9	3.96*
Range	0-130	15-60	
% Cover	46.0+23.5	47.8+12.7	0.10 (n.s.)
Range	15-95	20-75	

*P<0.05; n.s. not significant

Table 4.9. Sightings of bettongs while walking spotlight transects on Bernier Island classified by habitat (n=16).

Habitat	Percentage of sightings	Percentage occurrence of habitat along transects
Beach/foredune/ unconsolid. dunes	31.3	19.2
Triodia	25.0	5.2
Heath	18.8	48.8
Inland dune	18.8	18.5
Travertine	6.3	8.2

Not enough sightings for X^2 analysis. The combined results for Dorre and Bernier give a $X^2 = 14.7$, d.f. = 4, $P < 0.01$, highly significant departure from expected.

Table 4.10. Habitat use by bettongs and bandicoots on Bernier Island - the number of animals caught in replicate grids of 12 traps over 48 trap nights in <u>Triodia</u>, coastal dune, travertine, heath, and tall scrub.

	Species					
	Bettongs			Bandicoots		
	Grid 1		Grid 2	Grid 1		Grid 2
Habitat						
Heath/*Triodia*	9	19	4	0	1	8
Coastal dune	6	13	4	4	2	6
Travertine/Heath	0	4	7	1	6	2
Tall scrub	10	6	2	1	2	1
	25	42	17	6	11	17

ANOVA of above data - 2 species x 4 habitats x 2 replicates.

	F
Habitats	0.51
Species	1.71
H x S	0.32

$F_{3,8}$ (0.05) = 4.07

Fig. 4.1 Barrow Island showing results of spotlight survey for bettongs. Numbers given are the number of animals sighted per kilometre. Sightings of animals in vehicle headlights are shown as dots.

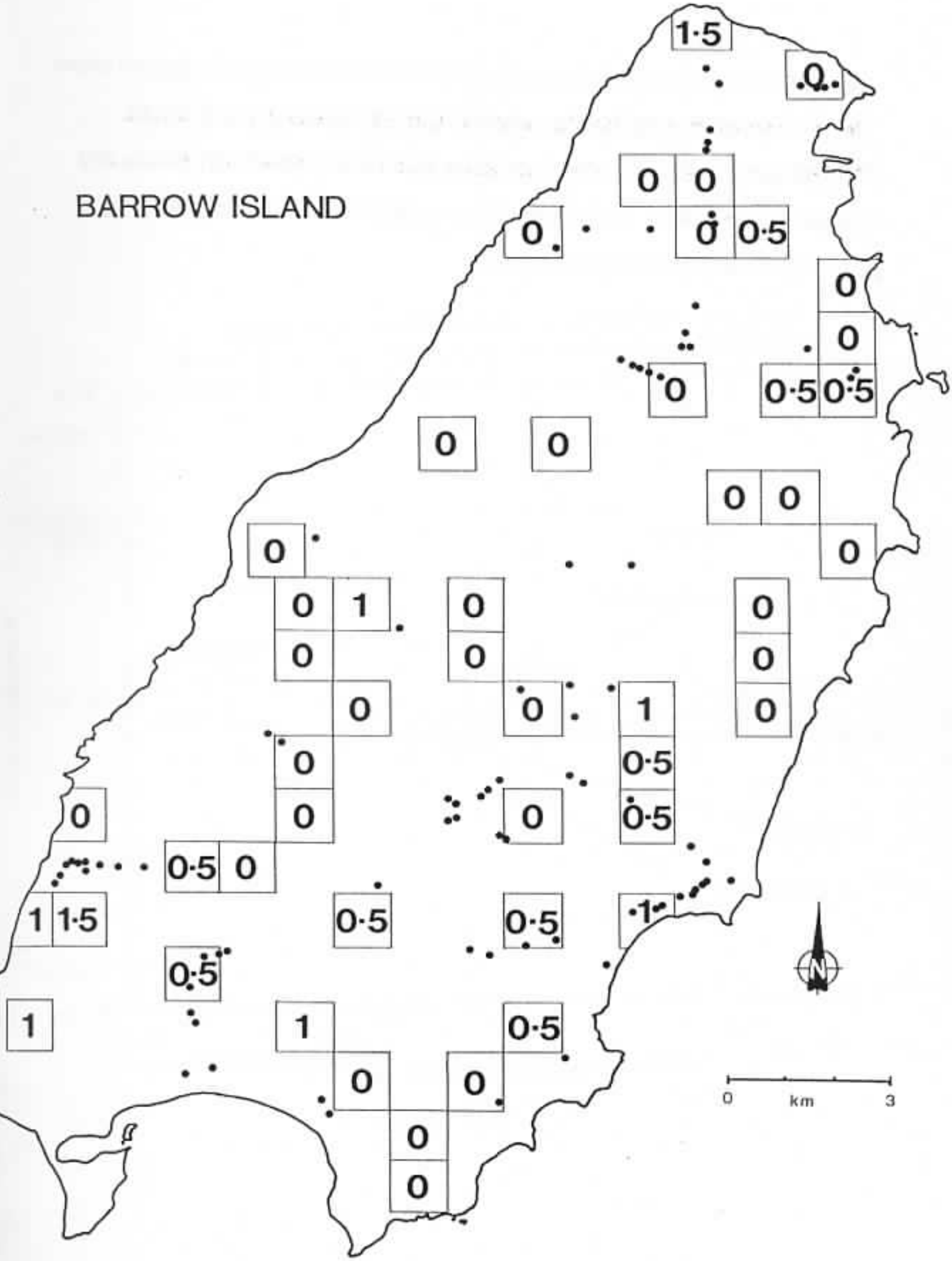

BARROW ISLAND
0
km
3

Fig. 4.2 Principal components analysis of 11 habitat variables on Barrow Island. Vectors represent each habitat variable. Circles represent the 24 blocks. Component 1 is a composite of variables that are correlated with altitude and distance from ocean. Component 2 is a composite of variables measuring disturbance due to oilfield operations.

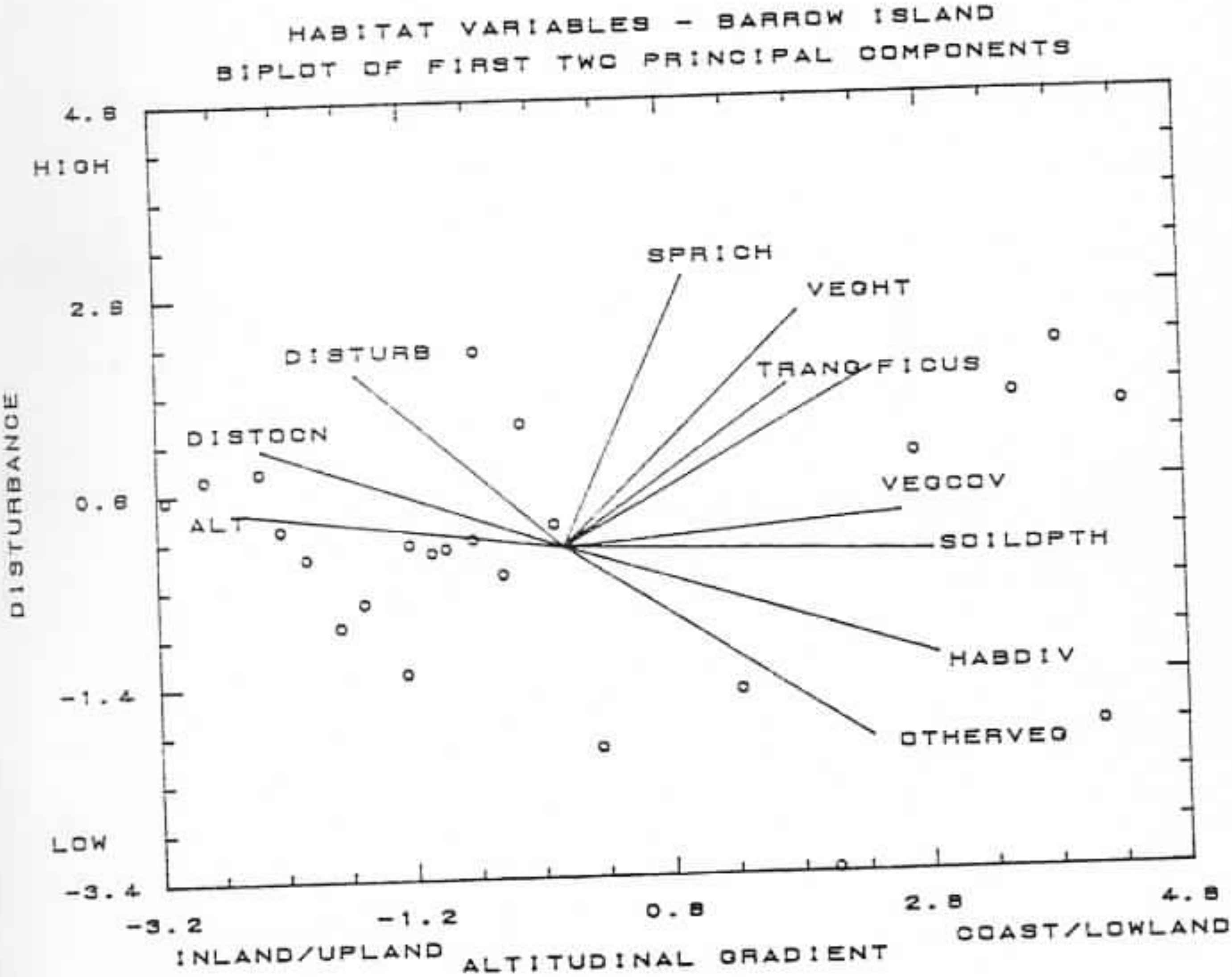

HABITAT VARIABLES - BARROW ISLAND
BIPLOT OF FIRST TWO PRINCIPAL COMPONENTS
4.6
HIGH
2.6
0.6
-1.4
LOW
-3.4
DISTURBANCE
SPRICH
VEGHT
TRANQ
FICUS
DISTURB
DISTOON
VEGCOV
ALT
SOILDPTH
HABDIV
OTHERVEG
-3.2
-1.2
0.8
2.8
4.8
INLAND/UPLAND
ALTITUDINAL GRADIENT
COAST/LOWLAND

Fig. 4.3 Presence/absence of bettongs on 24 trapping grids plotted as a function of the first two principal components. The presence or absence of bettongs does not appear to be related to either component.

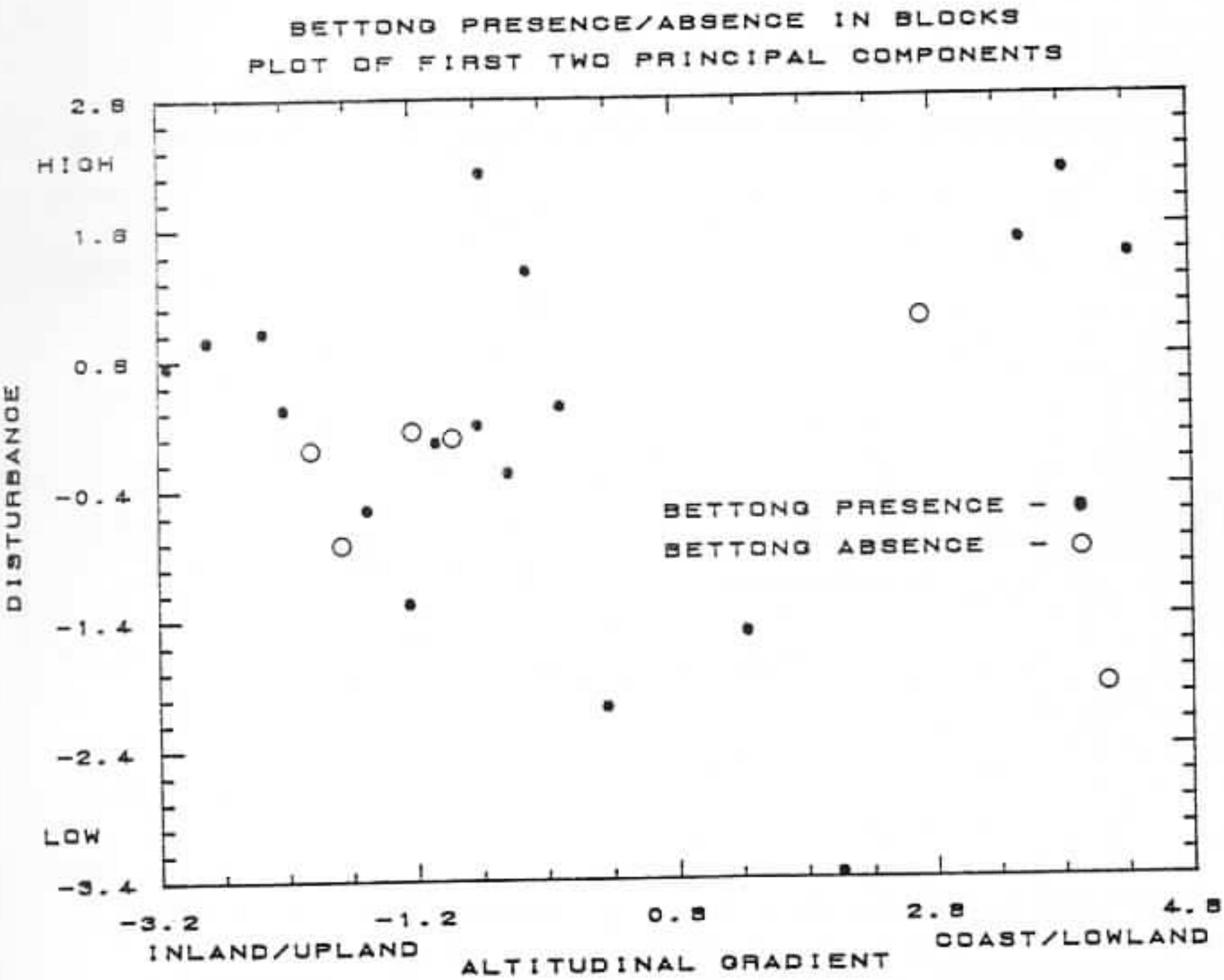

BETTONG PRESENCE/ABSENCE IN BLOCKS
PLOT OF FIRST TWO PRINCIPAL COMPONENTS
2.8
HIGH
1.8
0.8
-0.4
-1.4
-2.4
LOW
-3.4
DISTURBANCE
BETTONG PRESENCE -
BETTONG ABSENCE -
-3.2
-1.2
0.8
2.8
4.8
INLAND/UPLAND
ALTITUDINAL GRADIENT
COAST/LOWLAND

Fig. 4.4 The condition of bettongs on 18 trapping grids plotted as a function of the first two principal components. Blocks are divided into those where bettong condition was above the average (1.10) and those were it is below average.

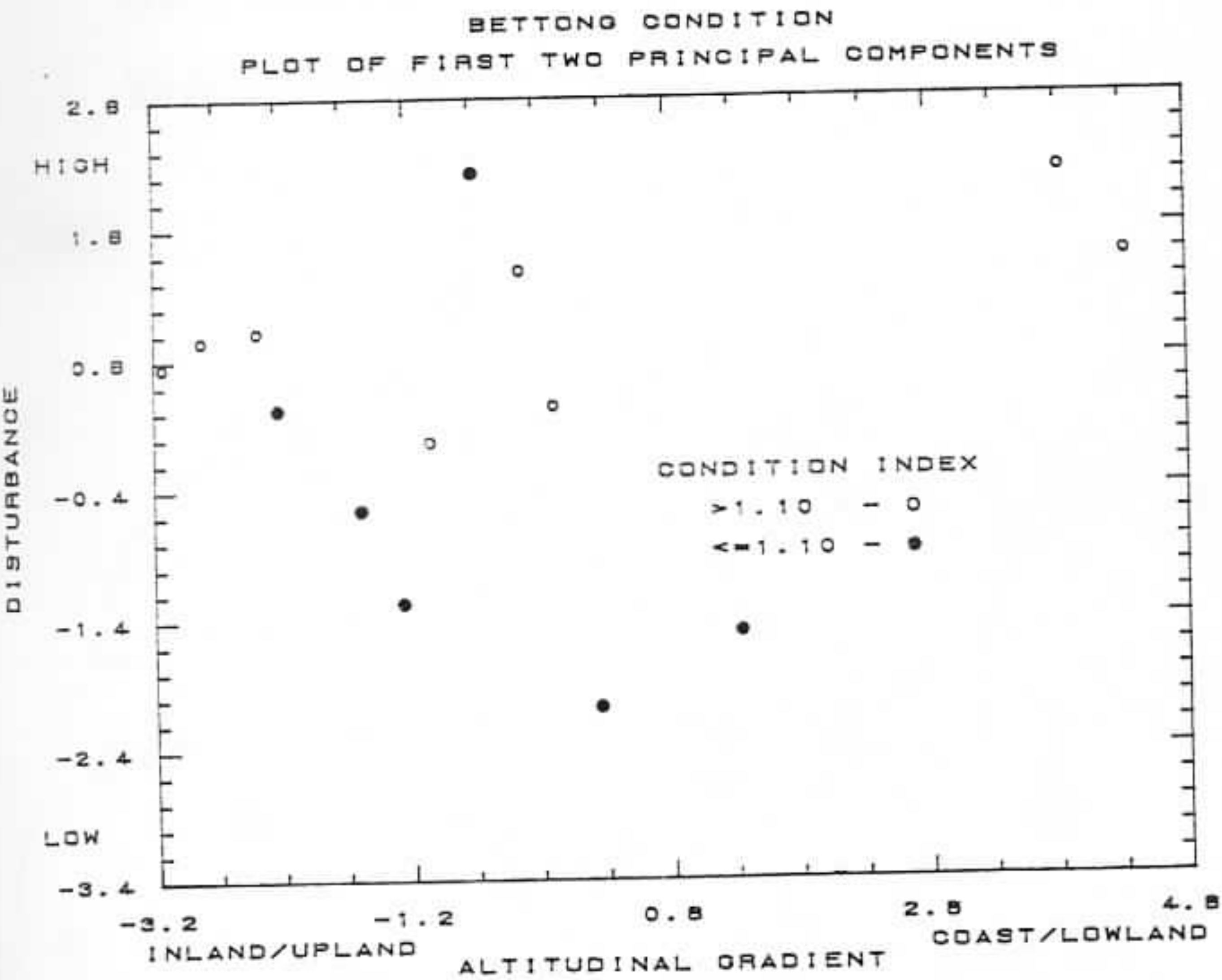

BETTONG CONDITION
PLOT OF FIRST TWO PRINCIPAL COMPONENTS
2.8
HIGH
1.8
0.8
DISTURBANCE
-0.4
-1.4
-2.4
LOW
-3.4
-3.2
-1.2
0.8
2.8
4.8
INLAND/UPLAND
COAST/LOWLAND
ALTITUDINAL GRADIENT
CONDITION INDEX
>1.10 - O
<=1.10 - ●

Fig. 4.5 The distribution of warrens on Barrow Island. Numbers are the number of active entrances.

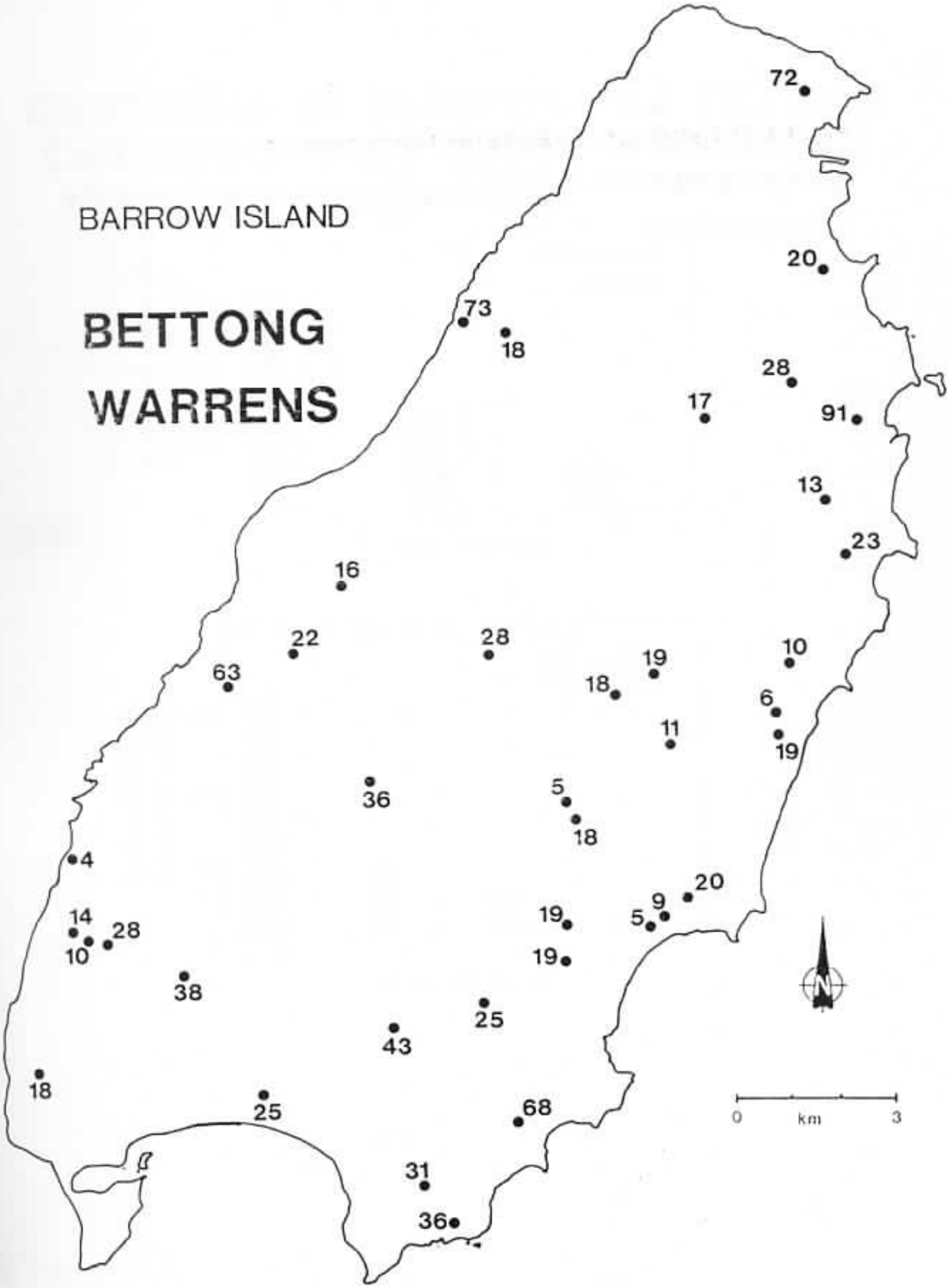
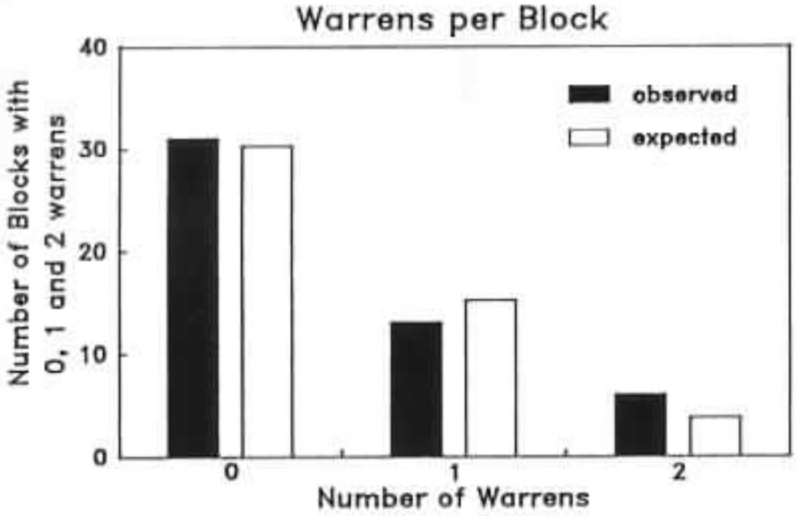

BARROW ISLAND
BETTONG
WARRENS
72
20
73
18
28
17
91
13
23
16
22
28
63
19
18
10
6
11
19
36
5
18
4
20
14
28
10
19
9
5
19
38
25
43
18
25
68
31
36
0
km
3

Fig. 4.6 a) Distribution of warrens per 1 km^2 compared to a Poisson distribution. b) Distribution of bettong sightings compared to a Poisson distribution.

Distribution of Bettongs and Warrens Compared to a Poisson Distribution



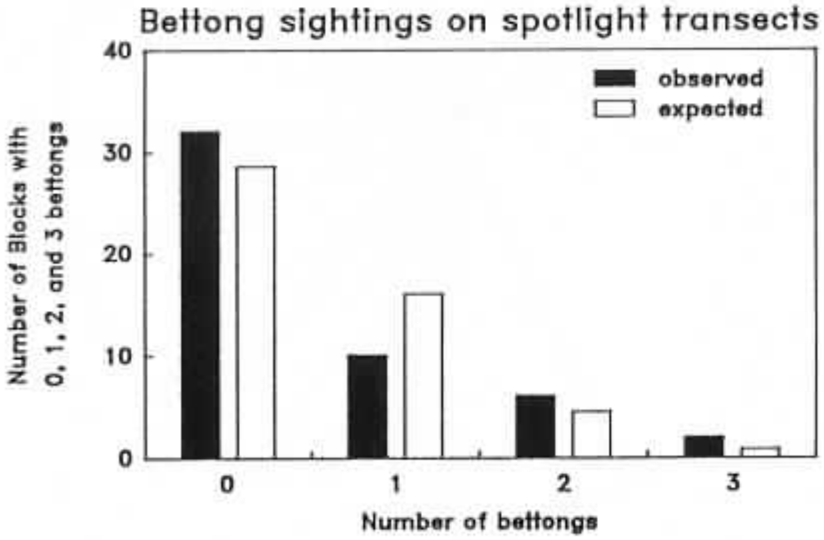


Fig. 4.7 The aspect of bettong warrens on Barrow Island.

ASPECT of BETTONG WARRENS on BARROW ISLAND

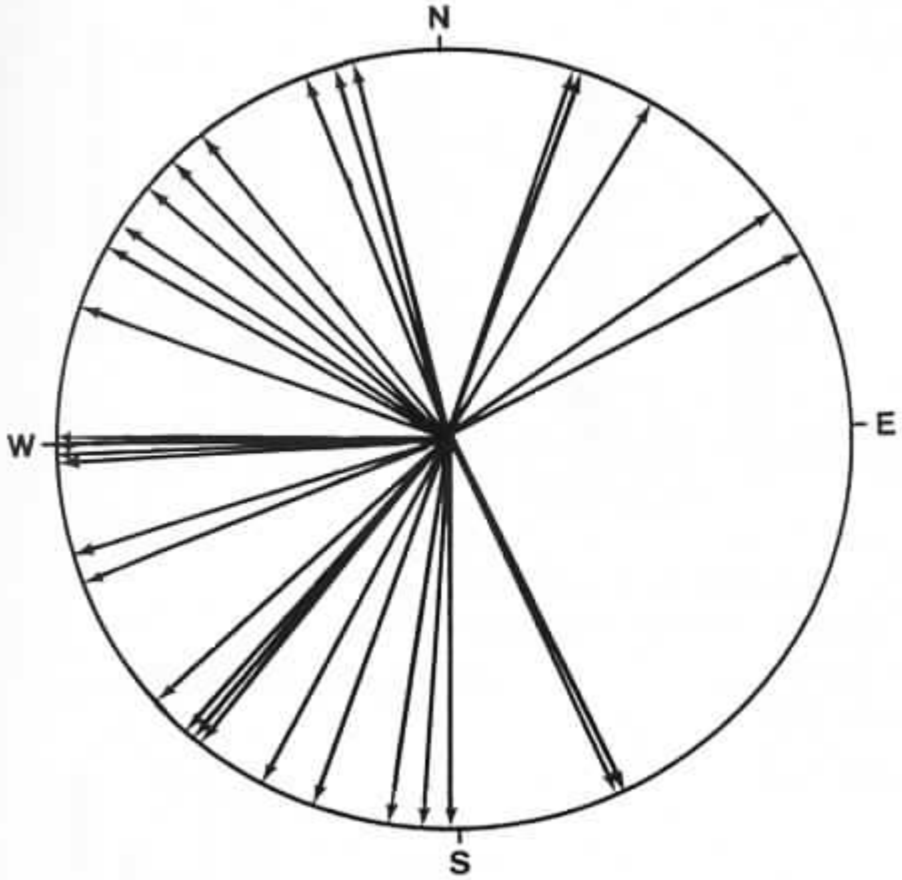
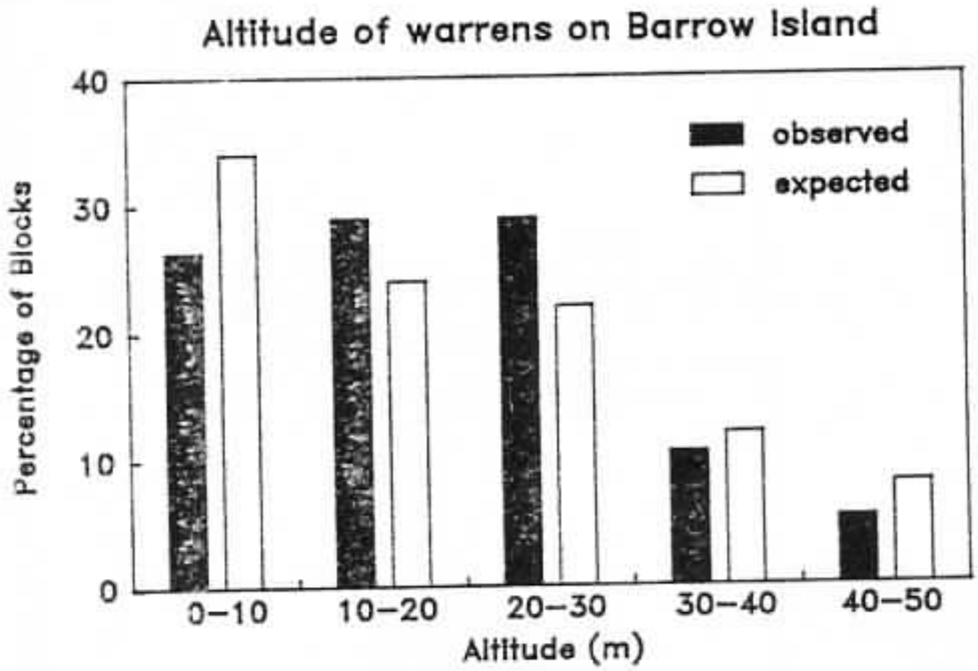


Fig. 4.8 Altitude (a) and distance from ocean (b) of bettong warrens on Barrow Island. Their distribution is compared to that expected from a random distribution.

Position of Warrens Compared to a Poisson Distribution.



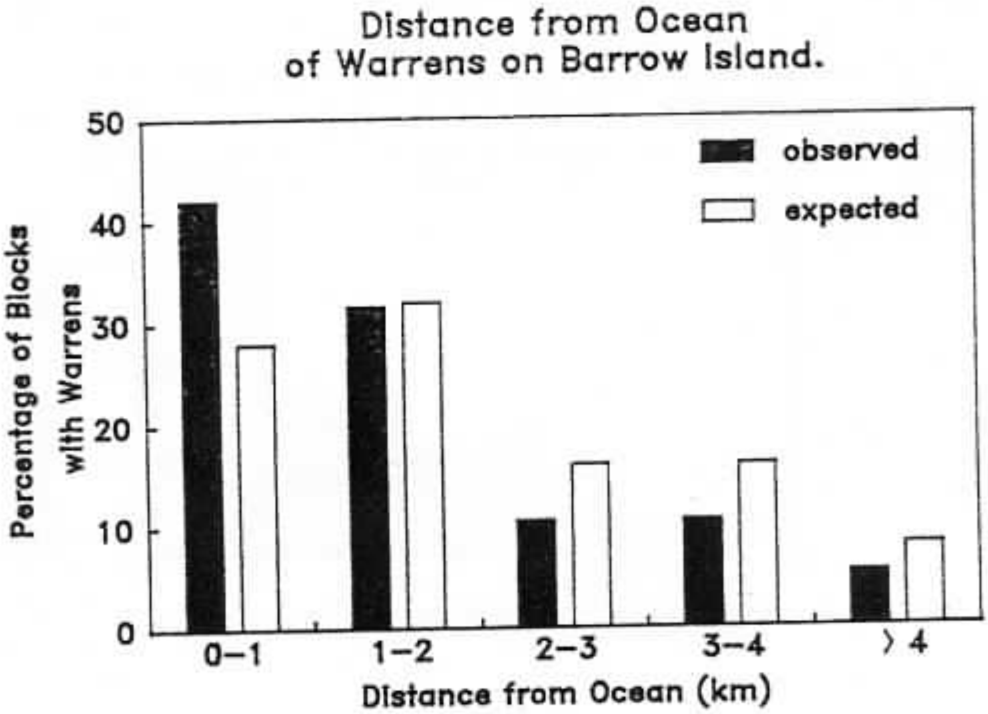
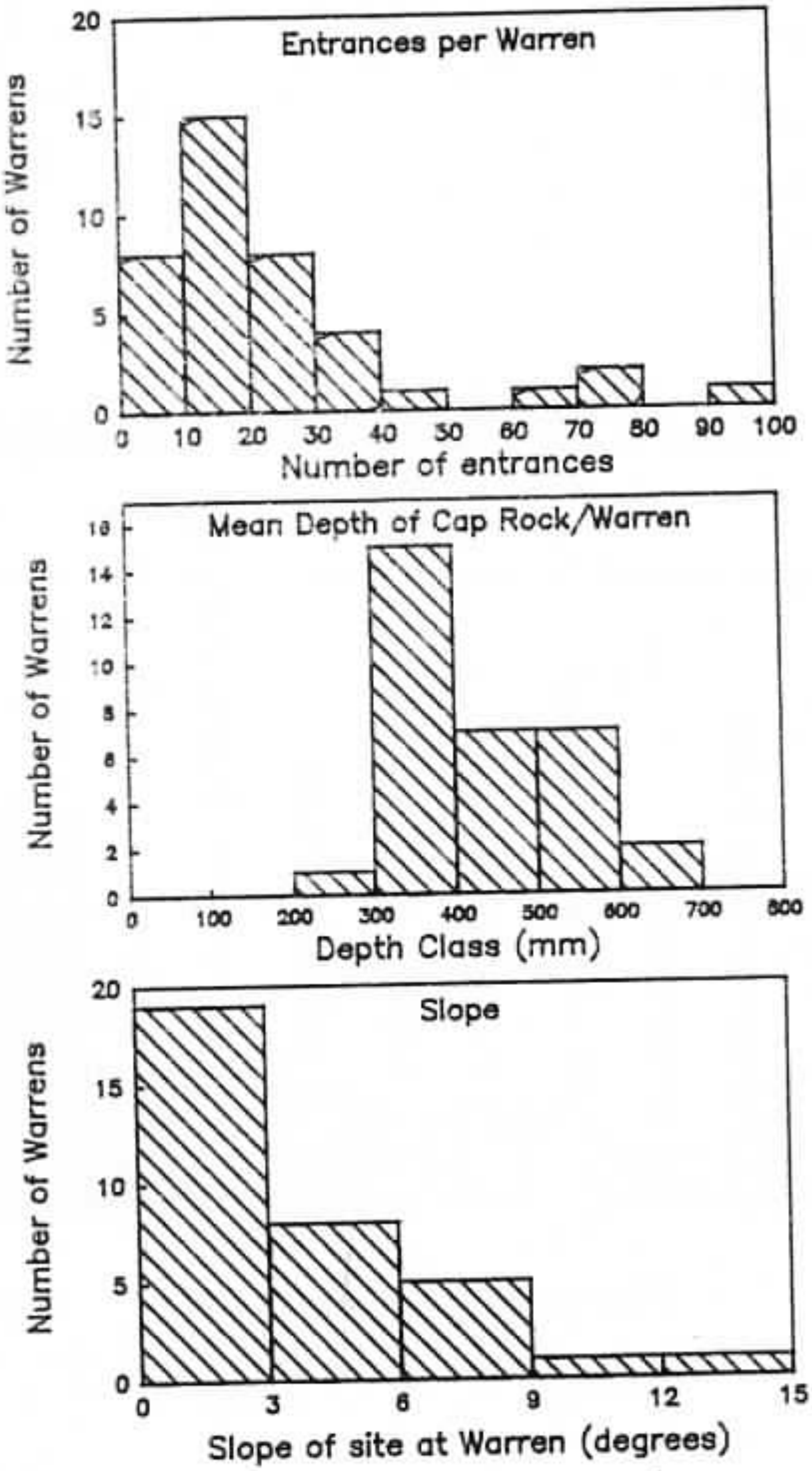


Fig. 4.9 The number of entrances per warren (a), depth of cap rock at burrow entrances (b), and the slope of the sites on which warrens were located (c) on Barrow Island.



Entrances per Warren
Number of Warrens
Number of entrances
Mean Depth of Cap Rock/Warren
Number of Warrens
Depth Class (mm)
Slope
Number of Warrens
Slope of site at Warren (degrees)

Fig. 4.10 The occurrence of trees and shrubs on warren sites on Barrow Island.

Occurence of trees or shrubs on warrens

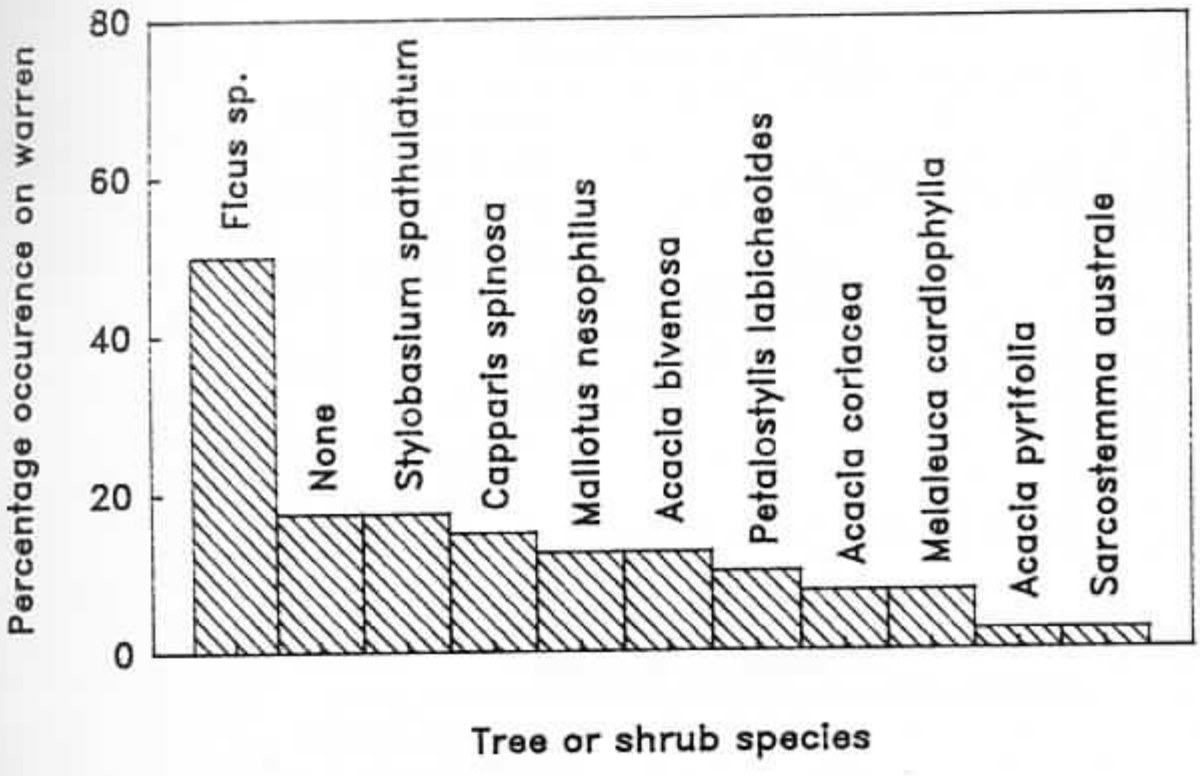
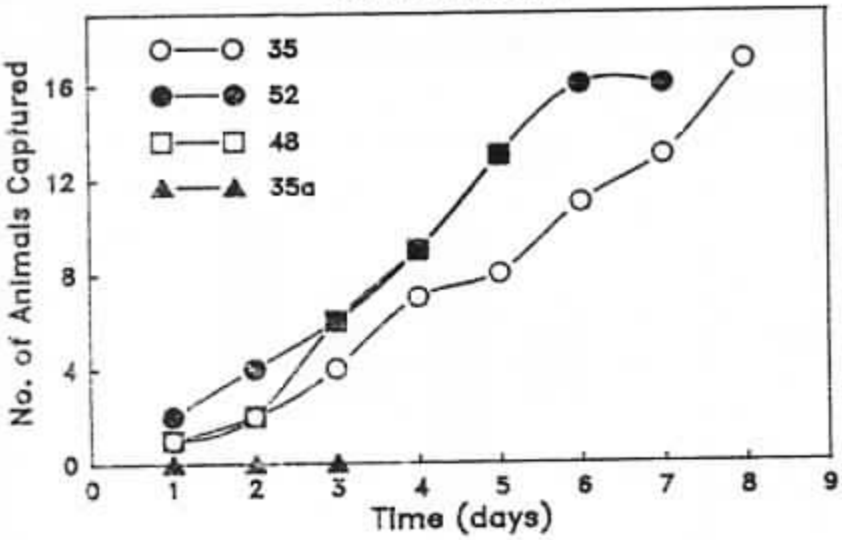


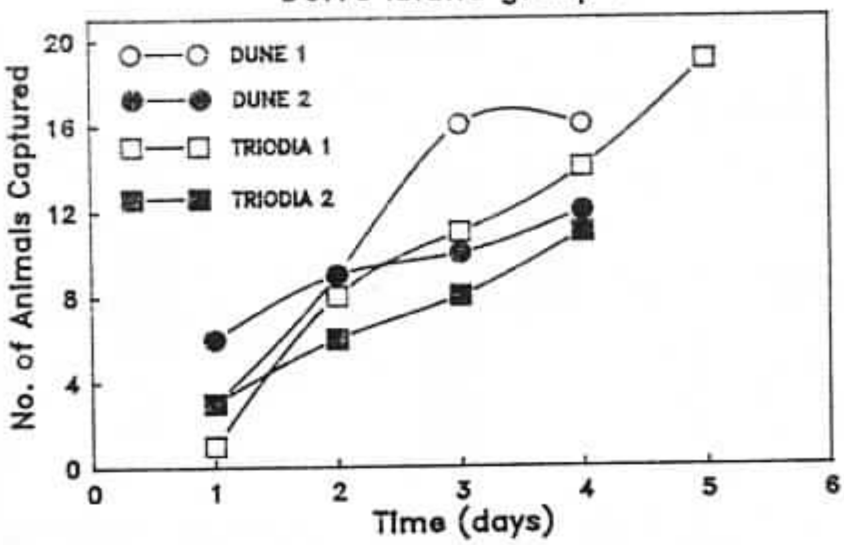
Fig. 4.11 Cumulative captures of bettongs on Barrow and Dorre Islands by habitat.

Cumulative Captures of Bettongs.

Barrow Island



Dorre Island group 1



Dorre Island group 2

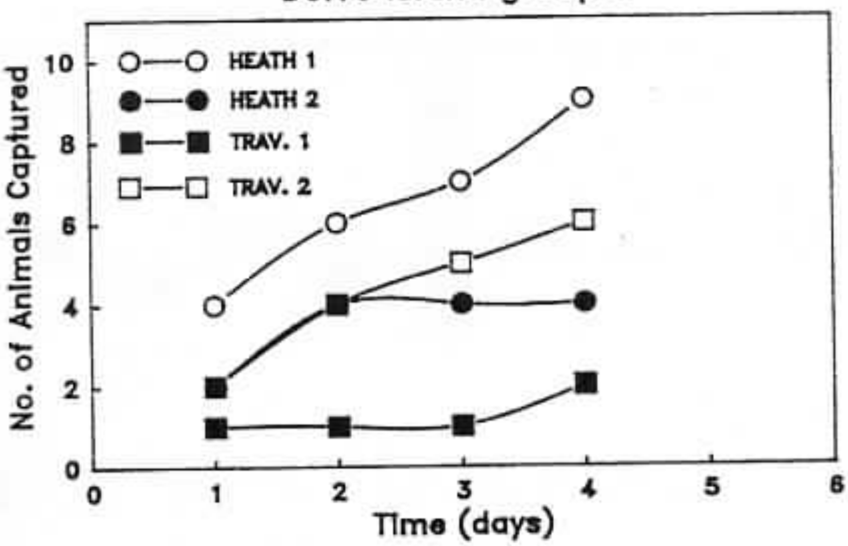
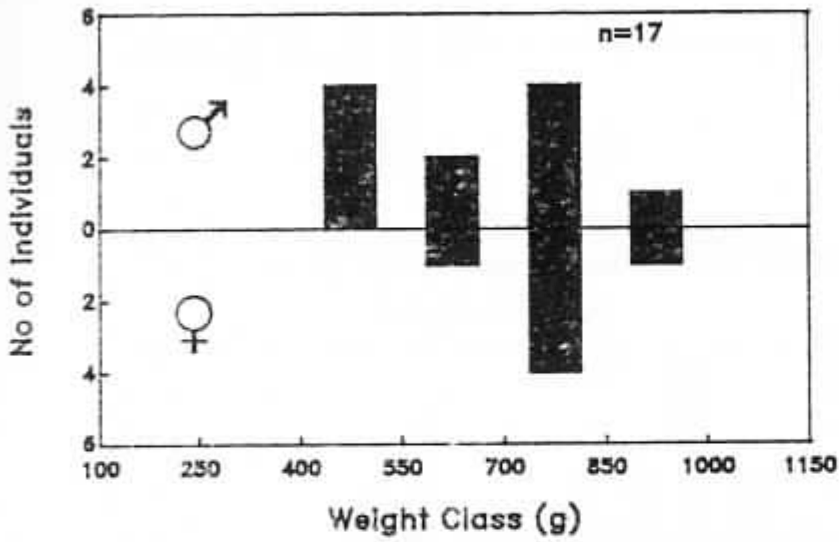
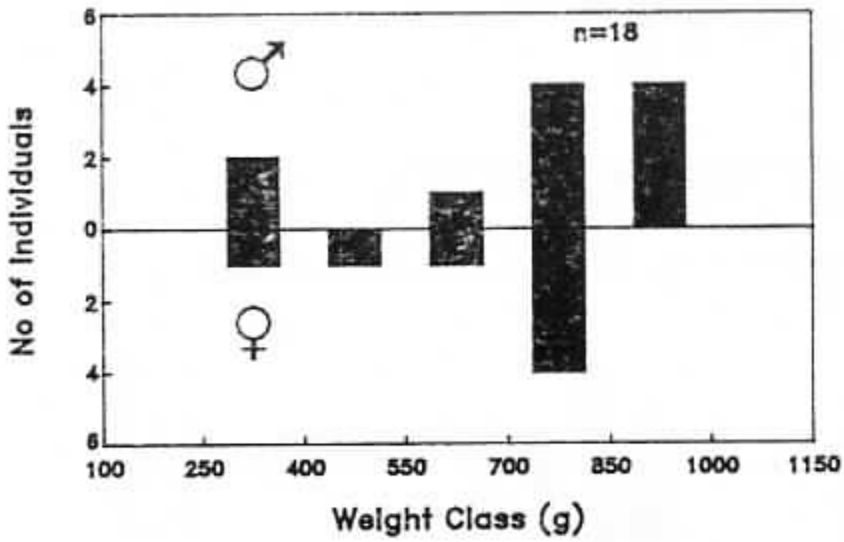


Fig. 4.12 The number, size class and sex of bettongs caught at three warrens on Barrow Island. Most animals within warrens 35 and 52 were probably caught. The 13 animals of warren 48 represent only a small fraction of the total population of this warren.

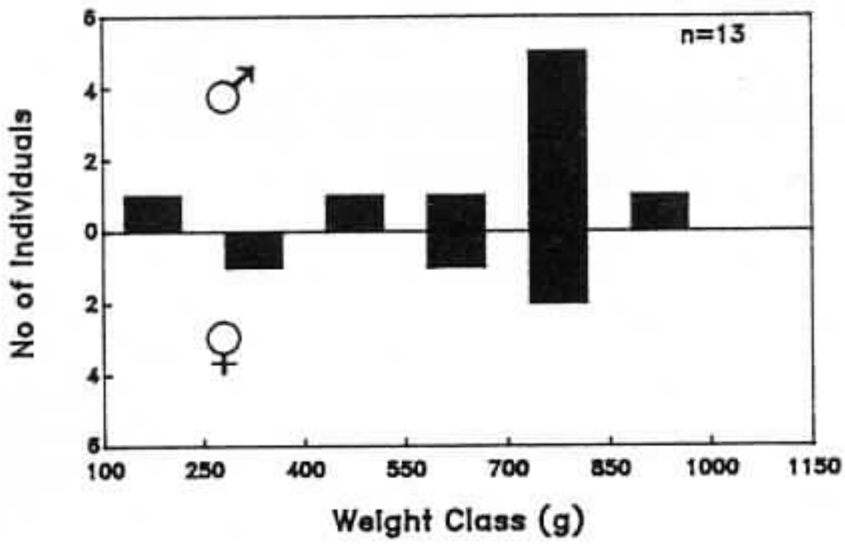
Number, Size Class and Sex of Bettongs within Warrens on Barrow Island.



Warren 35
19 entrances

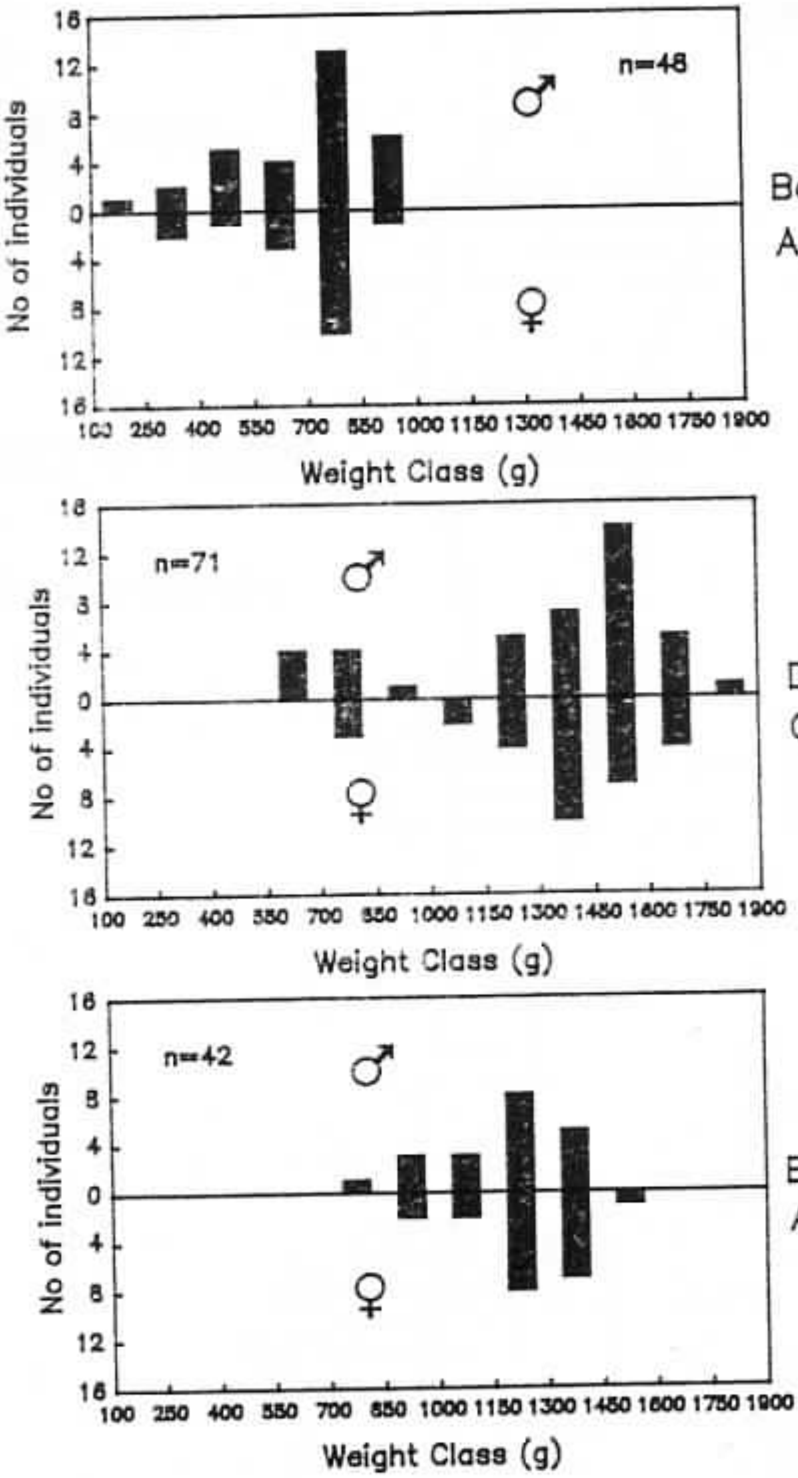


Warren 52
25 entrances



Warren 48

Fig. 4.13 The number, size class and sex of bettongs caught on Barrow, Dorre and Bernier Islands.

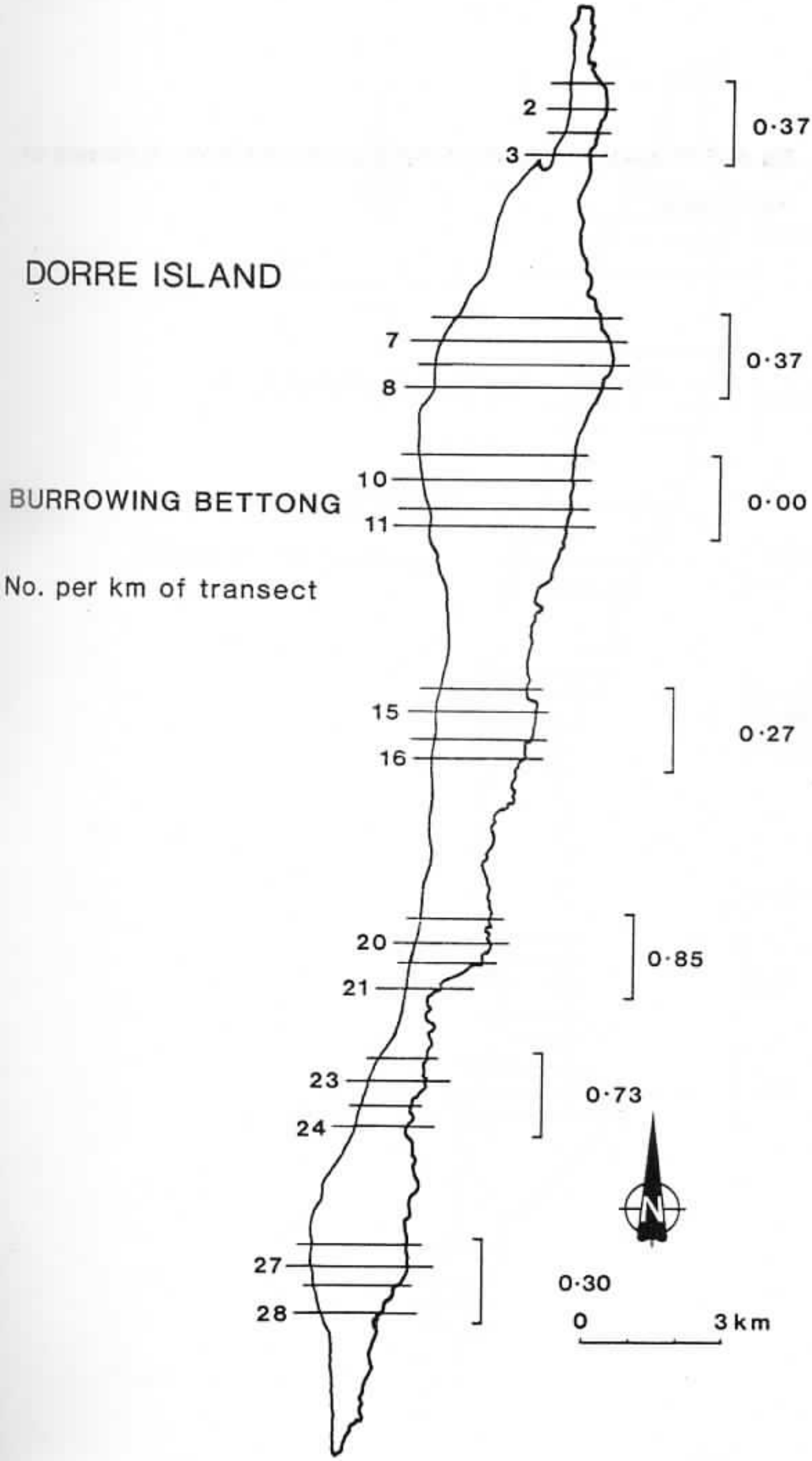


Barrow Island
April 1989

Dorre Island
October 1988

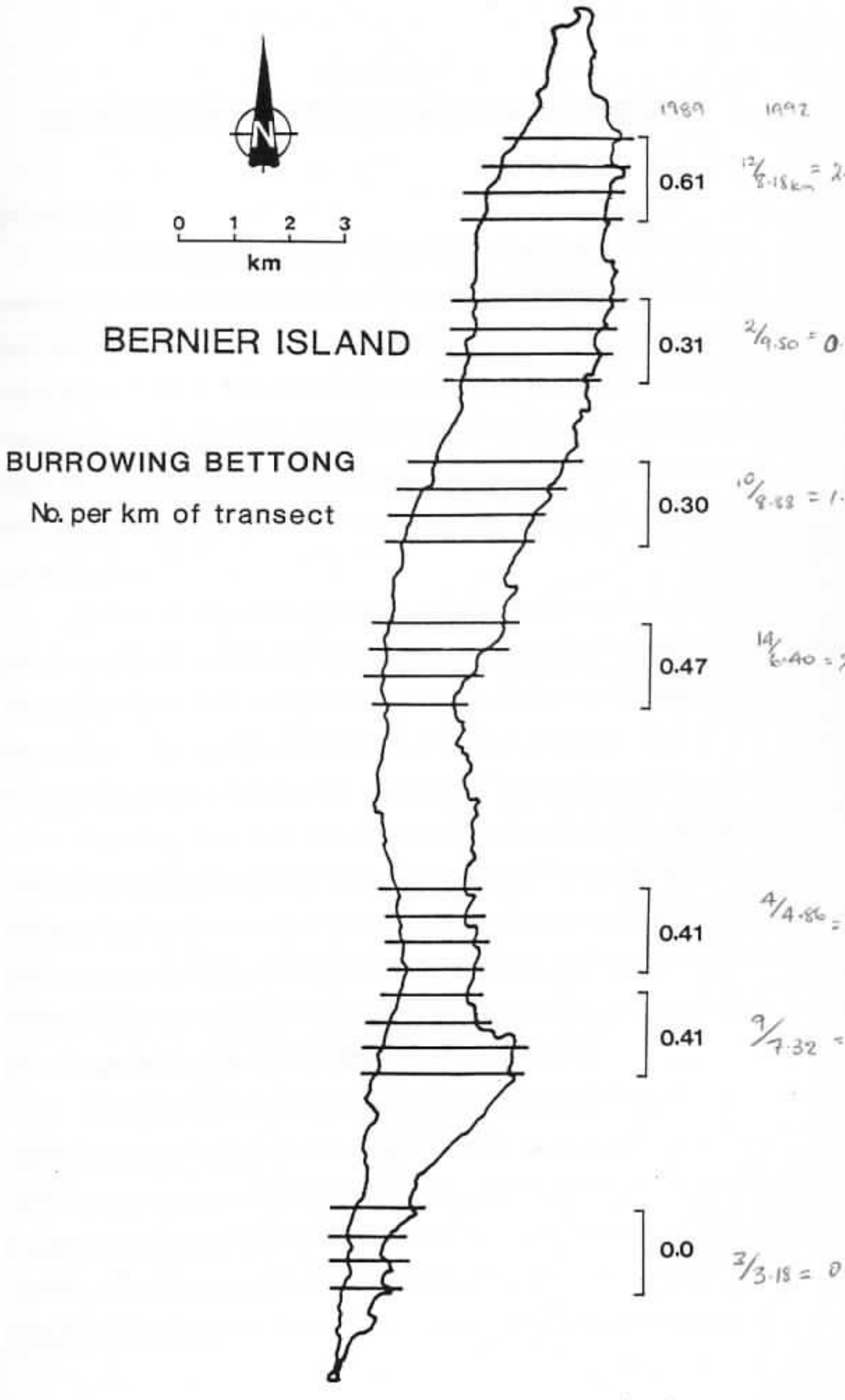
Bernier Island
August 1989

Fig. 4.14 Relative densities of bettongs (number per kilometre of transect) on Dorre Island.



DORRE ISLAND
BURROWING BETTONG
No. per km of transect
2
3
0·37
7
8
0·37
10
11
0·00
15
16
0·27
20
21
0·85
23
24
0·73
27
28
0·30
N
0
3 km

Fig. 4.15 Relative densities of bettongs (number per kilometre of transect) on Bernier Island.



0 1 2 3
km
BERNIER ISLAND
BURROWING BETTONG
No. per km of transect
1989
1992
0.61
12/8.18km = 2
0.31
2/9.50 = 0
0.30
10/8.88 = 1
0.47
14/6.40 =
0.41
4/4.86 =
0.41
9/7.32 =
0.0
3/3.18 = 0
Total km = 48.32

Chapter 5

DISTRIBUTION OF OTHER MACROPODS AND BANDICOOTS

Barrow Island

Density indices (number per kilometre) for euros, spectacled hare-wallabies, possums, and bandicoots from spotlight transects walked in July 1988 are presented in Figs 5.1, 5.2, 5.3, and 5.4. Euros are most abundant in the deeply dissected country in the central west of the island, and in areas where there are floodout flats (south-west, south-east and north). The latter areas are the only places on Barrow that are dominated by grasses other than Triodia or Spinifex. This is a minor habitat by area but is favoured by euros (Fig. 5.5).

Spectacled hare-wallabies are the most abundant of the macropods and are widely distributed across the island in all habitat types. They showed a preference for dune and floodout flats, being encountered more frequently in these than was expected from their relative areas (Fig 5.5). However the combined areal extent of these habitats is small (<3%).

Possums, also, occur widely. We encountered few in the central-north of the island while spotlighting. Our impression is that they are common in upland areas where Ficus platypoda are common, and where there are many solution tubes penetrating cap rock to provide subterranean shelter. Trapping on 24 grids scattered widely across the island suggested an average density of 0.45 ha^{-1} (Short and Turner 1989b).

Bandicoots are abundant and ubiquitous on Barrow Island. The rather sparse spotlighting results presented in Fig. 5.4 are in direct contrast with their omnipresence on trapping grids across the island. This suggested a population density of 2.5 ha^{-1} or *c.* 60,000 for the island (Short and Turner 1989b). Spotlighting results indicated that they were more common in beach and dune habitats than would be expected from the relative areas of these habitats (Fig. 5.5). This may, in part, be a function of their greater visibility in these habitats.

Disturbed sites (seismic lines, pipelines, roads, well-heads) were favoured most by bettongs, bandicoots, hare-wallabies and euros in decreasing order (Fig. 5.6)

Dorre Island

The distributions of banded and rufous hare-wallabies and western barred bandicoots are shown in Figures 5.7, 5.8, and 5.9. The values on the right-hand side of these figures give measures of the number of animals sighted per kilometre of spotlight survey during October 1988.

Banded hare-wallabies were most abundant in the south of the island (Fig. 5.7). Rufous hare-wallabies were widespread at low densities (Fig. 5.8). Both hare-wallabies were common on the inland dunes and the narrow band of travertine along the west coast of the island (Table 5.1). Both used these habitats to a much greater extent than would be expected from their areas. Rufous hare-wallabies were often seen on the beach or in the dunes immediately behind the beach. Banded hare-wallabies were rare in this habitat except for one site immediately north of White Beach where there were dense shrubs close to the coast.

Bandicoots used coastal habitats, *Triodia* steppe, and inland dune almost equally but spent little time in travertine (Table 5.1). They were sighted in heath at approximately the frequency expected from its area. This contrasts with the results from trapping (see Table 5.7) where 40% of bandicoots were caught in this habitat. Bandicoots were present at low densities throughout the island, although few were sighted in the north (Figure 5.9).

Bernier Island

Banded hare-wallabies were abundant in the northern half of Bernier Island but rare in the south. The distribution of rufous hare-wallabies was the reverse: they were common in the south but sparse in the north. The abundance of banded hare-wallabies seemed linked to the presence of dense thickets of vegetation. These were provided mainly by *Acacia ligulata*, *A. coriacea*, and *Heterodendrum oleifolium* on the inland plain and *Diplolaena dampieri* and *Heterodendrum oleifolium* on the dunes or dune/travertine interface. The general height and density of vegetation increased sharply northward from ankle-height heath on the inland plain near Red Cliff Point to denser mid-calf to mid-thigh height vegetation in the north. The inland plain was generally devoid of *Acacias* in the south and the odd clump of *H. oleifolium* was a rarity. In the lee of dunes *D. dampiera* provided the only substantial shelter. In the north *Abutilon* sp., *Acacia coriacea*, *A. ligulata*, *H. oleifolium* were abundant.

Western barred bandicoots were relatively common on the inland plain and in the dunes near Red Cliff Point. However we made few sightings elsewhere. They were noticeably less common than on Dorre Island.

Table 5.1 Percentage of sightings of western barred bandicoots (WBB), rufous hare-wallabies (RH-W), and banded hare-wallabies (BH-W) seen in particular habitats while walking spotlight transects on Dorre and Bernier Islands.

Habitat	WBB	RH-W	BH-W	% occurrence of habitat
Dorre				
Beach/ coastal dune	8.3	0.0	0.0	5.0
Triodia	41.7	19.2	19.2	46.4
Sandplain heath	8.3	23.1	9.6	8.5
Consolid. Dune	41.7	42.3	48.1	21.7
Travertine heath	0.0	15.4	23.1	18.3
Bernier				
Beach/ unconsol. dune	33.4	11.3	17.7	19.2
Triodia	0.0	13.6	12.9	5.2
Heath	50.0	47.7	58.1	48.8
Consolid. dune	16.7	27.7	9.7	18.5
Travertine	0.0	4.5	1.6	1.2

Dorre WBB: n = 12; RH-W: n = 26, X^2 = 9.7, d.f. = 2, significant departure from expected; BH-W: n = 52, X^2 = 125.7, d.f. = 4, highly significant departure from expected.

Bernier WBB: n = 6; RH-W: n = 44, X^2 = 2.96, d.f. = 3, no significant departure from expected; BH-W: n = 62, X^2 = 17.7, d.f. = 4, significant departure from expected.

Fig. 5.1 Density indices (number per kilometre of spotlight transect) of euros in 50 blocks of 1 km^2 on Barrow Island.

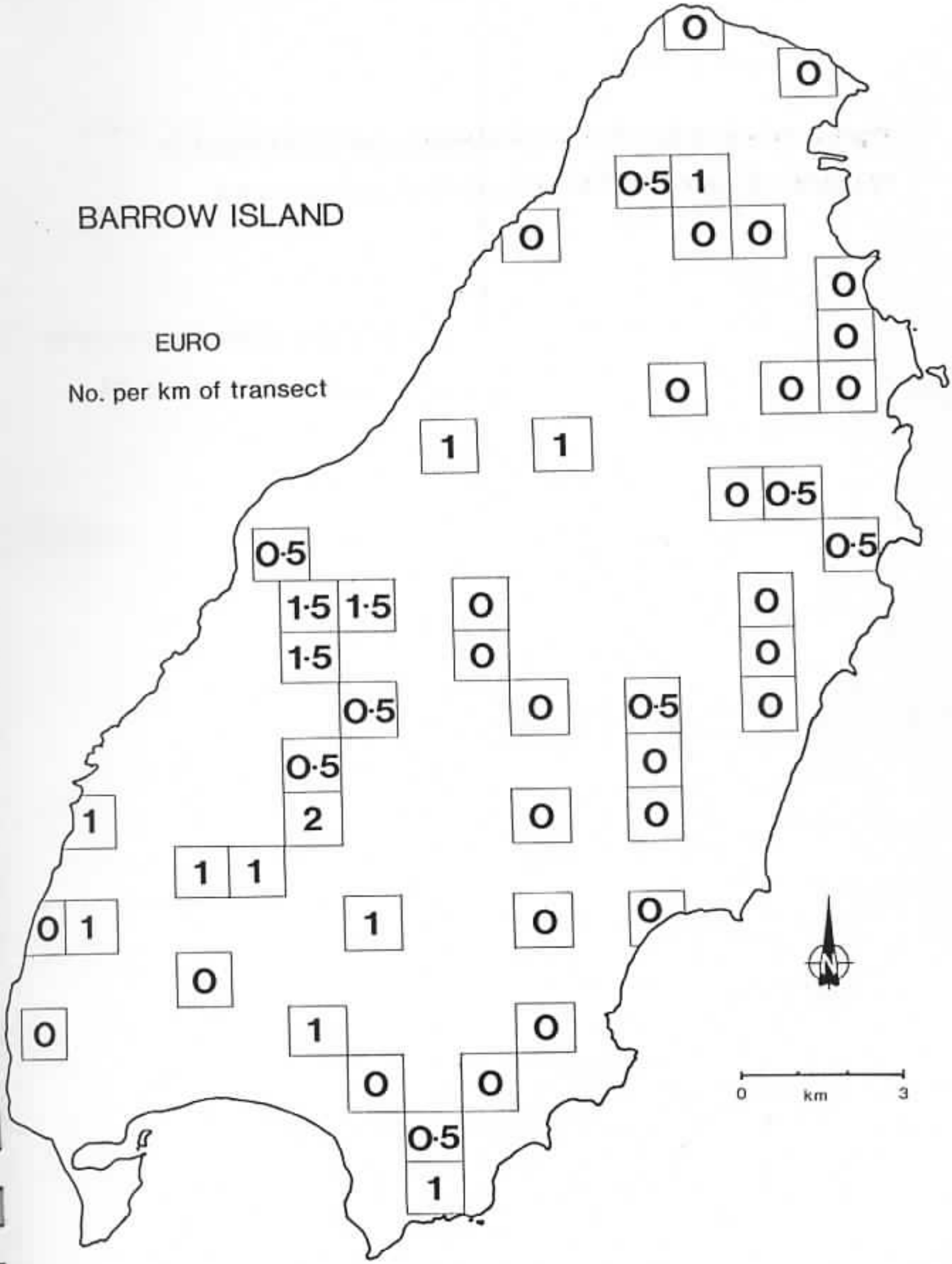

BARROW ISLAND
EURO
No. per km of transect
0 km 3

Fig. 5.2 Density indices (number per kilometre of spotlight transect) of spectacled hare-wallabies in 50 blocks of 1 km^2 on Barrow Island.

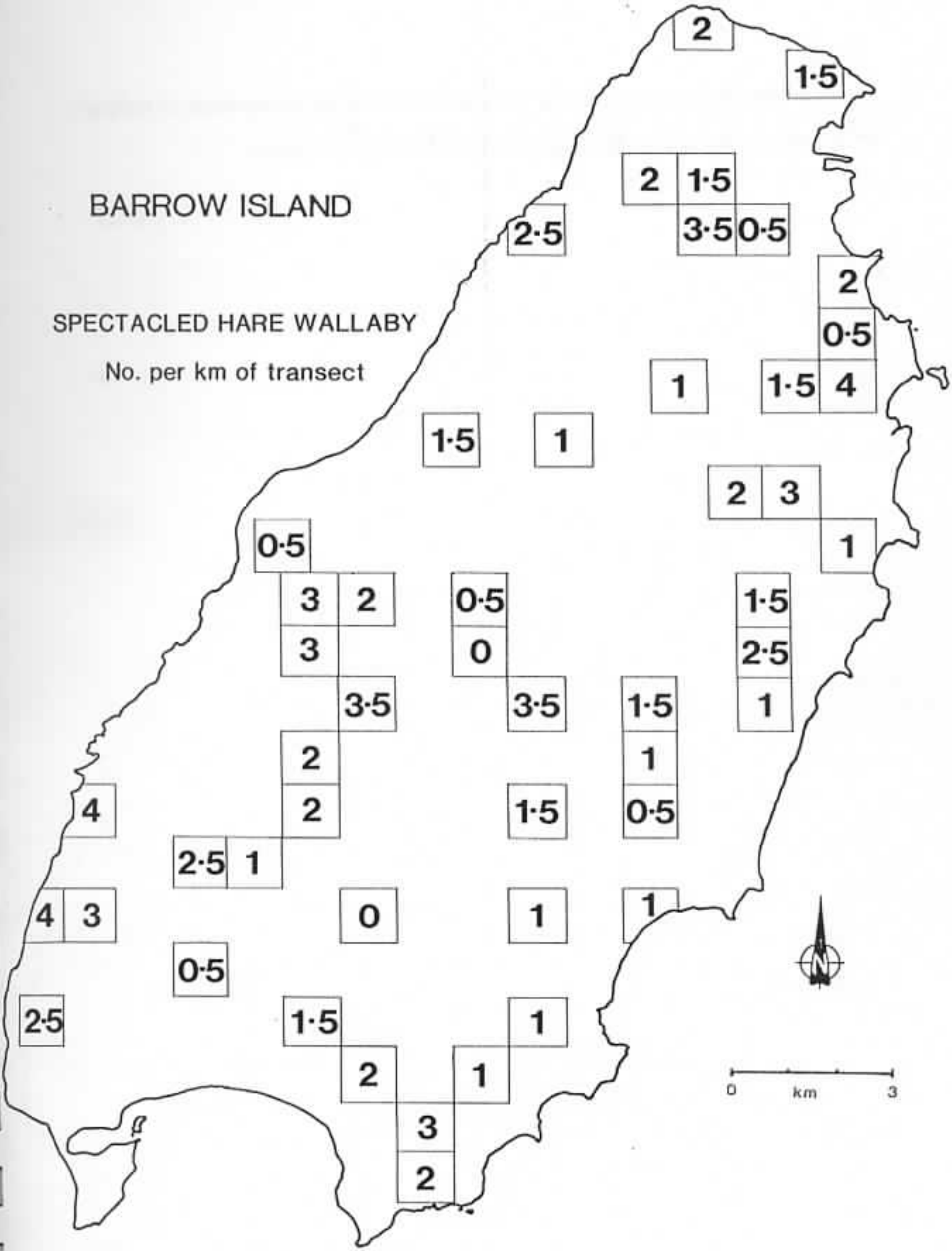

BARROW ISLAND
SPECTACLED HARE WALLABY
No. per km of transect
0
km
3

Fig. 5.3 Density indices (number per kilometre of spotlight transect) of northern brush-tailed possums in 50 blocks of 1 km^2 on Barrow Island.

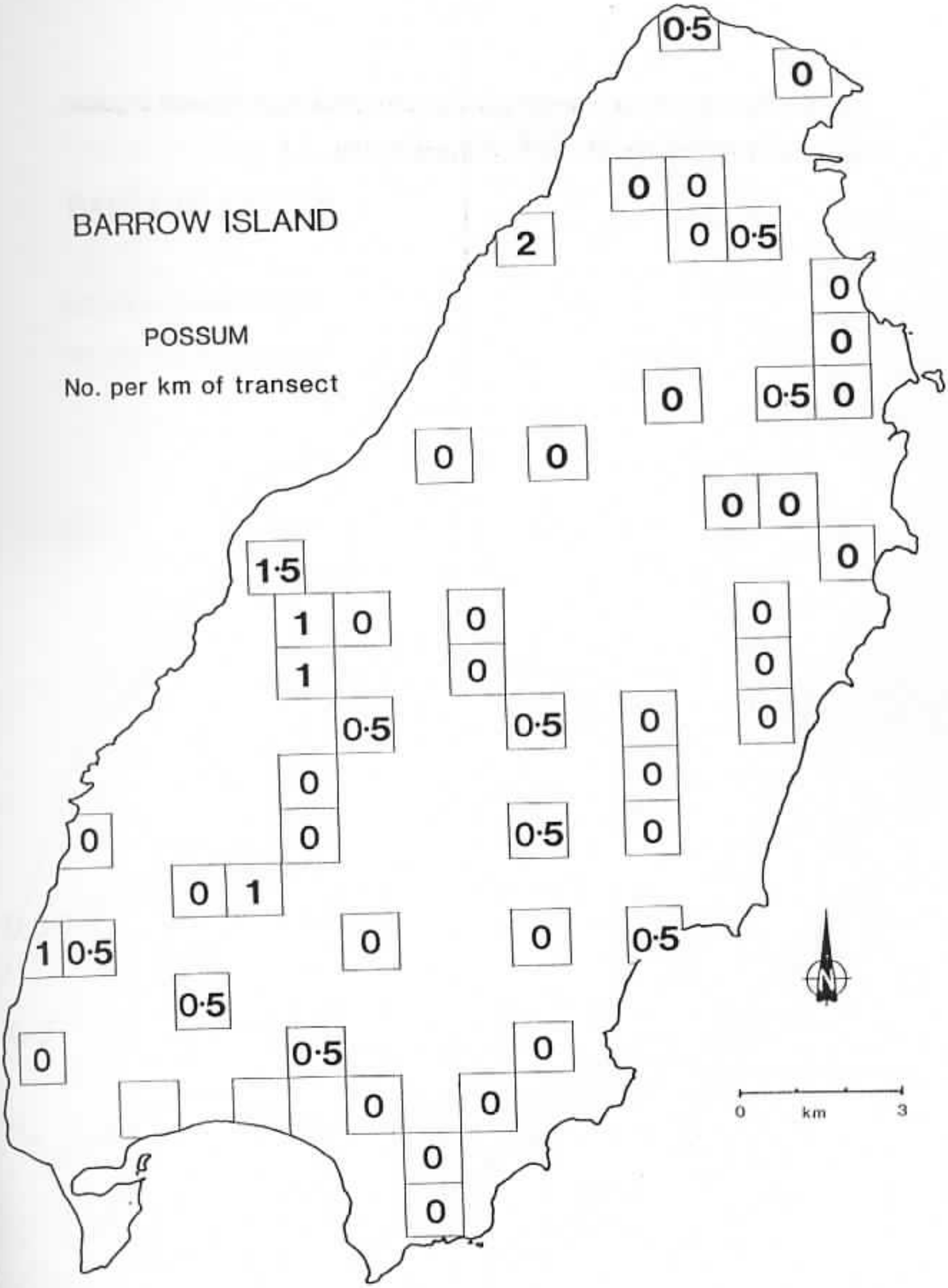
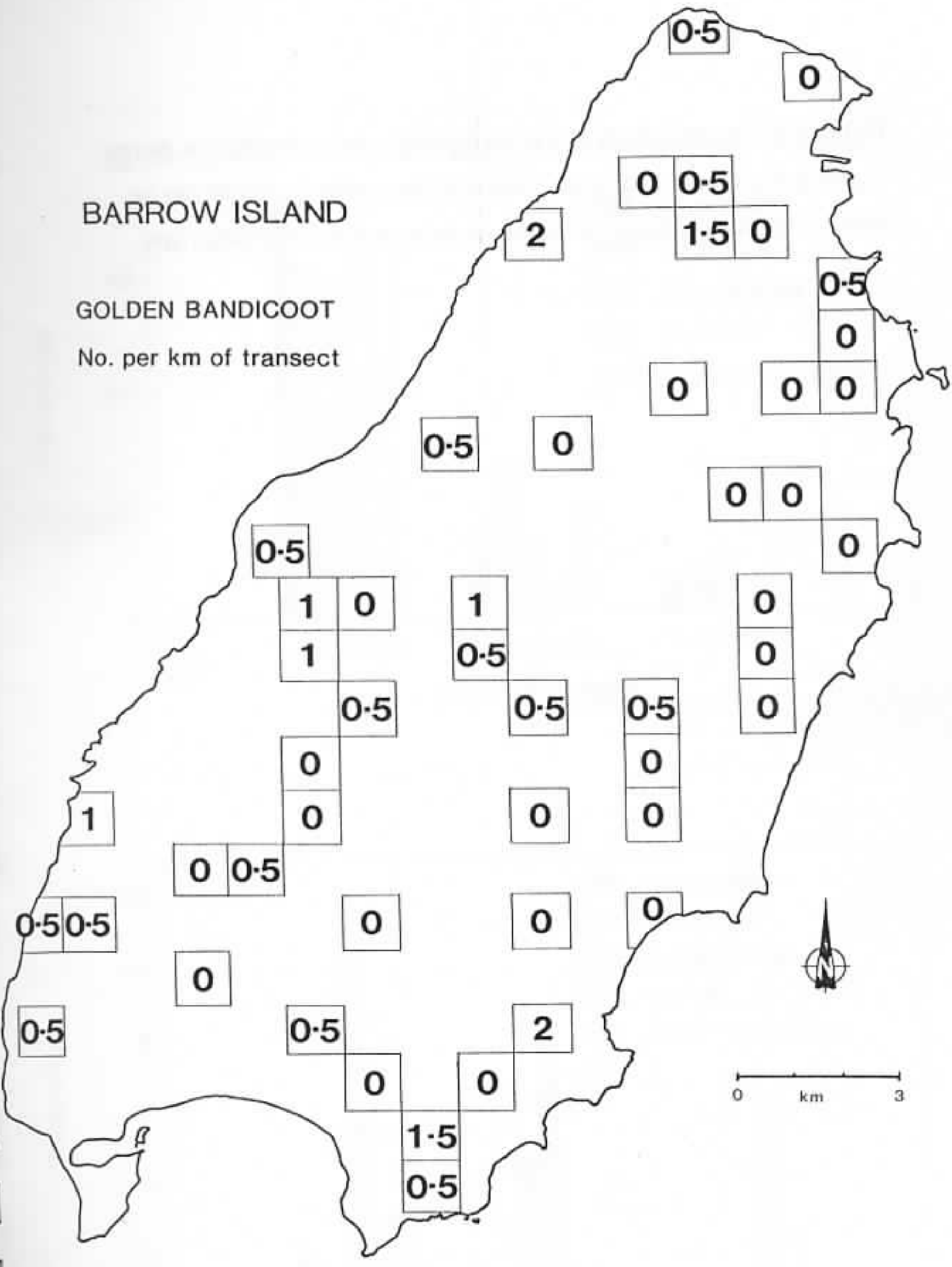

BARROW ISLAND
POSSUM
No. per km of transect
0
km
3

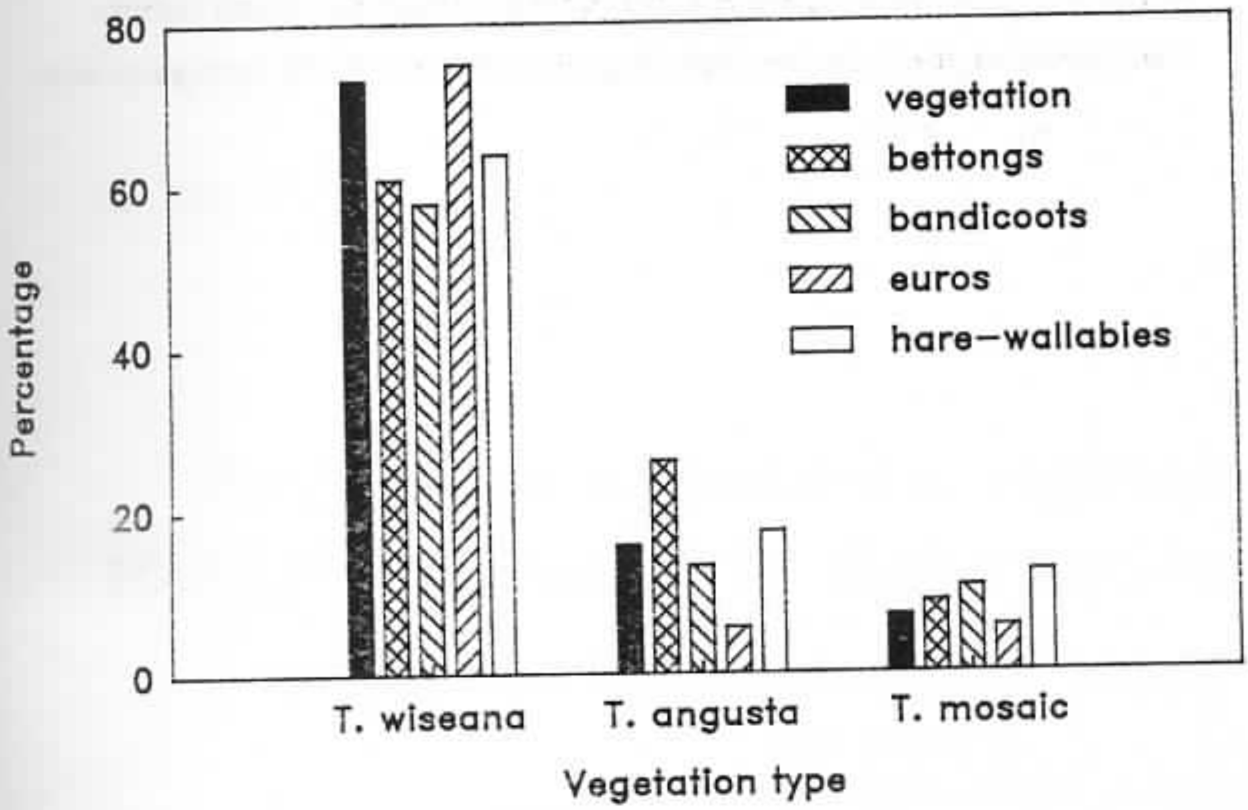
Fig. 5.4 Density indices (number per kilometre of spotlight transect) of golden bandicoots in 50 blocks of 1 km^2 on Barrow Island.



BARROW ISLAND
GOLDEN BANDICOOT
No. per km of transect
0·5
0
0
0·5
2
1·5
0
0·5
0
0
0
0
0·5
0
0
0
0·5
0
1
0
1
0
1
0·5
0
0·5
0·5
0·5
0
0
0
1
0
0
0
0
0·5
0·5
0·5
0
0
0
0
0·5
0·5
2
0
0
1·5
0·5
N
0
km
3

Figure 5.5 The percentage of animals sighted in various habitats on Barrow Island during spotlight surveys. Preference for a particular habitat can be deduced by comparing to the relative abundance of that vegetation type.

a)


80
60
40
20
0
Percentage
vegetation
bettongs
bandicoots
euros
hare-wallabies
T. wiseana
T. angusta
T. mosaic
Vegetation type

b)

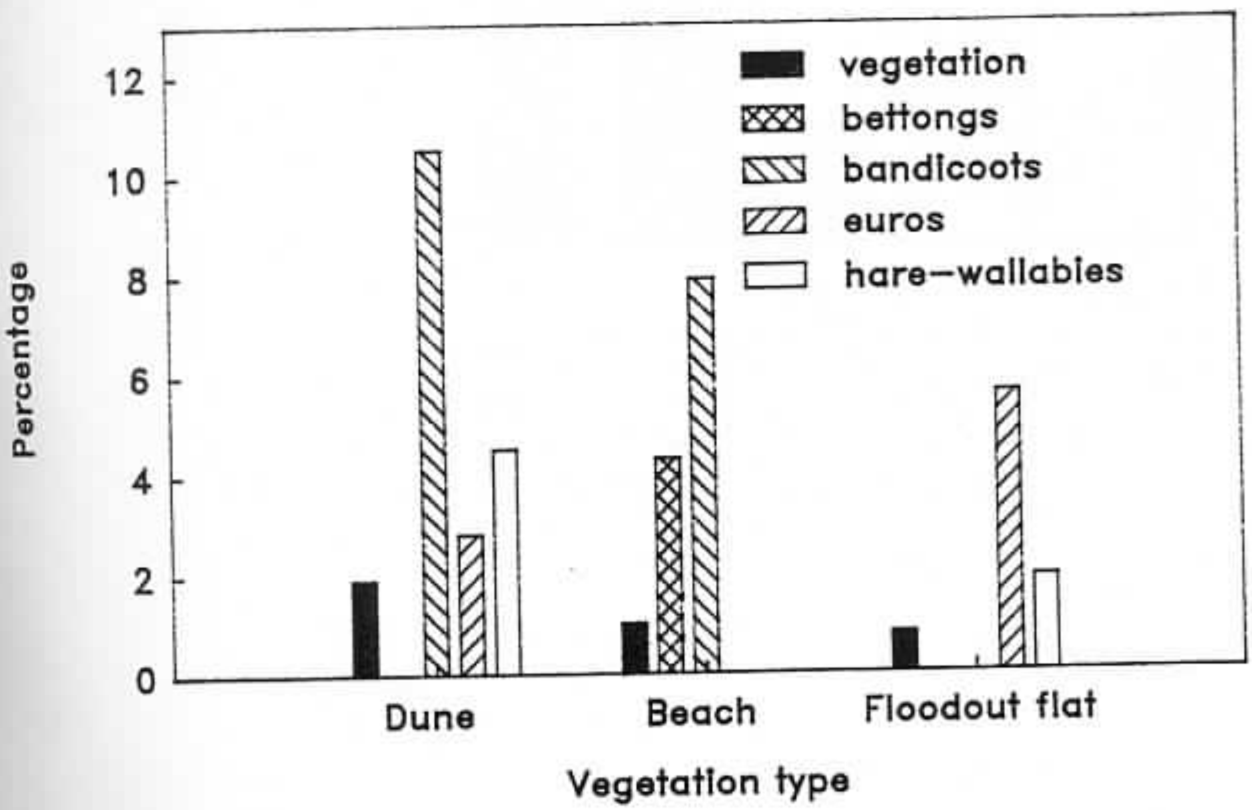

12
10
8
6
4
2
0
Percentage
vegetation
bettongs
bandicoots
euros
hare-wallabies
Dune
Beach
Floodout flat
Vegetation type

Figure 5.6 The percentage of animals sighted in disturbed habitats (seismic lines, pipelines, roads and well heads) on Barrow Island during spotlight surveys.

Percentage of animals sighted on spotlight transects in disturbed habitats

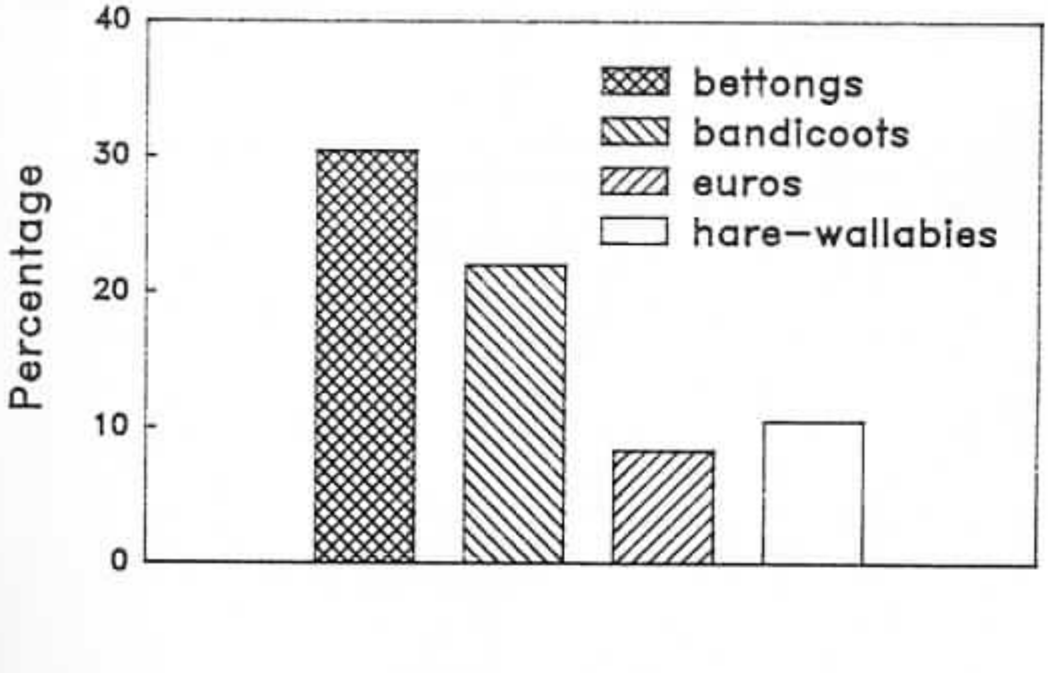


Fig. 5.7 The distribution of the banded hare-wallaby on Dorre Island.

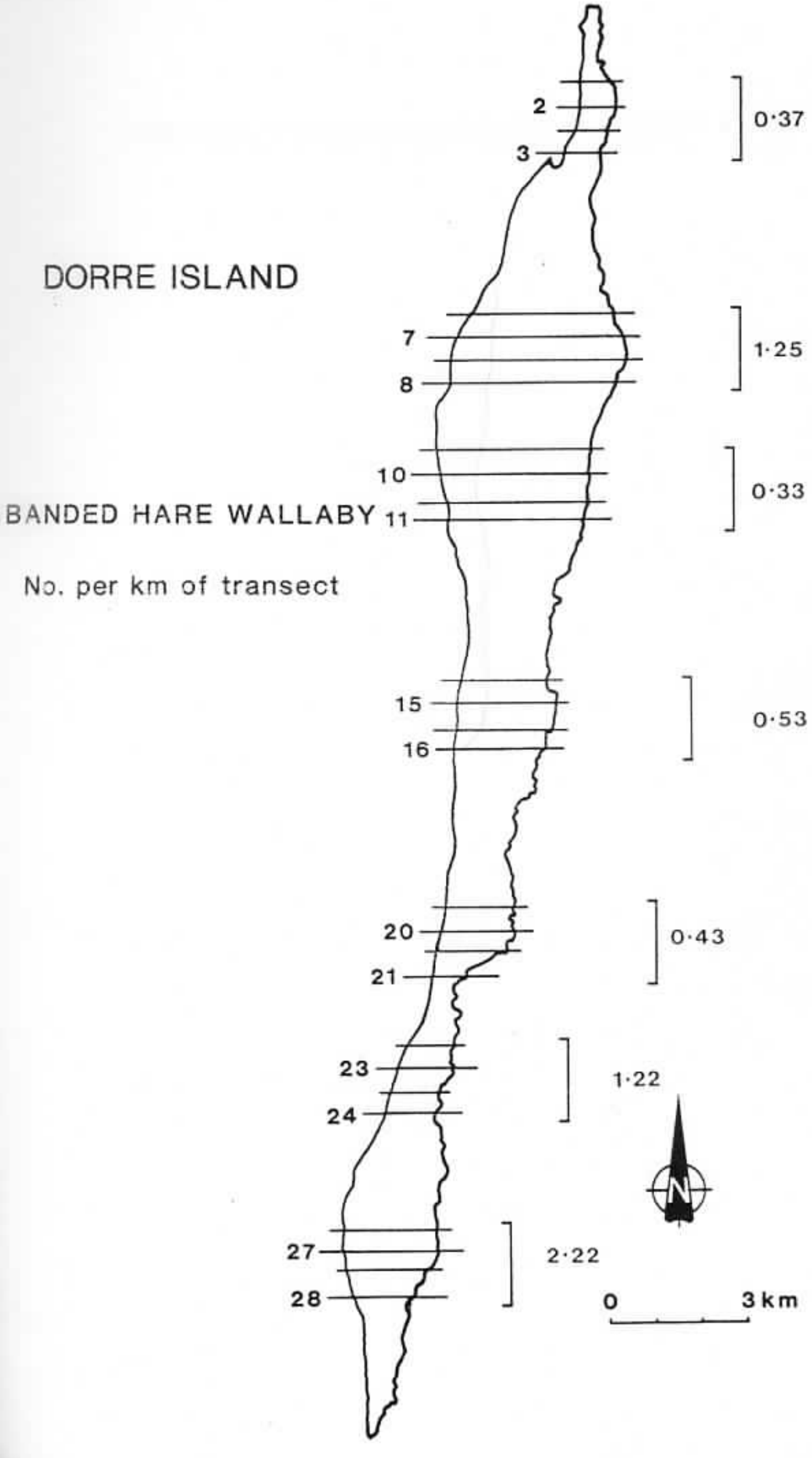

DORRE ISLAND
BANDED HARE WALLABY
No. per km of transect
2
3
0·37
7
8
1·25
10
11
0·33
15
16
0·53
20
21
0·43
23
24
1·22
27
28
2·22
N
0
3 km

Fig. 5.8 The distribution of the rufous hare-wallaby on Dorre Island.

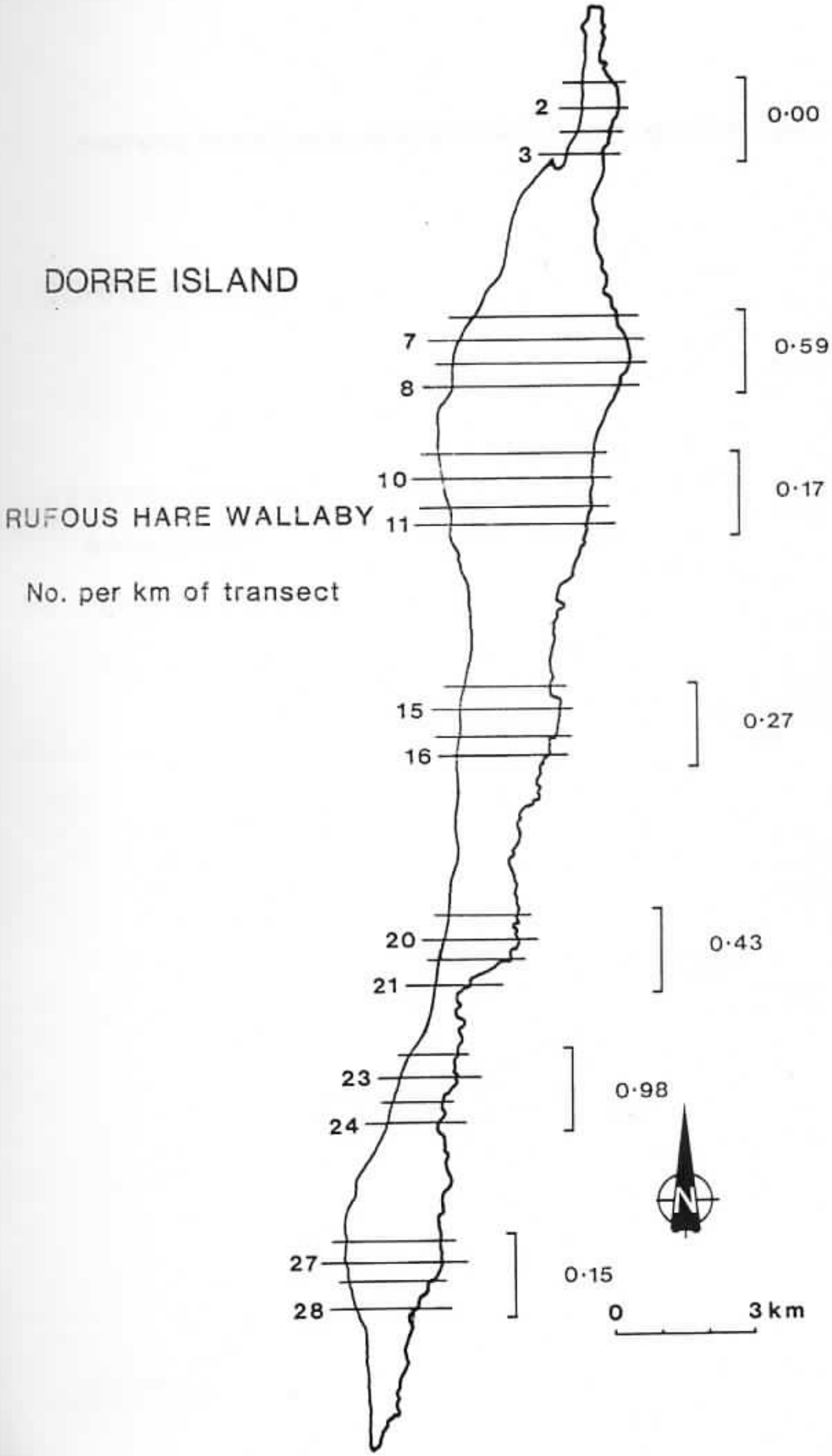

DORRE ISLAND
RUFOUS HARE WALLABY
No. per km of transect
2
3
0·00
7
8
0·59
10
11
0·17
15
16
0·27
20
21
0·43
23
24
0·98
27
28
0·15
N
0
3 km

Fig. 5.9 The distribution of the western barred bandicoot on Dorre Island.

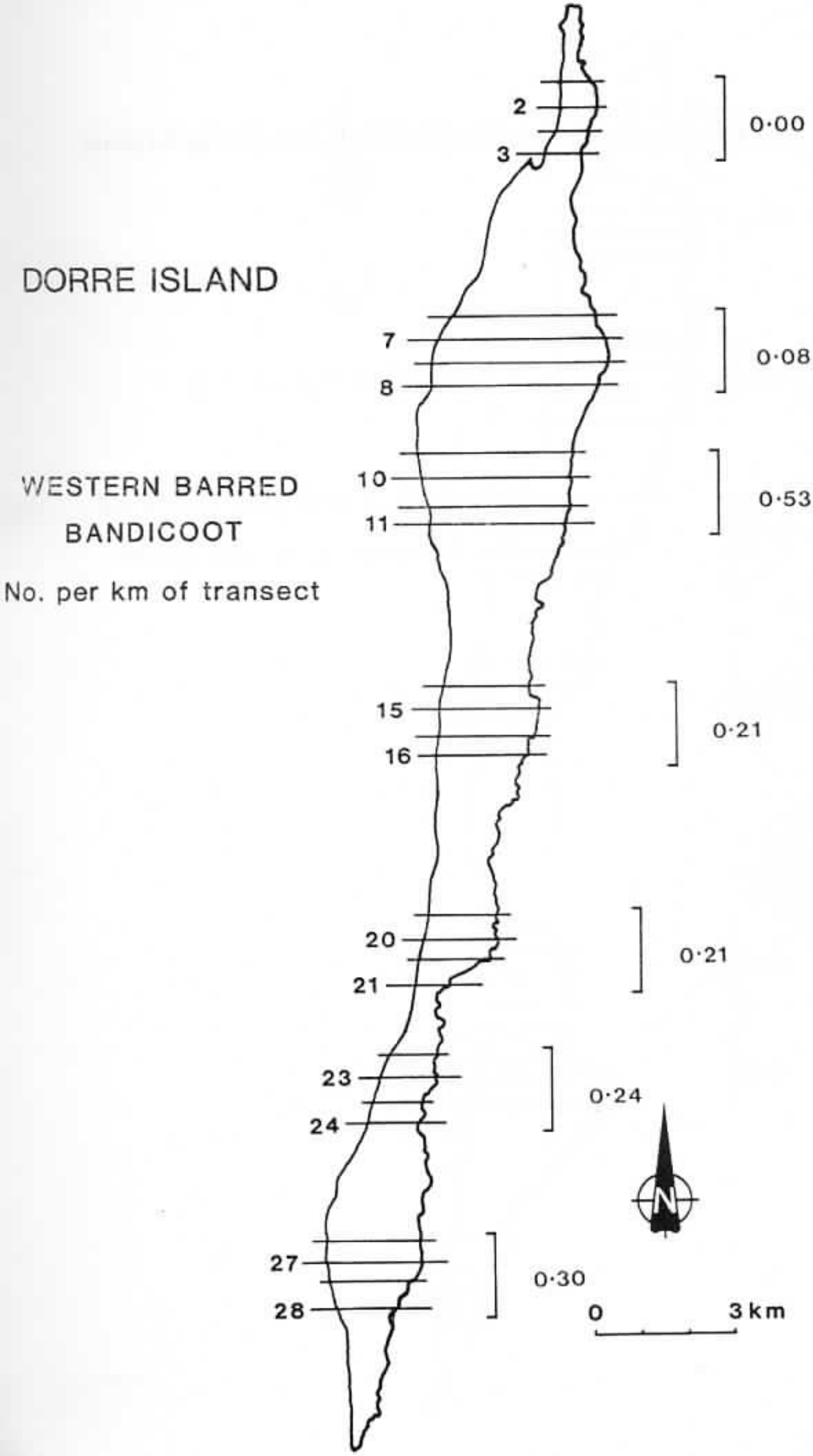
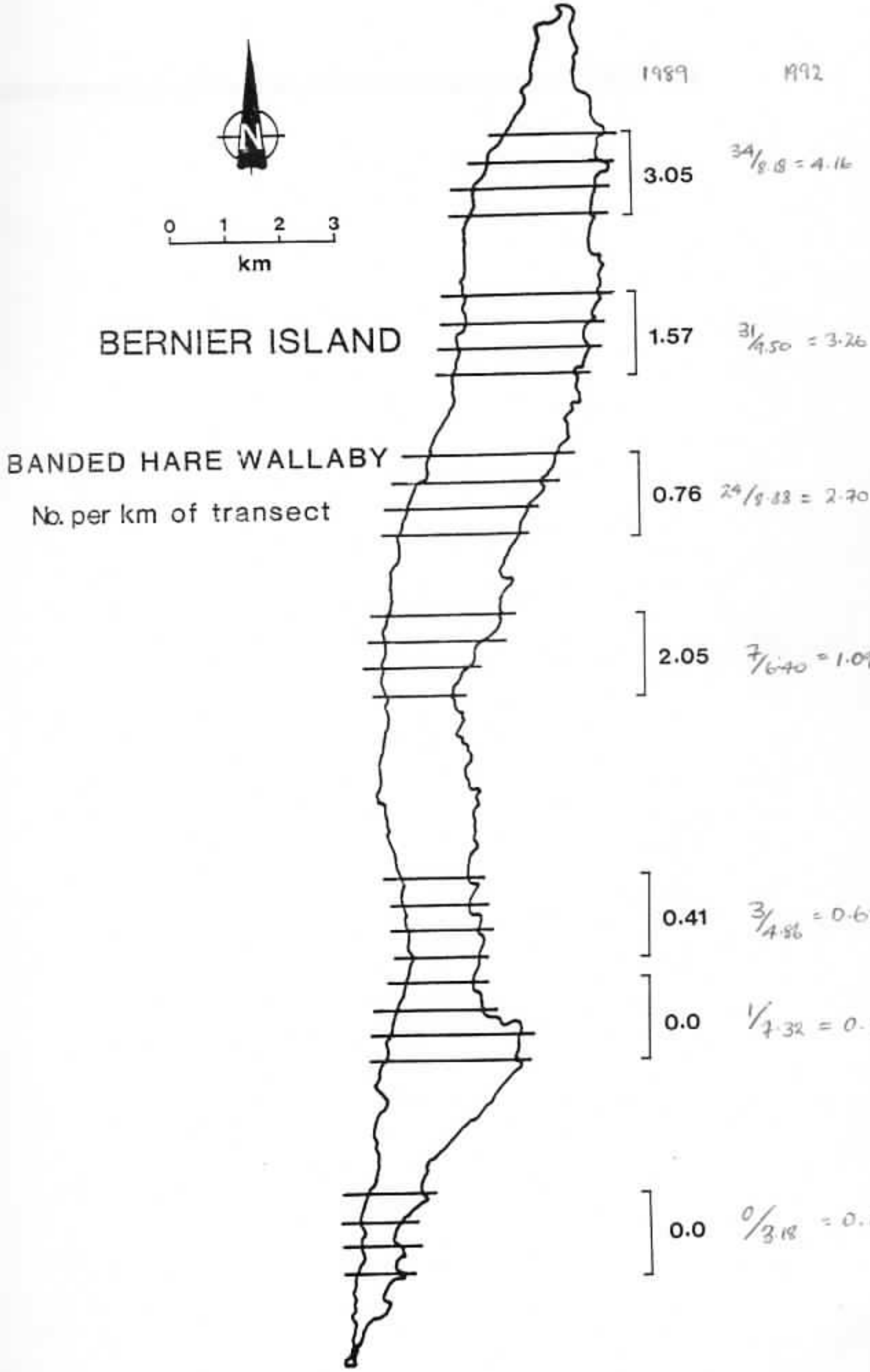
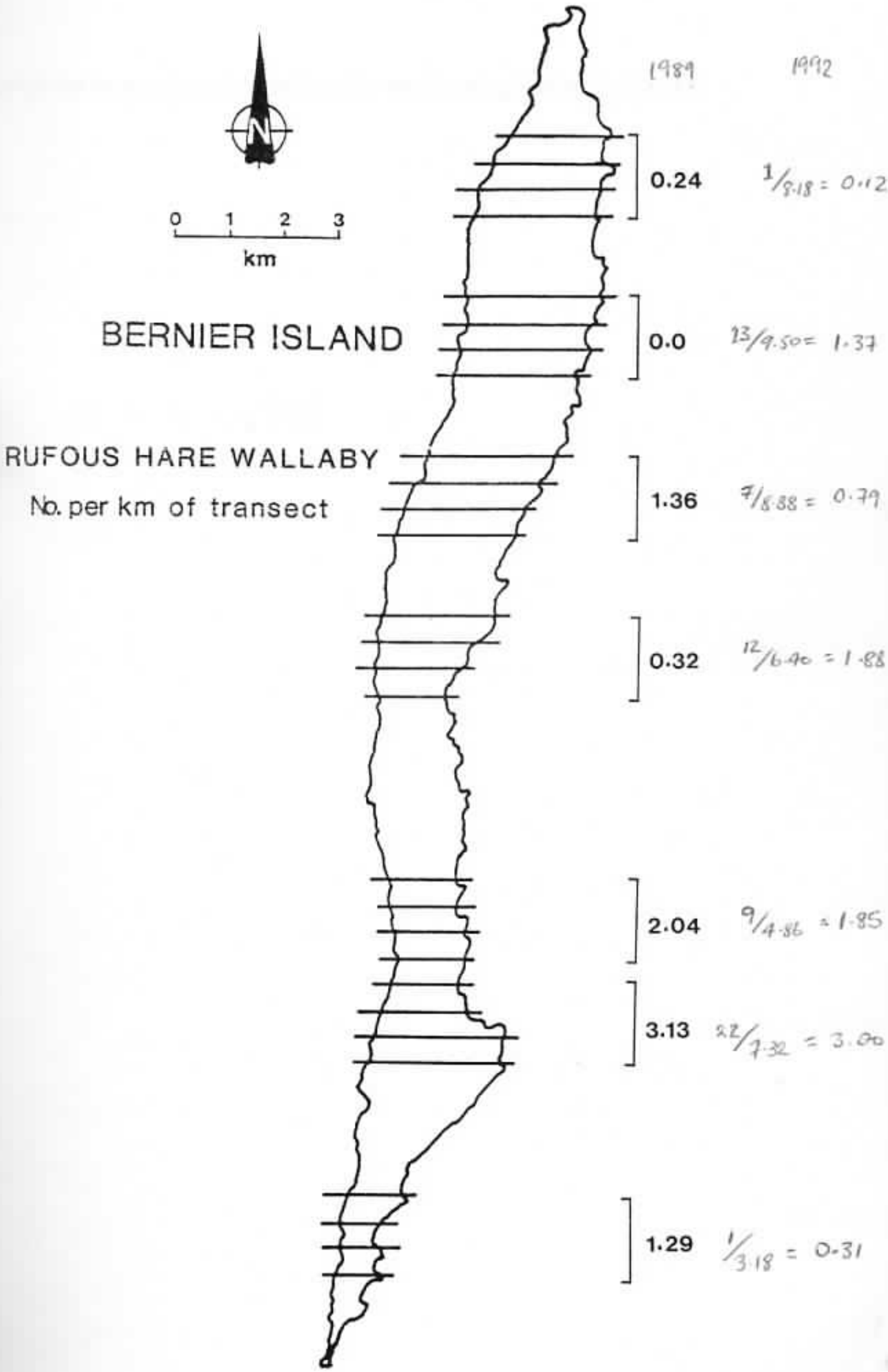

DORRE ISLAND
WESTERN BARRED
BANDICOOT
No. per km of transect
2
3
0·00
7
8
0·08
10
11
0·53
15
16
0·21
20
21
0·21
23
24
0·24
27
28
0·30
N
0
3 km

Fig. 5.10 The distribution of the banded hare-wallaby on Bernier Island.



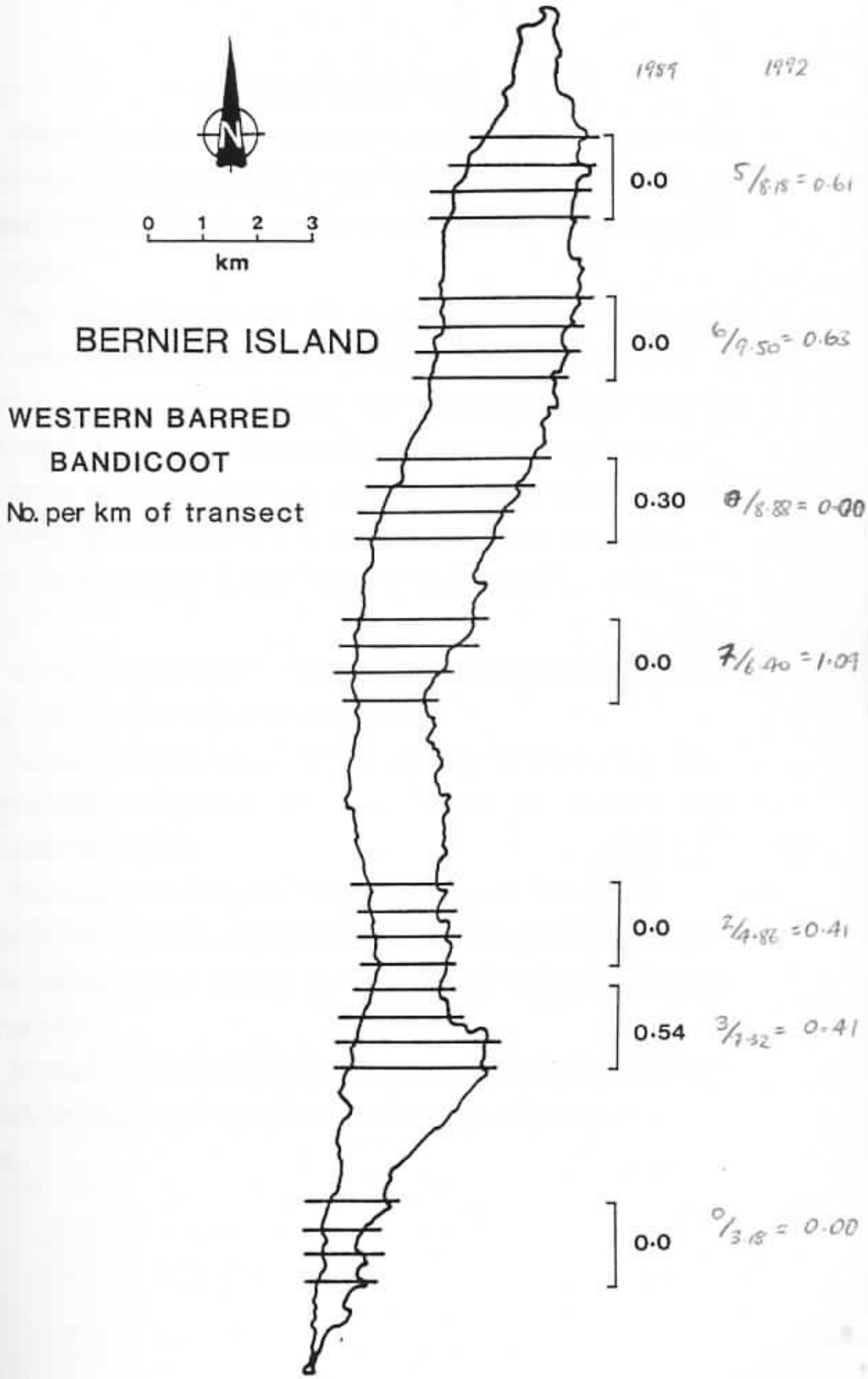
N
0 1 2 3
km
BERNIER ISLAND
BANDED HARE WALLABY
No. per km of transect
1989
1992
3.05
34/8.18 = 4.16
1.57
31/9.50 = 3.26
0.76
24/8.88 = 2.70
2.05
7/6.40 = 1.09
0.41
3/4.86 = 0.6
0.0
1/7.32 = 0.
0.0
0/3.18 = 0.

Fig. 5.11 The distribution of the rufous hare-wallaby on Bernier Island.



1989
1992
0 1 2 3
km
BERNIER ISLAND
RUFOUS HARE WALLABY
No. per km of transect
0.24
1/8.18 = 0.12
0.0
13/9.50 = 1.37
1.36
7/8.88 = 0.79
0.32
12/6.40 = 1.88
2.04
9/4.86 = 1.85
3.13
22/7.32 = 3.00
1.29
1/3.18 = 0.31

Fig. 5.12 The distribution of the western barred bandicoot on Bernier Island.



BERNIER ISLAND
WESTERN BARRED
BANDICOOT
No. per km of transect
0 1 2 3
km
N
1989
1992
0.0
5/8.18 = 0.61
0.0
6/9.50 = 0.63
0.30
0/8.88 = 0.00
0.0
7/6.40 = 1.09
0.0
2/4.86 = 0.41
0.54
3/7.32 = 0.41
0.0
0/3.18 = 0.00

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