THE DISTRIBUTION AND ECOLOGY OF THE KANGAROO ISLAND DUNNART *SMINTHOPSIS AITKENI*

Jody A. Gates

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Preface

This survey and research project on the Kangaroo Island Dunnart *Sminthopsis aitkeni* was undertaken as a consultancy for National Parks and Wildlife South Australia, with funding provided by the Endangered Species Program, Environment Australia. This report details the methods and results for all aspects of the study and outlines management and research recommendations. This information provides the basis for the recovery plan for the species (see Gates 2001).

Acknowledgments

Pip Masters, Graeme Moss and Peter Copley contributed significantly to discussions regarding survey design and methodology.

NPWSA staff at Flinders Chase National Park, in particular Karin Bruce, Gordon Warner, Chris Jones and Michael Murphy assisted with survey site establishment. Fiona Gill, Dale Smithyman and Roger Collins assisted with checking trap-lines.

A range of volunteers assisted with fieldwork. In particular Colin Bailey and Kylie Moritz assisted with radio-tracking, and establishing and checking traps. Nerissa Haby assisted with checking traps and undertaking habitat surveys. Dave Dowie, Jason Nichols, Chris Bald, Rebekah Collins, Lynn Pedler, Lesley Stephensen also assisted with checking traps and/or site establishment.

A range of landholders provided access to their properties for this survey. Dennis Shearing and Peter and Janet Martin in particular helped with establishing survey sites on their properties and undertook surveys on my behalf.

Jeff Foulkes, Graeme Moss, Pip Masters and Peter Copley provided comments and discussion on this report. Kylie Moritz and Fiona Gill assisted with proof reading the report.

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EXECUTIVE SUMMARY

The Kangaroo Island Dunnart *Sminthopsis aitkeni* is a Nationally endangered species of dunnart (*Environment Protection and Biodiversity Conservation Act* 1999) that is endemic to Kangaroo Island. The species is also listed as Endangered in South Australia (Schedule 7, *National Parks and Wildlife Act* 1972), and these listings are consistent with IUCN (2000) Red List criteria (see Appendix A). Prior to this project the Kangaroo Island Dunnart was only known from ten records from six locations. Despite intensive survey effort during the 1990s only four animals were captured from two locations in Flinders Chase National Park.

A total of 46 sites were surveyed during this project, with over 13,700 pitfall trap-nights and 8,900 Elliott trap-nights carried out. This resulted in 22 dunnarts being captured from six locations, including four new locations. All locations occurred within Flinders Chase National Park. Fifteen of the dunnarts captured were juveniles or sub-adults, and no adult females were captured. All captures occurred between January and May, although this partly reflected the timing of trapping at the sites where captures occurred. This survey confirmed the rarity of the species.

Two male and two female dunnarts were fitted with ‘Sirtrack’ radio-transmitters on cable-tie collars. Unfortunately two transmitters fell off, and one animal was lost after transmitter failure, within three days of release. A fourth animal was radio-tracked over a period of nearly nine days. The limited data obtained provided a small insight into the movements and home range size of the dunnarts. Observed range length was 169 m and 185 m for the females, and 289 m and 380 m for the males, and home range size estimates ranged from 0.34 ha to 2.32 ha, with overlap between the males and females. Further studies are required to better understand temporal and spatial use of habitat, however, this preliminary data assists with determining sizes of dunnart management areas around the sites where they occur.

The locations of dunnart population(s) were layered with the vegetation map for Kangaroo Island (see Ball and Carruthers 1998) using the Arcview GIS program to investigate the type and extent of potential habitat. The dunnarts have been recorded in a range of different vegetation types and formations suggesting that they are habitat generalists. Based on the vegetation types at the locations of recent records much of the potential habitat has been cleared for agriculture, however, based on the vegetation formations at these sites, much of the remaining vegetation on the island is potentially suitable habitat for the dunnarts.

The floristics and structure of the habitat at all surveys sites was measured in detail, although there was no apparent difference between the sites with dunnarts and those without, which was not surprising given the variation in habitat at the sites where they were captured (pers. obs.). Preferences for post fire age-classes are difficult to determine due to an incomplete fire history.

A total of 25 scats were collected from the dunnarts that were captured, and analysis of the contents revealed that spiders and ants were the most common food groups, occurring in 59% and 56% of scats respectively. Beetles and scorpions were also recorded in over one third of the scats, with grasshoppers and centipedes recorded in less than 5% of scats. There was little difference recorded between prey items consumed by males and females. The recorded diet is consistent with dasyurids generally. Given the regularity of seasons, and lack of conspecific competition, food resources are unlikely to be limiting for this species. Further studies on the seasonal abundance of food resources, and diet, are required to confirm this.

The timing of the breeding season was estimated based on the known growth rates of the Common Dunnart *S. murina* from a laboratory study. The capture of two cohorts of juveniles at one site suggested that like the Common Dunnart, the Kangaroo Island Dunnart is polyoestrous. The data suggests that mating at this site occurred around late September, and again around late December, with other dates falling within this period. The lack of adult females makes it impossible to determine other aspects of the species breeding biology.

Although much of the remaining native vegetation on western Kangaroo Island provides potential habitat for the dunnarts, large-scale and severe wildfires, and associated back-burns, potentially pose a serious threat to the species. Wildfire will cause the extirpation of some populations and the elimination of habitat, at least in the short-term. The ability of the dunnarts to recover from fires, and to recolonise burnt areas, is likely to be reduced if wildfires in locations like Flinders Chase National Park are extensive and few unburnt patches remain. Reducing the severity and extent of wildfires, and encouraging the development of a mosaic of successional stages of vegetation, is likely to help ensure the long-term viability of the species.

Conservation management and research recommendations are listed at the end of the report, and focus on protecting the known populations, particularly from wildfire, undertaking further survey work to clarify the distribution of the species, and continuing population monitoring and research at the major dunnart site. Detailed recovery actions are listed in the Recovery Plan (Gates 2001).

Note:

At the time of printing the remains of *S. aitkeni* were reported from within an owl pellet collected from Royston Head in Innes National Park, Yorke Peninsula, in 1988 (G. Medlin, pers. comm.). Based on this observation, and similar records for other species from the *S. murina* complex more work is required to clarify the species within this complex and their distributions (G. Medlin, pers. comm.).

1.0 INTRODUCTION AND BACKGROUND INFORMATION

The Kangaroo Island Dunnart *Sminthopsis aitkeni* is a Nationally endangered species of dunnart (*Environment Protection and Biodiversity Conservation Act* 1999) that is endemic to Kangaroo Island. The species is also listed as Endangered in South Australia (Schedule 7, *National Parks and Wildlife Act* 1972), and these listings are consistent with IUCN (2000) Red List criteria (see Appendix A). This species is distinguished from other similar species (especially the Common Dunnart *S. murina*) by the dark sooty colour of the dorsal fur and the light grey colour of its ventral fur, and by its slender pointed muzzle (Strahan 1995). The tail is always longer than the body length, and is never incrassated (Strahan 1995). However, the Kangaroo Island Dunnart is the only species of dunnart occurring on Kangaroo Island, eliminating problems with identification.

The Kangaroo Island Dunnart was first discovered in 1969 by a farmer as he cleared native vegetation, with an animal captured by his dog as it was fleeing from a felled Yacca *Xanthorrhoea semiplana tateana*. At this time the species was identified as the Common Dunnart. Over the following four years another four dunnarts from three locations were captured in similar circumstances, and a further record was obtained in 1979 (see Figure 1). All of these records came from the eastern end of the Island.

In the early 1980s, morphological (Kitchener *et al*. 1984) and electrophoretic studies (Baverstock *et al.* 1984) on the Common Dunnart complex identified and described four new species, including the Kangaroo Island Dunnart. The Kangaroo Island species was subsequently named after Peter Aitken, who was the Curator of Mammals from the South Australian Museum at the time of its discovery. The importance of the Kangaroo Island species of dunnart was highlighted by these studies.

It was 1990 before the species was captured again during the biological survey of Kangaroo Island (Robinson and Armstrong 2000) in Flinders Chase National Park (FCNP). In 1996 the Nature Conservation Society of South Australia funded a four week survey in an attempt to further knowledge of the species (Herbert 1996). Unfortunately no dunnarts were captured, although this result helped to focus more attention on the species, and concern for its status. Based on the available information (or lack of it) the Kangaroo Island Dunnart was subsequently listed as endangered in the *Action Plan for Australian Marsupials and Monotremes* (Maxwell *et al*. 1996) and ranked as the fourth highest priority species.

With increased interest in the species, Rangers from FCNP established four survey sites in the general vicinity of the 1990 capture record. This effort was rewarded with the capture of two dunnarts at a new site in 1997/98. A further record was obtained early in 1999 from the biological survey site, taking the total number of records to just ten.

Just prior to the printing of this report a further record of the Kangaroo Island Dunnart has been obtained from owl pellets collected at Innes National Park, on Yorke Peninsula, on the adjacent mainland of South Australia. The age of this record is indeterminable, but poses interesting questions regarding the past distribution of the species.

The recent records from Kangaroo Island provided the impetus for the current project and funding was provided for intensive survey and research on the Kangaroo Island Dunnart. The aims of the project were to:

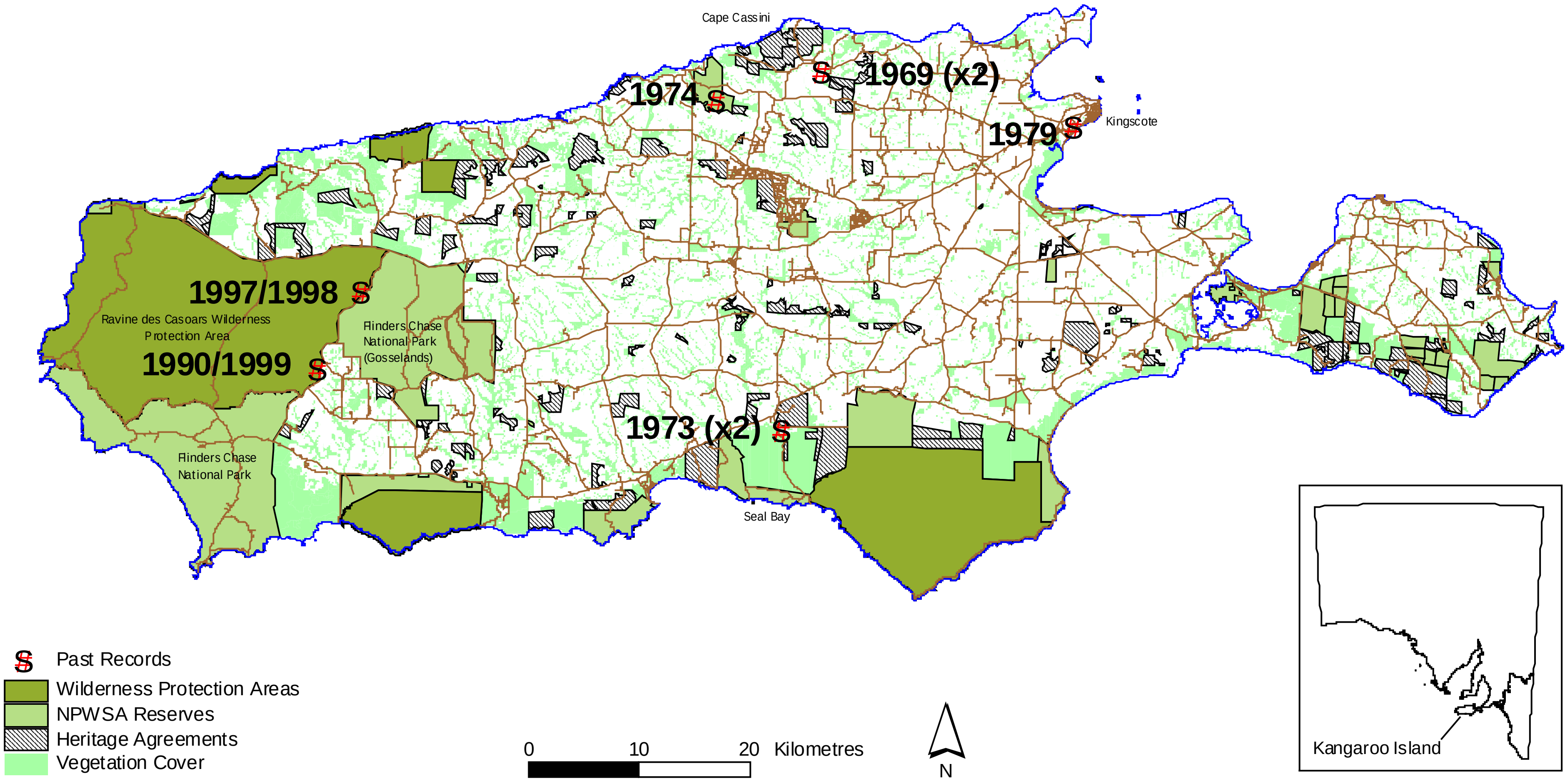
1. Increase understanding of the distribution of the Kangaroo Island Dunnart.
2. Determine habitat preferences of the Kangaroo Island Dunnart.
3. Undertake research into breeding biology, home range and movement patterns and diet of the Kangaroo Island Dunnart.
4. Identify threats to the species and make management recommendations to mitigate threats.
5. Prepare a recovery plan for the Kangaroo Island Dunnart.

This report outlines the results of this project, and provides the background information to the Recovery Plan (Gates 2001). The report consists of six sections:

- 2.0 Distribution and Status;
- 3.0 Macro and Micro-Habitat Selection;
- 4.0 Home Range Size and Movement Patterns;
- 5.0 Diet;
- 6.0 Breeding Biology; and
- 7.0 Conservation Management.

Figure 1: Location of past records of the Kangaroo Island Dunnart *Sminthopsis aitkeni*.

The year of each record is indicated with multiple records shown in parantheses.



2.0 DISTRIBUTION AND STATUS

2.1 Introduction

The Kangaroo Island Dunnart was only known from six widely spaced locations prior to this survey (Figure 1). The majority of records came from the late 1960s and early 1970s when clearance of natural vegetation for agriculture was at its greatest. These records came from the north-east of the island, near Cape Cassini and Kingscote, and from near Seal Bay. More recently records have come from the western end of the island in FCNP, suggesting a wide distribution, at least in historical times. Despite intensive surveys in the last 10 years the limited captures provided a very poor picture of the current distribution of the Kangaroo Island Dunnart, which is essential to understanding the status and potential threats to the species.

This section reports on an island-wide survey that was undertaken between November 1999 and May 2001. Although focused on the Kangaroo Island Dunnart, a brief account of the other vertebrates captured, especially regionally significant species, is included here.

2.2 Methods

2.3.1 Selection of survey sites

A total of 46 sites were surveyed across Kangaroo Island (Figure 2). The habitat across the Island was stratified according to vegetation associations (see Ball and Carruthers 1998) to assist with site selection, although time constraints, and the need to ensure adequate survey effort at each site, prevented all associations and/or fire ages from being sampled. An attempt was made to sample within a range of post fire age-classes of vegetation, although this information is incomplete for most of the island.

Initially effort was focussed on the area within FCNP where recent captures occurred (Figure 2). The focus then shifted to the eastern end of the island, on Dudley Peninsula, and along the South Coast between Flour Cask Bay and Seal Bay. Sites were also established near Cape du Couedic in the south-west of the island in FCNP. The failure to capture dunnarts at sites on the east end of the island led to an increased focus on the western end of the island during the final stages of the project. Despite the intensive nature of this survey there were still many areas where few or no survey sites were established (Figure 2).

2.3.2 Survey site design

Data from the Biological Databases of South Australia indicated that pitfall trapping was the most successful method for capturing dunnarts (H. Owens pers. comm.). This was therefore employed as the primary survey method, along with Elliott traps.

Each survey site consisted of two sub-sites placed ~100m apart. Each sub-site consisted of four pitfall traps arranged in a square and placed 20m apart (Figure 3). Five meters of drift fence was extended from each side of the pitfall traps. Two sizes of pitfall traps were trialed: 150 mm diameter by 500-600 mm deep white PVC pipe; and white 20 litre buckets of 395 mm diameter by 295 mm deep. A proportion of pitfall traps were also spray-painted black on the inside (the top ~200mm) to reduce their visibility to small mammals and therefore potentially increase trap success. Comparisons between the effectiveness of these pitfall traps will be reported elsewhere (see Gates in prep.). All pitfall traps had lids that were used to close the pits between trapping sessions.

Four sites, including two where dunnarts were known to occur, already had established pitfall trap-lines. These lines were consistent with the standard guidelines for vertebrate surveys in South Australia (Owens 2000) and consisted of two lines of six pits (~10m apart) with a continuous length of drift fence between them. These pitfall lines were retained and used throughout the survey.

Up to 15 Elliott traps were also placed out at each sub-site approximately 10m apart. Traps were approximately arranged in a semi-circle that incorporated the pitfall traps (Figure 3) to increase ease of re-locating and checking of the traps. Elliott traps were predominantly baited with a mixture of peanut butter and oats. Strips of leather (~50 mm x 15 mm) soaked in tuna oil was also trialed as bait and placed in the Elliott traps in order to try to reduce the capture of off-target species (in particular Bush Rats *Rattus fuscipes*), however, this was unsuccessful. The capture of off-target species therefore effectively reduced the total trap-effort of Elliott traps, and also considerably increased the time required to check traps. Towards the end of the study Elliott trap-effort was reduced (to seven traps per sub-site), or they were removed altogether to increase pitfall trap effort as much as possible.

At the two known sites with dunnarts where trap lines were already in place additional sub-sites were established to try to increase the numbers of captures to facilitate more detailed

Figure 2: Locations of survey sites from the current survey, and survey sites from previous surveys on Kangaroo Island.

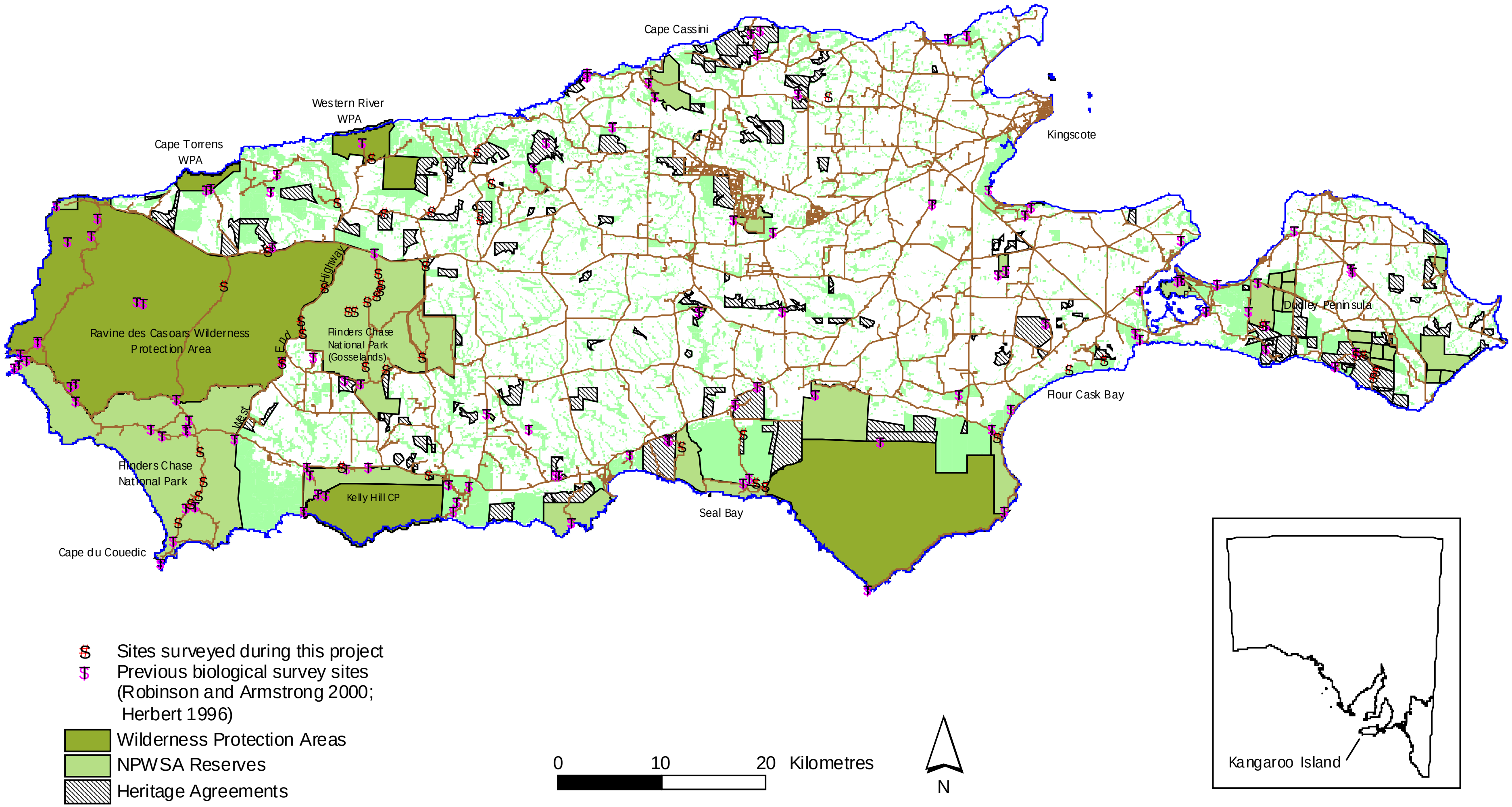
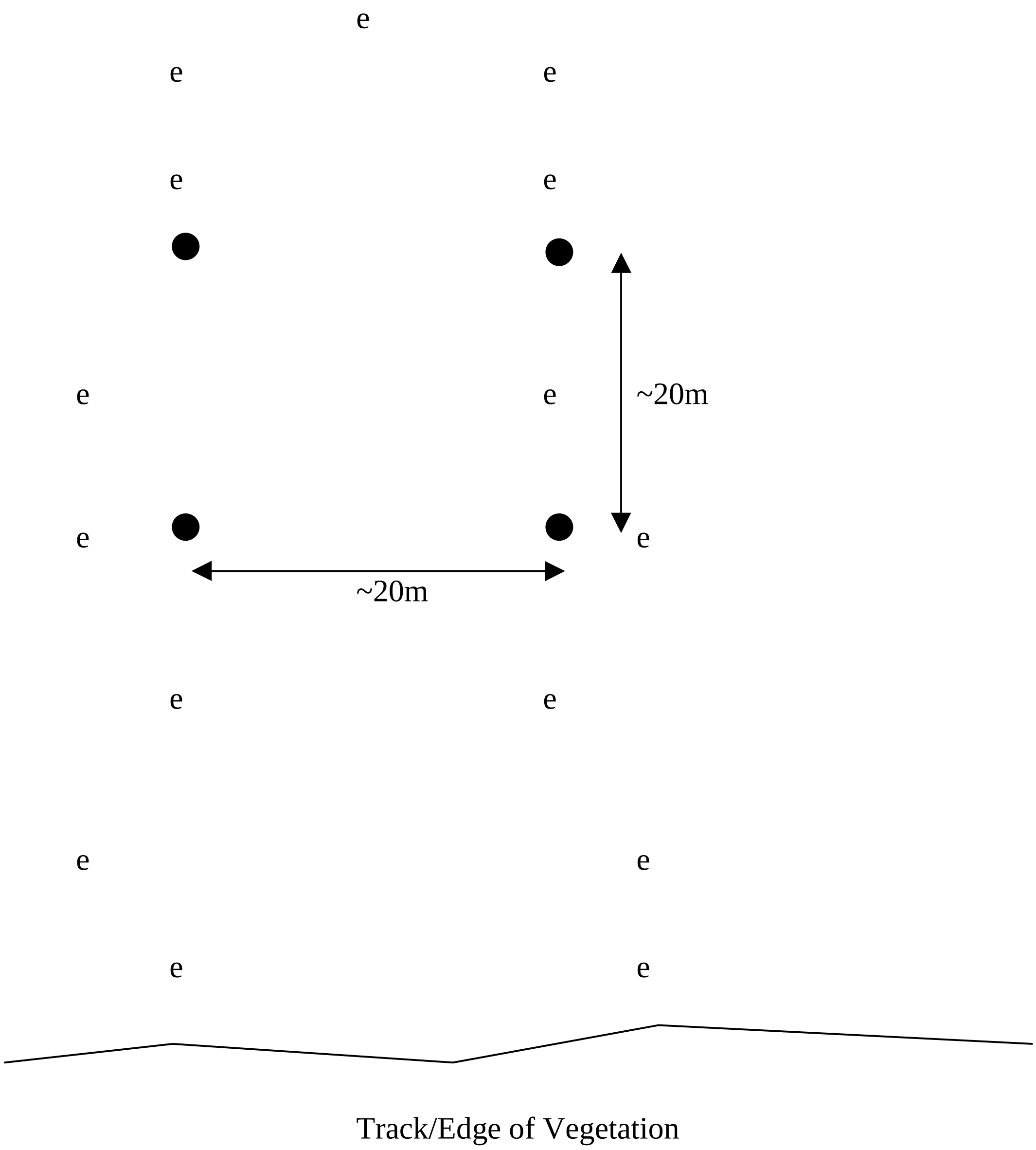


Figure 3: Arrangement of pitfall traps and Elliott traps at each survey site.



● Pitfall traps

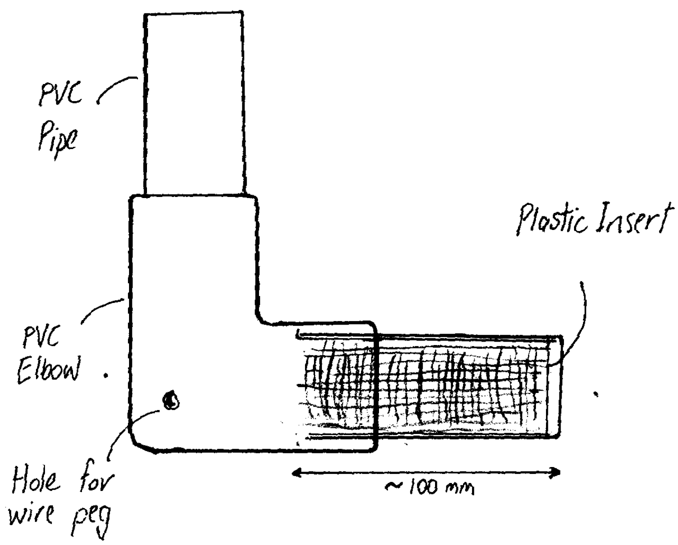
e Elliott traps (placed randomly in an arc that incorporated the pitfall traps to ensure ease of locating/checking traps) research. These additional sub-sites were placed ~100 m apart each side of the existing lines and parallel to the track where the site occurred. A small number of sub-sites were placed ~100 m further into the vegetation, away from the access tracks. Six sub-sites were established at each site, with a further four added to the site where most dunnarts were subsequently captured.

At the major site known to have dunnarts hair tubes were trialed (see Figure 4). These were baited with strips of leather as outlined above, and were placed in the vicinity of pitfall traps (see Figure 3). Two sizes of tubes were trialed (Figure 4).

Survey sites were generally opened for four consecutive nights, although occasionally trapping continued for up to 10 consecutive nights. Surveying was alternated between groups of up to 10 sites at any one time. The aim was to open each survey site for at least 15 nights. Ongoing trapping occurred at the known dunnart sites throughout the whole survey period,

Figure 4: Design and dimensions of hair tubes.

Tubes were made from PVC elbows and pipe. Doubled-sided carpet tape was stuck to a plastic insert (cut from a tubestock pot) for ease of removing/replacing tape. Each tube was held in place with a wire peg, and the 'bait' was also threaded onto this wire.



and therefore the resulting trap effort at these sites was much higher. It was necessary to try to balance the need to intensively survey each site to increase the chance of catching dunnarts with the need to survey as widely as possible across the island.

All captures of mammals, reptiles and frogs were recorded on data-sheets consistent with the guidelines for vertebrate surveys in South Australia (Owens 2000) and all data were entered into an Access data-base developed for the project. Trap-effort was also recorded in the data-base. All dunnarts were toe-clipped and toes were preserved in saline solution before being passed onto the Evolutionary Biology Unit at the South Australian Museum. At sites that were repeatedly surveyed bush rats were individually marked with ear tags. All pygmy-possums *Cercartetus* spp. were temporarily marked by clipping a small patch of fur from their lower back.

2.2.1 Community Involvement

This project was promoted via a number of articles placed in local newsletters and the local newspaper. An information sheet with details of identification features of the small mammals that occur on the island (see Appendix B) was also distributed to all landholders. This was undertaken to encourage landholders to report any potential sightings of the dunnart.

2.3 Results

2.3.1 Location of survey sites

Each Regional Ecological Area (see Willoughby *et al.* 2001) was surveyed approximately proportionally to the percentage of remnant vegetation occurring within it (Figure 5), although clearly it was not possible to comprehensively survey all areas on the island. However, consideration of survey effort at this scale can assist with site selection in the future.

Five of the 14 *Eucalyptus* vegetation associations occurring on Kangaroo Island were surveyed during this project (Table 1), although most of the unsurveyed vegetation types are of limited extent (i.e. <0.5%; Table 1), and are also relatively fragmented and isolated (pers. obs.). Survey effort within each vegetation type was approximately proportional to the extent of each type. However, large areas of vegetation remain unsurveyed on Kangaroo Island.

A range of post fire age-classes of habitat were also surveyed, from 3 years to 40+ years. However, for most sites age-class data was not available, making it difficult to adequately

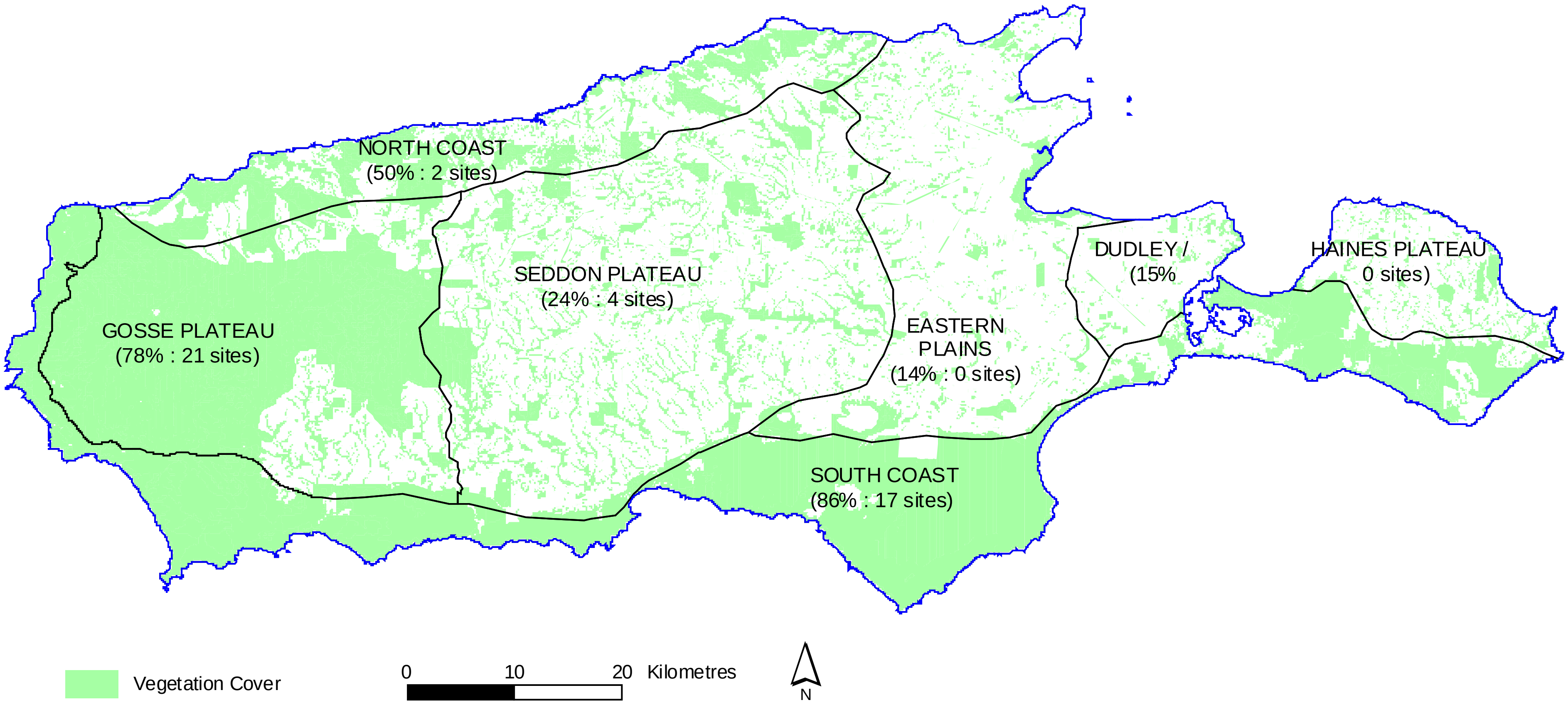
Table 1: Survey effort within the *Eucalyptus* vegetation associations on Kangaroo Island.

Primary species, association codes and area data follow Ball and Carruthers (1998).

Vegetation Association: Primary Species	Association Group Code	Area (ha)	% of Island Area	No. of Survey Sites
E. remota	1	39,292	9	13
E. diversifolia	2	76,830	17.5	16
E. baxteri	3	24,740	5.6	9
E. rugosa	4	3,748	0.9	2
E. cladocalyx	5	32,242	7.3	4
E. cosmophylla	6	6,826	1.6	0
E. fasciculosa	7	1,031	<0.5	0
E. lansdowneana ssp. albopurpurea	8	535	<0.5	0
E. viminalis spp. cygnetensis	9	158	<0.5	0
E. leucoxylon ssp. leucoxylon	10	746	<0.5	0
E. cneorifolia	11	5,582	1.3	0
E. ovata	14	3,383	<0.5	0
E. camaldulensis var. camaldulensis	17	154	<0.5	0
E. obliqua	28	616	<0.5	0

Figure 5: Survey effort relative to percentage of remnant vegetation within each Regional Ecological Area on Kangaroo Island.

Six Regional Ecological Areas have been defined for Kangaroo Island (see Willoughby *et al*. 2001). These broad areas are characterised by different soils, vegetation and environmental provinces (see Laut *et al*. 1977). Each areas has a different percentage of remnant vegetation and is subjected to the effects of the various major threatening processes in varying degrees. These areas therefore provide the ideal basis for further development of a scientific approach to future survey work.



sample the habitat based on this variable. The exception to this is FCNP where fire history data is available for most of the park, although even there some data is missing.

The selection and location of survey sites based on stratification of habitat is discussed in more detail in Section 4.0, which deals with habitat selection by the dunnarts.

2.3.2 Total trap effort

The total trap effort for the project was 24,255 trap nights with 57% of this effort resulting from pitfall trapping (Table 2). Elliott trap effort was also considerable, at 8,941 trap-nights, which was concentrated during the earlier stages of the project. Towards the end of the project Elliott trap effort was considerably reduced due to poor success rates (i.e. only one dunnart captured) and the effort required to deal with off-target species that were captured.

Table 2: Summary of total trap effort for the Kangaroo Island Dunnart *Sminthopsis aitkeni* survey between November 1999 and April 2001.

Pitfall Trap-nights	Elliott Trap-nights	Hair Tube Nights	TOTAL
13,714	8,941	1,600	24,255

During the early stages of the survey most of the trap-effort was concentrated at the sites where dunnarts had been recently captured (along the West End Highway, FCNP) and at other nearby sites. Additional trap effort was also undertaken at the sites where dunnarts were subsequently captured during the survey. For this and logistical reasons the trap effort was not evenly spread across all sites. The mean number of nights that survey sites were opened was 26±14 s.d. (range 6-62) with all but four sites opened for at least 15 nights. Two of the four sites opened for <15 nights were destroyed during wildfire suppression activities.

Between late May and September 2000 (winter/spring) it was not possible to undertake trapping at sites in FCNP because a combination of high rainfall and ground water movement regularly caused the pitfall traps to fill with water. During this period trap effort was shifted to sites along the south coast where deep sandy soils eliminated this problem. This introduced a potential bias because the trappability of dunnarts possibly varies throughout the year, and in particular activity levels may be lower during the cooler and wetter months, possibly reducing the likelihood of catching dunnarts at the survey sites along the south coast. To address this problem a selection of the sites that were predominantly sampled during winter/spring were also sampled in summer/autumn. However, this did not increase the mammal species list at any of these sites.

A complete summary of the trap effort for each site can be seen in Appendix C.

2.3.3 Details of the Kangaroo Island Dunnarts caught

A total of 22 dunnarts were captured from six sites, including the two sites where previous recent captures originated (Figure 6). The majority of captures (10) came from one site (WEH04), which was where the 1990 biological survey record came from. Four or fewer dunnarts were caught at all other sites.

All of the sites where dunnarts were caught occur within a relatively small part of eastern FCNP, centred around the West End highway (Figure 6). In this area dunnarts were recorded at three of four sites surveyed on the western side of the Highway (WEH01, 02 and 04) and three of nine sites located within the Gosselands to the east of the Highway (NS02 and 05, WAL01).

Fifteen of the 22 dunnarts caught were ≤16 g and were classed as juveniles or sub-adults (Table 3), and at the major site with dunnarts nine of the ten captures were juveniles/sub-adults. The largest female was 16 g and none of the females had developed pouches, indicating that no adult females were captured. In contrast, six of the males were classed as adults, weighing between 17.5 g and 21 g. The overall sex ratio was approximately equal when all dunnarts were considered, and this was also the case for each individual survey site. However, the sex ratio for the juvenile/sub-adult dunnarts was strongly female biased (1.0:0.3; Table 3).

The full details of each animal captured, including size measurements can be seen in Appendix D. These results are discussed further relative to breeding biology in Section 6.0.

Figure 6: Locations of sites where the Kangaroo Island Dunnart *Sminthopsis aitkeni* was captured during the current survey project.

Annotations refer to the survey site code names with the number of individuals captured in parentheses.

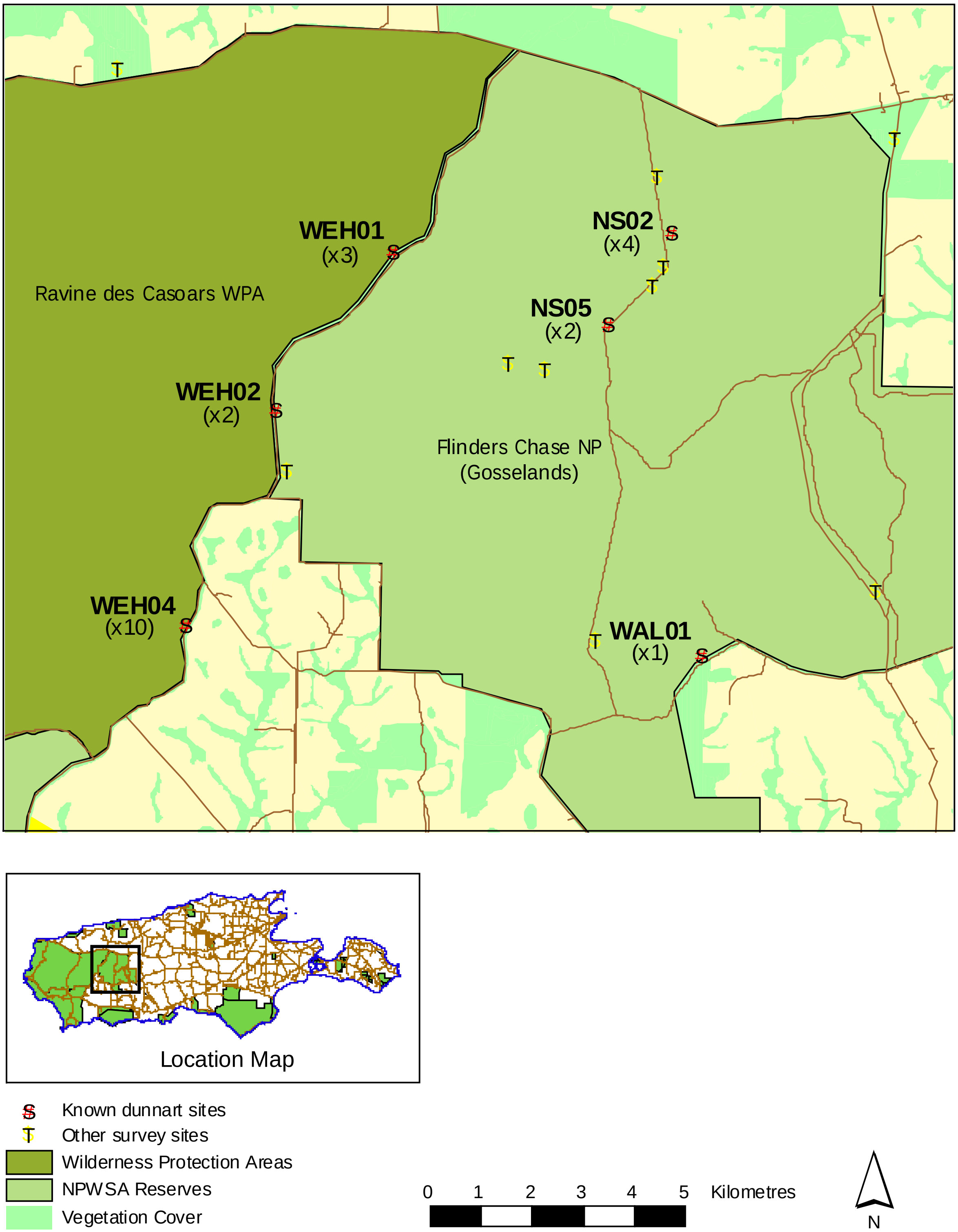


Table 3: Summary of the captures of the sex and age-class of all Kangaroo Island Dunnarts *Sminthopsis aitkeni* captured.

	MALES		FEMALES		
Site	**Adults**	**Sub-adults/Juveniles**	**Adults**	**Sub-adults/Juveniles**	**Totals**
WEH01	1			2	**3**
WEH02	1				**1***
WEH04	1	4		5	**10**
NS02	2			2	**4**
NS05				2	**2**
WAL01	1				**1**
Totals	**6**	**4**	**0**	**11**	**21**

* another animal was recorded as skeletal remains only.

<u>2.3.4 Seasonality of captures</u>

All captures occurred between January and May, although this in part reflects the timing of trapping at the sites where dunnarts were caught. The earliest capture occurred on the 11th of January and the latest on the 5th May. This appears to coincide with a post-breeding dispersal period (see Section 6.0) and accounts for the high number of juveniles/sub-adults caught. The population is likely to be at its highest at this time because of the addition of these newly independent juveniles, which increases the likelihood of detecting the species.

For the reasons outlined above no trapping occurred at the sites with dunnarts in the months from June to October. However, considerable trap effort occurred during November and December at some of these and nearby sites without success. It is therefore likely that the timing of the captures was not solely accounted for by the timing of trapping, with the activity of newly independent young from January onwards being an important contributing factor.

<u>2.3.7 Patterns of captures relative to trap effort</u>

Consideration of the trap-effort undertaken at the six sites with dunnarts (Table 4) highlights how infrequently captures occurred, suggesting that population densities are very low, or Kangaroo Island Dunnarts are trap shy. Captures per 100 pitfall trap-nights at these sites ranged from 0.17 to 0.83 (Table 4), although direct comparisons are possibly confounded by

Table 4: Trap effort and capture rates of Kangaroo Island Dunnarts *Sminthopsis aitkeni* at the six sites where dunnarts were captured.

Site Name	Nights Open	Total Trap-nights: Elliott's	Total Trap-nights: Pitfalls	Total Trap-nights: Hair Tubes	TOTAL	Dunnarts Captured	Capture Rate[1.]
WEH01	62	1920	1808	0	4788	3	0.17
WEH02	53	120	660	0	780	2	0.3
WEH04	70	1920	3044	1600	4964	10	0.32
NS02	45	240	360	0	600	4	0.83[2.]
NS05	42	300	396	0	696	2	0.5
WAL01	27	120	208	0	328	1	0.48
TOTALS	n/a	4620	6476	1600	12156	22	-

1. Capture rate is per 100 pitfall trap nights.
2. At NS02 one dunnart was captured in an Elliott trap, and this is not included in the capture rate.

variation in the timing and effort of sampling at each site. Despite this, the data suggests that the total population of the species is likely to be small, indicating that the species is genuinely rare.

The cumulative number of trap-nights undertaken before the first and subsequent captures of dunnarts at each of the six sites provides an interesting insight into the temporal variability of captures (Table 5). At each site trap effort for each trap-night was generally consistent through time, except for the two sites with additional sub-sites (WEH01 and WEH04), in which case not all sub-sites were opened on all occasions. The mean number of trap-nights until the first capture was 16±9 s.d. (range 1-27). This data supports the original aim of trapping at each site for at least 15 nights, although it also suggests that even after considerable trap-effort without success it is not possible to definitively rule out the presence of dunnarts. At one site (NS02) two dunnarts were captured in the same pitfall trap on the first night of trapping, however, at another site (WAL01) 27 nights of trapping were undertaken before the first dunnart was caught. This animal was captured on the very last day of the trapping program. At the site where most dunnarts were captured (WEH04) the first

Table 5: The cumulative number of trapping nights for each Kangaroo Island Dunnart *Sminthopsis aitkeni* caught at the six sites where they were captured.

Trap effort varied between sites, but was consistent for each night at each site, except for sites WEH01 and WEH04 where not all sub-sites were opened on all nights.

	Captures									
Site	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**
WEH01	18	32	53	-	-	-	-	-	-	-
WEH02	19	40+[1.]	-	-	-	-	-	-	-	-
WEH04	9	10	12	16	43	43	62	63	64	68
NS02	1	1	8[2.]	41	-	-	-	-	-	-
NS05	22	27	-	-	-	-	-	-	-	-
WAL01	27	-	-	-	-	-	-	-	-	-

1. This animal was captured when a lid was accidentally dislodged from a pitfall trap, and therefore the timing of capture is not known.
2. This animal was caught in an Elliott trap.

capture occurred on the ninth night. This information is important to consider when designing trapping programs for this species.

2.3.8 Unconfirmed Community Records

A number of unconfirmed sightings of Kangaroo Island Dunnarts were reported throughout the course of the project. Based on descriptions and/or circumstances relating to the sightings the majority of these were considered unlikely to be dunnarts. However, three sightings were considered probable based on the details provided.

Two reports resulted from observations made whilst people were involved with suppression activities associated with a wildfire in the East Gosselands section of FCNP, an area adjacent to the current known locations for the species. On the first occasion a 'dunnart' was observed by an ex-FCNP Ranger (Bob Furner) as it ran across the Snake Fire Track just in front of his vehicle. He got a good look at the animal from the driver's side window as he pulled up because the animal paused briefly on the side of the track before continuing into the vegetation. Bob helped initiate the trapping program in FCNP in 1997 and is familiar with the species. The second report came from another National Parks and Wildlife South Australia

(NPWSA) Ranger from the mainland, who observed what he thought was an '*Antechinus*'. This person was familiar with *Antechinus* from the Adelaide Hills, and given the generally similar morphology to dunnarts this sighting is also considered probable. There are no *Antechinus* on Kangaroo Island.

A further probable sighting was made by a Telstra staff member on the northern boundary of FCNP, on the Playford Highway. On two occasions the animal was observed within an 'inspection pit' when maintenance on telephone lines was occurring. This person was able to get a good look at the animal because it was confined within the pit, and the identification was made after checking the small mammal identification sheet prepared for this project. I inspected this location on approximately five occasions without success, however, a small nest of leaves had been constructed in the pit, and it was apparent that an animal could find its way in and out. The location is also within the likely distribution of the species, and based on the nature of the observation it is also considered probable that this animal was a Kangaroo Island Dunnart.

People also commonly reported seeing 'hopping mice' although there are no true hopping mice on Kangaroo Island. It is likely that the majority of such sightings are simply of House Mice *Mus musculus* or young Bush Rats, which tend to bound along when crossing open ground, giving the appearance of a hopping motion.

2.3.9 Captures of other small vertebrates

A total of five other small mammal species, 11 species of reptiles and all six species of frogs present on Kangaroo Island were also captured throughout the trapping program (Table 6). Appendix E summarises the total number of captures of all small vertebrate species for each site.

The vertebrate fauna of Kangaroo Island is well known as a result of numerous surveys, and in particular the biological survey of the island (Robinson and Armstrong 2000). The patterns of distribution for all species captured during this survey were consistent with known distributions (pers. obs.), although three species were of particular note as outlined below.

Table 6: Summary of the total number of captures of small mammals captured during the survey.

Common Name	Scientific Name	Total Captures
Western Pygmy-possum	*Cercartetus concinnus*	358
Little Pygmy-possum	*Cercartetus lepidus*	72
Southern Brown Bandicoot	*Isoodon obesulus*	7
House Mouse	*Mus musculus*	283
Bush Rat	*Rattus fuscipes*	1700
Swamp Rat	*Rattus lutreolus*	17
Kangaroo Island Dunnart	*Sminthopsis aitkeni*	22

The Little Pygmy-possum *Cercartetus lepidus* was previously known from only five specimens from five locations on the western end of Kangaroo Island (Robinson and Armstrong 2000). During this survey an additional 72 captures of Little Pygmy-possums from 19 new sites were recorded. Similarly the Swamp Rat *R. lutreolus* was previously known from only six records from three locations (Robinson and Armstrong 2000). During this study an additional population was located at site WEH01. Four individuals were captured 17 times, with two of these being regularly re-trapped at a sub-site that was adjacent to a small lagoon. This site record extends the range considerably to the north, although like all other locations it was still within FCNP.

Finally, the Southern Grass Skink *Pseudemoia entrecastauxii* was previously known from only six specimens from five locations (Robinson and Armstrong 2000) within FCNP. A further two specimens from two sites (WEH01 and GRR01) were recorded during this survey.

2.4 Discussion

The rarity of the Kangaroo Island Dunnart has been confirmed in this study with few animals captured relative to the trap effort undertaken. However, the total number of records for the species has been increased from just 10 to 32, and subsequently our understanding of the species has been increased substantially.

Clearly considerable trap-effort is required to detect the species, even where it is known to occur. The major dunnart site (WEH04) provides a useful example for discussion. Dunnarts were most consistently captured at this site and the total number of trap-nights and pitfall trap-effort was very high (Table 4). Captures were very infrequent, even when trapping occurred over consecutive weeks or up to nine consecutive nights. These results highlight the importance of maintaining trap effort over long periods to increase the chances of catching this species, which is consistent with Moseby and Read (2001) who determined that repeated 7-night trapping sessions for up to 21 nights are recommended for detecting rarer species.

The configuration of the pitfall traps may also influence trapping success. Interestingly the majority of captures at WEH04 occurred in the original trap lines established by NPWSA staff several years earlier (pers. obs.), which raises the question of whether the use of individual pitfall traps is as effective as continuous lines of traps. This is difficult to determine, particularly as the vegetation structure varied between sub-sites, and may have influenced the movements of the dunnarts. It is possible that the dunnarts used the longer drift fences as 'run-ways' (P. Masters, pers. comm.). However, whilst the original trap sites have been in place longer, prior to this project the drift fences were not left in situ between visits. During this project all fences were left in situ between visits. Therefore, unless the animals preferentially only used the longer fences as 'run-ways' this is unlikely to have resulted in bias. Radio-tracking data (see Section 3.0) showed that the animals did move quite widely across the site, and the longer drift fences may have simply been more effective. Unfortunately, even with future surveys, it is difficult to make comparisons due to the variation in habitat, and other intrinsic factors, that may influence the capture of dunnarts at any particular site. One of the major reasons for using groups of four individual pitfall traps in this study was that this required less effort than establishing continuous lines of six pits, which was an important consideration given limited resources. Clearly there is still plenty of scope to trial new methods for capturing the dunnarts, and suggestions have included the use of nest boxes (on the ground).

The timing of trapping is clearly an important issue with the results of this survey indicating that surveys will be more successful during the post-breeding period when the population is theoretically at its highest. The fact that all animals were caught between January and May, and that over half were juveniles/sub-adults highlights the importance of focussing any future survey work at this time. Surveying during this period also avoids problems with pitfall traps becoming water-logged. However, any studies aimed at increasing our understanding of the breeding biology of the species will need to occur during late winter and spring. This will require further investigation into trapping methods to try to overcome the problem with pitfall trap flooding. With a flexible program it may be possible to opportunistically trap during drier periods, although high ground water levels may still present difficulties.

By necessity survey work was also undertaken during winter and spring, but only at sites along the south coast of the island where deep sands allowed rainfall to drain away. It is possible that the trappability of the dunnarts was reduced during this period, and probable that the population was also near its lowest level (just prior to the breeding season), so a selection of these sites were also surveyed during summer, however, without success. Despite this, increased effort is required to determine of the dunnarts occur within this habitat, or elsewhere on the east end of the island.

The distribution of the sites where the dunnarts were caught was focussed on a relatively small part of eastern FCNP. Whilst many areas were unable to be surveyed the results suggest that the distribution of the Kangaroo Island Dunnart has contracted to the western end of the island. The distribution of all known records indicates that the dunnart previously occurred widely across much of the island, particularly across the Seddon and Gosse Plateaus. Approximately 50% of the native vegetation on Kangaroo Island has now been cleared, including areas in the vicinity of where historical records were obtained. Most of this clearance has occurred on the eastern end of the island. It is likely that a commensurate decline in the dunnart population has occurred, with the clearance alone possibly reducing the population by up to 50% (see Recher 1999). Ongoing impacts associated with habitat fragmentation are likely to have contributed to further declines. However, based on the results of this project, the possibility that dunnarts persist in small pockets on the east end of the island can not be ruled out. This is discussed further in Section 4.0, under potential habitat.

The fact that six sites where dunnarts were located all occur within a relatively small area is undesirable from a conservation perspective. It is not possible to determine if this area forms the core distribution area for the species, or simply reflects the sampling effort. Regardless, this area is potentially at risk from major natural events such as wildfire, creating genuine concern for these populations, and potentially the species. These sites also provide the only opportunities for undertaking further monitoring and research and in the short-medium term at least, the protection of these sites is important for that reason.

The lack of any adult females is difficult to account for, especially given the high numbers of juveniles/sub-adults captured. Clearly adult females must be present at, or near, the survey sites, although it is not clear how far the juveniles will disperse from their natal area. It is possible that the survey sites are located on the fringes, or close to, core breeding habitat. Undertaking surveys during the breeding season may help to solve this mystery.

The focus on surveying sites in the vicinity of FCNP towards the end of the project to locate populations of dunnarts outside the park was not successful. However, with the resources available it was only possible to establish and manage relatively few widely spaced sites. Therefore it is highly likely that other populations occur in the large remnants adjacent to FCNP, including Western River and Cape Torrens Wilderness Protection Areas (Figure 2). Many of these areas have not been burnt for long periods, and this may influence the likelihood of the species occurring there. Much more surveying is required to try to locate such populations. The most effective approach would be to survey only one area per year (in summer/autumn) and to establish a high number of sites in each area. This approach would assist with making the task more manageable, with sites placed relatively close together, reducing the effort required to monitor traps.

Although the Kangaroo Island Dunnart is not constrained by interspecific competition from other dasyurids there is the potential for interactions with a range of other species of small mammals. In New South Wales year to year variation in the abundance of Brown Antechinus *Antechinus stuartii* was negatively correlated with other small mammal species diversity, and Bush Rats in particular were shown to interact aggressively with, and cause injury to this species (Fox 1982). In this study Bush Rat abundance varied considerably between the sites where dunnarts were caught and ranged from a relatively high abundance to very few individuals (pers. obs.). The major site with dunnarts had very few Bush Rats. Therefore, Bush Rats may interact agonistically with dunnarts and this may in part determine the distribution and abundance of the species. More research is required to confirm this.

2.4.1 Other significant species captured

The capture of Little Pygmy-possums at 19 sites makes an important contribution to the understanding of the distribution of this species on the island, and indicates that it is not as uncommon as previously thought. As pointed out by Robinson and Armstrong (2000) the ecological separation between this species, and the much more abundant, widespread and cooccurring Western Pygmy-possum *C. concinnus* is not understood and warrants further research.

It was suspected that targeted searches in suitable habitat (swamps with dense sedge vegetation) would reveal more populations of Swamp Rats and this was confirmed in this study, with the species caught at a site adjacent to a small lagoon. The species is therefore likely to be much more widespread on western Kangaroo Island than records suggest.

The capture of two Southern Grass Skinks was also a significant result. The fact that one skink was caught at two sites is intriguing, particularly given the considerable trap effort undertaken at one of these sites WEH01, which was known to have dunnarts (see Table 4). The habitat at these sites is consistent with where the species was expected to be found (M. Hutchinson pers. comm.), but it is not clear why only two individuals were caught.

2.4.1 Conclusions

The true status of the Kangaroo Island Dunnart is still difficult to determine especially given the difficulties with detecting the species. However, given the lack of knowledge it is appropriate to apply the precautionary principle and assume the species is endangered (see Maxwell *et al*. 1996), until additional information suggests otherwise. This study has highlighted that considerable effort is required to catch the species, although standard pitfall trapping techniques are quite effective, suggesting that rather than being difficult to catch the species appears to be genuinely rare.

Future survey work is required to clarify the factors influencing the distribution of the species, and this requires a scientific approach to sampling, beginning with stratifying habitat to assist with selection of survey sites. The Regional Ecological Areas identified in Willoughby *et al.* (2001) provide a good starting point for survey design, and the percentage of remnant vegetation within each of these areas should be used to determine appropriate survey effort in each area. This is covered in more detail in Section 4.0.

3.0 Home range size and movement Patterns

3.1 Introduction and Background Information

This section presents data describing the home range and movement patterns of four Kangaroo Island Dunnarts. The spatial use of habitat by the dunnarts provides information critical to understanding the requirements of the species and importantly assists with developing conservation strategies for protecting the sites where the dunnarts are known to occur.

Defining home range and movements, and therefore habitat use, is difficult for small mammals that are generally active at night. Grid trapping is one technique that has been employed for many years (Barnett *et al.* 1978, Braithwaite *et al.* 1978, Garavanta *et al*. 2000) and usually involves placing Elliott traps at set intervals over areas of one to several or more hectares. This method relies on the recapture of individual animals to determine movements across the grid. More recently with the advent of micro-transmitters a combination of grid trapping and radio-tracking has been employed (e.g. Lazenby-Cohen and Cockburn 1991, Laidlaw *et al.* 1996). The standard trapping methods used in this study (see Section 2.0) were developed with a view to establishing grids using pitfall traps, however, this approach was never fully implemented due to the low capture rates and lack of recaptures. Therefore this study relied on radio-tracking alone, with mixed success.

A wide range of activity areas are quantified and defined in studies of temporal and spatial use of space by animals. These include home area, home range, territory, foraging area (Quin *et al*. 1992). The most commonly used is the concept of home range as defined by Burt (1943). Burt (1943) defined the home range of an animal as the area traversed by an individual in its normal activities of food gathering, mating, and caring for young, with occasional, perhaps exploratory, movements outside that area, not considered as part of the home range. However, there is no consensus regarding the most appropriate definition of home range or the most reliable technique for estimating the size of home ranges (Dixon and Chapman 1980, White and Garrott 1990, Quin *et al*. 1992). For the purposes of this study 'home range' is referred to in the traditional sense, although the short periods of time over which data can be collected with small radio-transmitters means that the total home range of each animal in unlikely to be sampled.

Few studies of home range sizes and movements of dunnart species in mesic Australian environments have been undertaken (e.g. Laidlaw *et al.* 1996) and few data are available on the closely related common dunnart, therefore limiting comparisons.

3.2 Methods

Dunnarts were fitted with 'Sirtrack' brand single stage transmitters that weighed ~1.5 g. Transmitters were attached around the neck using cable ties as collars. This type of transmitter was purchased based on anticipated weights of dunnarts being ~20 g. The use of these transmitters was considered inappropriate on animals <15 g (i.e. 10% of body weight), although even on weights between 15-18 g, they were considered marginal. Each transmitter had a maximum battery life of 15 days.

Radio-tracking was undertaken on foot using a hand-held directional antenna. During the day den locations were checked at least twice, just after sunrise and prior to dusk. These locations were re-checked after sunset, and fixes were obtained approximately every 45-60 minutes thereafter, depending on the time required to locate the animals. Signal strength was used as a guide of proximity to the animals, and they were generally approached to within ~15 m, although this was varied according to the nature of the vegetation and weather conditions. It was difficult to determine if approaching the animals altered behaviour, which was a primary consideration, and it was necessary to balance this with the need to obtain accurate positions. Each location was marked with flagging tape, with the direction and estimated distance to the animal noted. Locations were revisited the next day to obtain a grid reference using a Garmin hand-held GPS unit, with error measures below 5 m, which was considered sufficient relative to the scale of movements of the animals. All data were entered into the Arcview GIS to analyse observed range lengths (ORL) and for presentation, and RangesV (Kenward and Hodder 1994) was used to estimate home range sizes. The minimum convex polygon (MCP) was the home range estimate technique used.

3.3 Results

Four dunnarts (two males and two females) were fitted with radio-transmitters (Table 7). Unfortunately the majority of dunnarts caught were too small for attaching transmitters (see Section 2.0) and two were captured when it was not logistically possible to undertake radio-tracking. Also two of the largest males captured were both stressed when caught and did not survive 24 hours in captivity, despite attempts to improve their condition by feeding them.

Table 7: Details of four Kangaroo Island Dunnarts *Sminthopsis aitkeni* that were radio-tracked

Capture Date	Weight (g)	Sex	Capture Site[2.]	Animal Code
12/01/00	18	Male	WEH04	M1
4/04/00[1.]	19.5	Male	NS02	M2
4/04/00[1.]	15	Female	NS02	F1
2/04/01	15	Female	WEH04	F2

1. Refer to Figure 1 for locations.
2. Caught in same trap and radio-tracked concurrently.

The radio-tracking effort varied for each animal (Table 8) with tracking occurring for periods of between two and nine days, which reflected the total amount of time that the transmitters remained on the animals, or kept functioning. The transmitters fell off three of the dunnarts and the fourth animal was lost after two days when the transmitter signal lost strength and could only be detected at a maximum of ~20 m. As a result the data were therefore limited, and only provides a preliminary insight into home range sizes and movements. Similarities in the size of the two males, and two females, and the fact that all tracking occurred in summer and autumn (i.e. during the post-breeding season) allows for comparisons between individuals and sexes.

The observed range length was 289 m and 380 m for M1 and M2 respectively, and 169 m and 185 m for F1 and F2 respectively (Table 8). The home range estimates for the data were 1.22 ha and 2.32 ha for the males and 0.34 ha and 1.41 ha for the females (Table 8). Generally the male dunnarts moved over greater distances, which is consistent with other studies, although there was some overlap between the sizes of male and female ranges. These results must be interpreted with care due to the limited timeframe over which data were collected, and they should not be taken to represent total home range areas used by the animals.

A brief summary of the results for each individual is outlined below. Use of micro-habitat is detailed in the next section 4.0.

Table 8: Tracking periods, number of fixes, observed range length and home ranges for four Kangaroo Island Dunnarts *Sminthopsis aitkeni* in January and April 2000 and April 2001.

Animal Code	Release Date	Total Tracking Period[1] (hours)	Number of Diurnal Locations[2]	Number of Nocturnal Locations[2]	ORL[3] (m)	Home Range[4] (ha)
M1	12/1/00	50	2/2	15/14	289	1.22
M2	4/4/00	61	6/2	14/12	380	2.32
F1	4/4/00	62	5/4	8/6	169	0.34
F2	3/4/01	206	13/	31/	185	1.41

1. Time is the total time between obtaining the first and last location, and does not include a 'settling' in period after release.
2. Figures are: total number of records / number of distinct locations. Effort was not consistent throughout these times.
3. Observed range length.
4. Home range estimate using Minimum Convex Polygon at 95%.

Male No.1 (M1)

This animal used a linear area and generally moved in one direction during the limited tracking period (Figure 7). After reaching the maximum distance from the capture site this dunnart back-tracked, possibly suggesting that he was using a discrete area as opposed to dispersing. Unfortunately the collar was found on the ground under a Banksia, having fallen off after only ~50 hours (Table 8), limiting data collection. The linear nature of the fixes resulted in a home range estimate of only 1.22 ha, which was smaller than the estimate of the female at the same site (see F2).

Male No. 2 (M2)

This animal was not tracked on the first night after release. On the second night it was located ~275 m (~2/3 of its ORL) north of its capture location (Figure 8). On the following night M2 returned to within ~30 m of the capture location before sheltering under a large Desert

Figure 7: Radio-tracking fixes and home range boundaries for one male and one female male Kangaroo Island Dunnart *Sminthopsis aitkeni* at site WEH04 in Flinders Chase National Park.

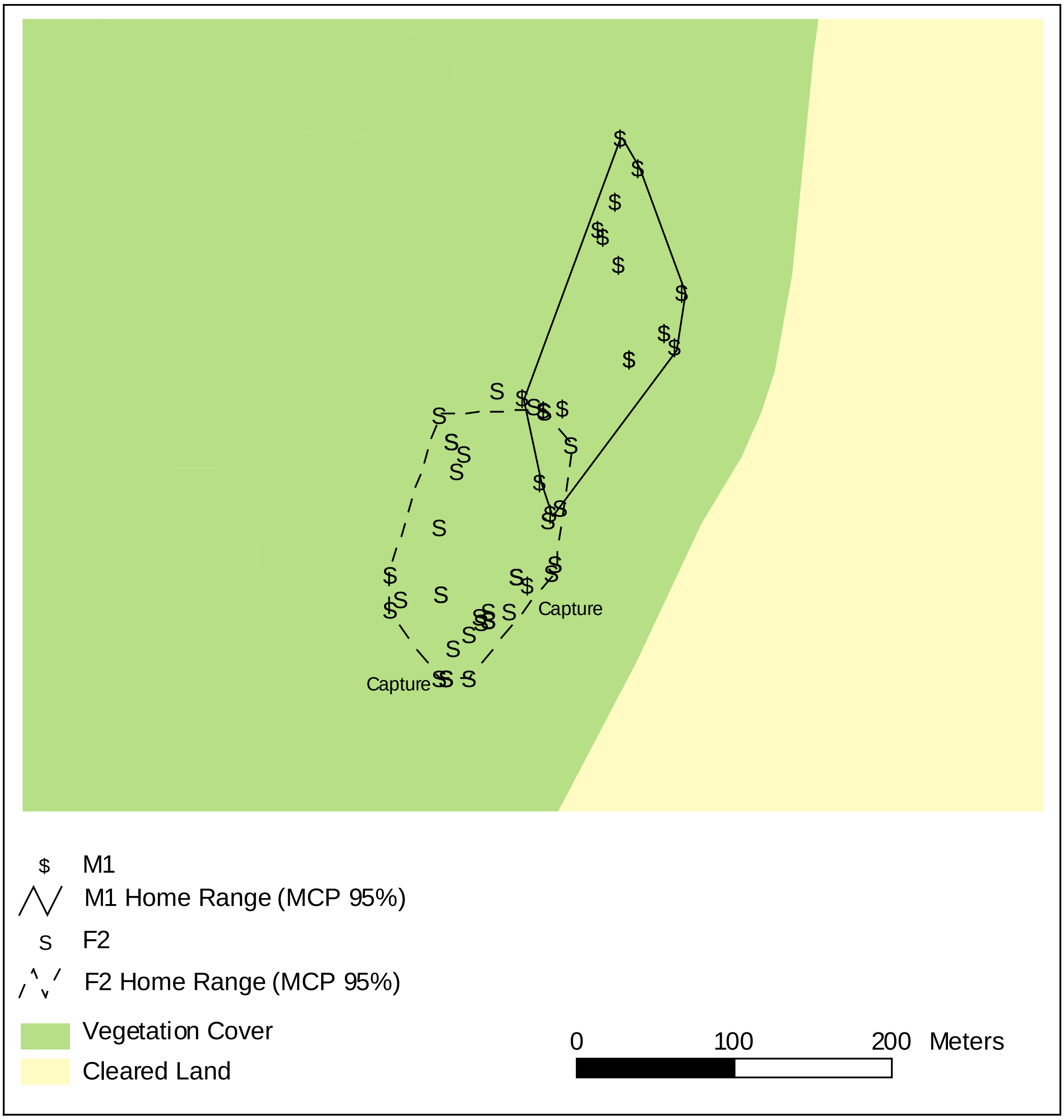
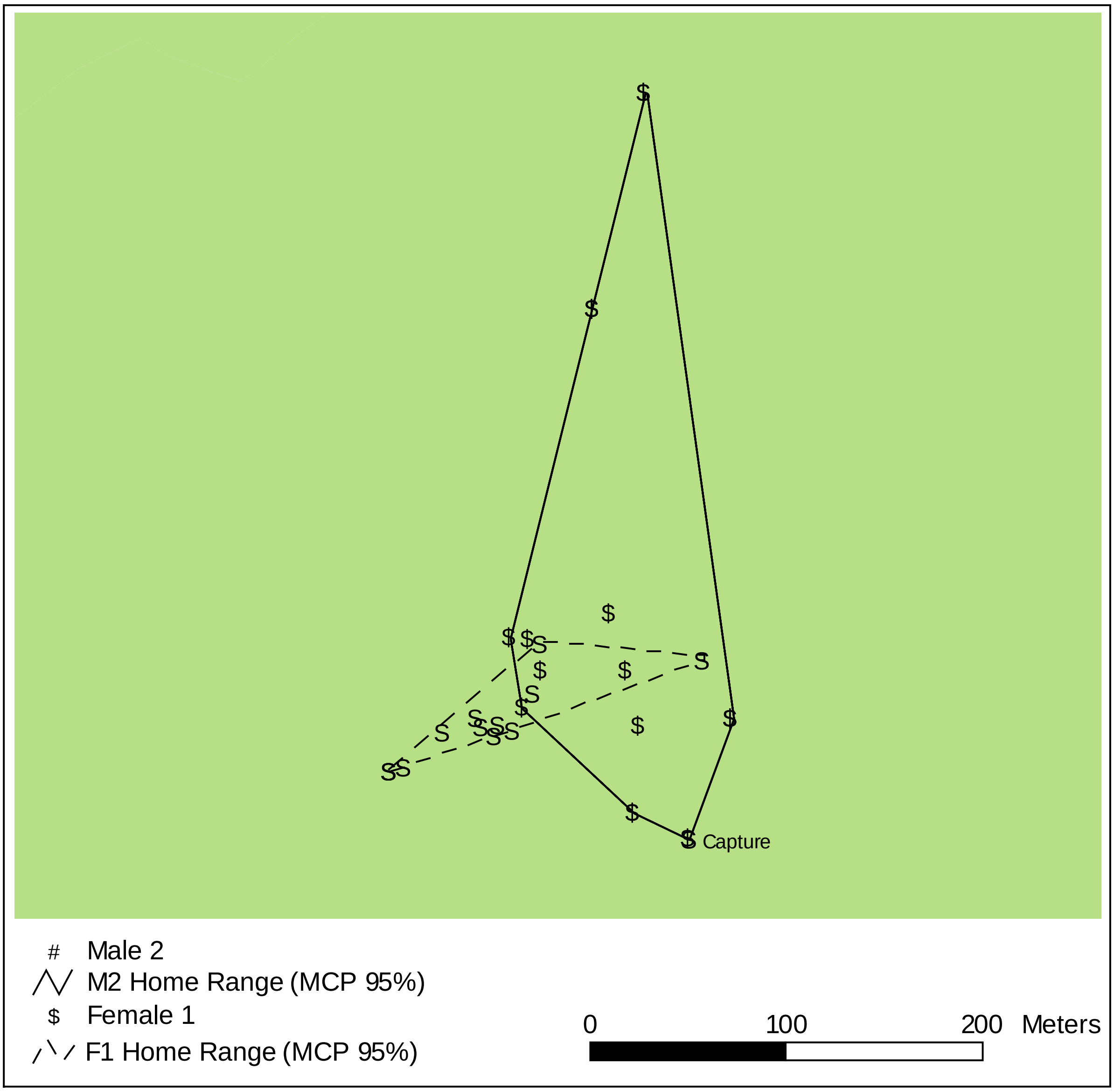


Figure 8: Radio-tracking locations and home range boundaries for two Kangaroo Island Dunnarts (M2 and F1) *Sminthopsis aitkeni* at site NS02 in the Gosselands, Flinders Chase National Park.



Banksia *Banksia ornata* for the day. It stayed within this general area for half the next night before making a rapid movement ~265 m to the north, which was the last recorded point before the animal was lost. During the last 24 hours of tracking the signal strength became very weak, which was the major factor contributing to the loss of the animal. This may have resulted from the loss of the antenna (pers. obs.). The movements of this animal and the relatively long ORL resulted in the largest home range estimate for all of the dunnarts radio-tracked (2.32 ha; Table 8).

<u>Female 1 (F1)</u>

F1 was captured and radio-tracked at the same time as M2. Unlike M2 all of F2's activity occurred within ~160 m of the capture location, and was focussed to the north of this area (Figure 8). After two nights the radio-transmitter fell off limiting the amount of data collected. The home range estimate for this animal was only 0.34 ha.

<u>Female 2 (F2)</u>

This animal was captured at the same site as M1 but in the following year. Although relatively small (at only 15 g), the collar stayed on this animal for nine days providing a relatively good data set (Table 8). The general pattern of movement was similar to M1 for most of the tracking period with the animal steadily increasing its range to the north (Figure 7). However, towards the end of the tracking period F2 doubled-back to the area used earlier in the tracking period. These movements suggest that the data provided a reasonable indication of the general area being used by this animal for that point in time. The ORL for this animal was 185 m and the home range estimate was 1.41 ha (Table 8).

<u>Temporal Patterns of Activity</u>

All four animals were predominantly active at night and inactive during the day, however, there were some exceptions. F1 was found to be active approximately two hours prior to dusk on one day. The weather was cool and there had been showers throughout the previous couple of days, contributing to dull conditions. The other dunnarts did not become active until after dusk when it was dark (pers. obs.). All animals were inactive for periods of up to two hours at night and remained in their dens. The dunnarts often used the same dens both during the day and night (see Section 4.0), but used a number of different shelters over the tracking periods.

3.4 Discussion

The capture of predominantly juvenile/sub-adult animals during this study was unexpected, and limited the number of animals that could be radio-tracked. The information obtained from the four radio-tracked animals only provides a preliminary insight into the movements and home ranges of the Kangaroo Island Dunnart, and more research is required.

As with other dunnarts, the Kangaroo Island Dunnarts are primarily nocturnal. The data suggests that the sizes of areas required by these animals are relatively small, especially for females, (only a few hectares), however, with no understanding of 'life-long' home ranges it is not possible to make firm conclusions. It was expected that the males would move over larger areas, and these would overlap with ranges of other animals and the data confirmed this. Studies of other species of dunnart have shown that females tend to inhabit discrete home ranges, along with a proportion of the males. Other males regularly move over longer distances (500 m-1500 m) back and forth through the same areas suggesting that they used large home ranges rather than simply dispersing (Menkhorst 1995). Further research should aim to determine if the Kangaroo Island Dunnart shows similar patterns of movement.

Given a better understanding of the body sizes of Kangaroo Island Dunnarts typically caught, in the future radio-tracking studies should aim to include juveniles and sub-adults by using smaller micro-transmitters. A range of transmitters weighing less than 1 g are now available, and these are usually glued to the animal's lower back. Although this method still needs refining, trials with pygmy-possum species and House Mice could be undertaken both in the field and in captivity. Given the low capture rates of the Kangaroo Island Dunnart it is likely that such trials could be undertaken prior to dunnarts being caught. Young dunnarts would provide valuable information on home range sizes and patterns of movements and/or dispersal, and differences between sexes. This would provide important information for management of habitat at known dunnart sites.

The sizes of ranges suggested by this study provide some information relative to managing habitat, and particularly fire, within the area inhabited by the species. The results suggest that dunnarts may be able to survive in relatively small patches of unburnt vegetation following fires (perhaps <10 ha), however, if few patches remain unburnt the chances of them containing dunnarts are dramatically reduced. Therefore, at least in the short-term, fire management should aim to reduce the severity and extent of wildfires and to increase the patchiness within the habitat.

4.0 MACRO AND MICRO-HABITAT SELECTION

4.1 Introduction and Background Information

Habitat selection is arguably the most important aspect of the ecology of the Kangaroo Island Dunnart because habitat can be directly affected by management actions, particularly those associated with wildfire control and suppression. Limited information from previous studies indicated that the Kangaroo Island Dunnart occupies a range of *Eucalyptus* formations, floristic groups and seral stages (Herbert 1996) suggesting it is a habitat generalist, which confounds its rarity. However, the use of a range of habitats is not surprising given the wide range of habitat types used by the closely related Common Dunnart, which include dry forest and woodland, mallee scrub and dry heath (Menkhorst 1995). These sites are characterised by sparse shrub and ground cover (<50%) but often have dense leaf and bark litter (Menkhorst 1995). Studies have shown that structural components of habitat provide a better description of habitat used by dasyurids than floristics (Fox and Fox 1984).

This study investigated habitat selection at the macro and micro level to determine if the Kangaroo Island Dunnart showed any preference for a particular habitat features.

4.2 Methods

4.2.1 <u>Defining macro-habitat selection based on existing vegetation maps</u>

The existing vegetation map for Kangaroo Island was developed by identifying mappable vegetation groups based on the dominant overstorey species and their structure (Ball and Carruthers 1998). Within each group, sub-groups were defined to account for variation amongst sub-dominant overstorey species. The number of survey sites within each vegetation group (see Ball and Carruthers 1998) can be seen in Section 2.0 (Table 1). Here, all past and present locations with dunnarts were plotted on the vegetation map in Arcview GIS (ESRI 1998) to identify the sub-groups of vegetation and structural formations in which the species has been recorded. The distribution of these vegetation sub-groups and structural formations was subsequently extracted from the vegetation map to show the extent of potential habitat for the species.

4.2.2 <u>Defining macro-habitat selection based on floristics, structural and physical features of survey sites</u>

Macro-habitat surveys were undertaken for each trapping sub-site (i.e. most survey sites had two sub-sites situated approximately 100 m apart; see Section 2.0) and were broadly similar to the standard biological survey techniques (Heard and Channon 1997). Sampling was undertaken within a 30 m by 30 m quadrat encompassing each sub-site. Within each quadrat all abundant plant species were recorded along with their life-form/height class (see Appendix F) and cover abundance as per Heard and Channon (1997). For each lifeform/height-class present the percentage cover was estimated to provide a vegetation structural summary.

A physical description of each quadrat was also undertaken, including litter cover, and details of fire history where it was known (Heard and Channon 1997). The presence of *Phytophthora* was noted. The location of each site was recorded with a hand-held GPS to an accuracy of ~5-10 m. Depending on the complexity of the habitat 30-45 minutes was required to undertake each survey.

4.2.3 Micro-habitat Use

Radio-tracking of four dunnarts (see Section 3.0) provided a small insight into micro-habitat use, and in particular the types of sites selected as day shelters. A description of each day shelter was recorded.

4.2.4 Data Analysis

The primary aim of data analysis was to determine if there were any differences between plant species richness and diversity, and structure, at sub-sites with (n=13) and without dunnarts (n=92). The statistical analysis program Primer v5 (Clarke and Gorley 2001) was used to undertake non-metric multi-dimensional scaling (MDS) of floristics and structural data for each sub-site. Bray-Curtis analysis of similarity (ANOSIM) was undertaken to statistically compare the features of sub-sites with and without dunnarts. Floristics data simply consisted of presence/absence of each species at each sub-site. Structural data consisted of a percentage cover estimate by strata, and this was log transformed (log x+1) prior to analysis. Leaf litter cover was included in the structural analyses. Floristics data was analysed with and without overstorey species (i.e. trees and mallee; see Appendix F). Comparisons between structural data (% cover for all lifeform/height-classes present; see Heard and Channon 1997) was analysed for (a) all lifeform/height classes; (b) understorey below 2.0 m only; and (c) understorey below 1.0 m only. All analyses were undertaken for all sites combined, as well as only for those sites that were located on the western end of the island, in and around FCNP.

Additionally, plant species richness for each lifeform/height class present at each subsite was compared for those sites with and without dunnarts.

4.3 Results

4.3.1 Potential habitat based on the Kangaroo Island vegetation map

The past and present locations of records of Kangaroo Island Dunnarts occur within five sub-groups of vegetation as defined by Ball and Carruthers (1998; see Table 9). The distribution of these sub-groups provides an indication of the possible distribution of this species (see Figure 9). The largest area of potential habitat occurs within FCNP and to the north of this park, and consists of Kangaroo Island Mallee-ash *Eucalyptus remota* and Brown Stringybark *E. baxteri* associations. Much of the Kangaroo Island Mallee-ash formations are preserved within FCNP, however, remnants of the stringybark formations are evident to the east of FCNP, and clearly much of this habitat has been cleared for agriculture. Based on past records a large area of potential habitat also occurs in the vicinity of Seal Bay and Cape Gantheaume (Figure 9).

In comparison, the extent of potential habitat based on structure alone is much greater and includes the majority of remnant vegetation on the island (Figure 9). This has implications for future survey work.

4.3.2 Comparison of floristics and structure of the habitat at sub-sites with and without dunnarts.

The floristics and structure of habitat was recorded at a total of 105 sub-sites, of which dunnarts were recorded at 13. Multi-dimensional scaling (MDS) plots showed no apparent difference between the floristics at sub-sites with and without dunnarts for all sites, and for the sub-sites on the west end of the island only, although the dunnart sites are clustering and are therefore relatively similar (Figure 10). The same result was obtained when the floristics of the understorey only were analysed (Figure 10). Based on the results above, which showed that Kangaroo Island Dunnarts have been recorded in a range of vegetation associations, this result is not surprising. A Bray-Curtis analysis of similarity (ANOSIM) of these data confirmed that there was no significant difference between the floristics of sub-sites with and without dunnarts (Table 10).

Table 9: The vegetation associations/formations occurring at the locations of all Kangaroo Island Dunnarts *Sminthopsis aitkeni* records, the number of sites with dunnarts in each association, and the extent of these associations (ha).

Source of vegetation descriptions: Ball and Carruthers (1998).

Vegetation Group	Vegetation Sub-group	Structural Formation	Current Extent (ha)	Current Sites	Past Sites
E. remota	*(1A) E. remota, E. cosmophylla, +/- E. baxteri*	Open Low Mallee	31,416	4	
E. baxteri	*(3B)* E. baxteri +/- *E. obliqua, +/- E. cladocalyx, E. cosmophylla*	Low Woodland	9,292	1	1*
	(3E) E. baxteri, E. remota +/- E. obliqua, E. cosmophylla	Low Open Woodland	3,704	1	
E. diversifolia	*(2N) E. diversifolia, E. rugosa +/- E. landsdowneana ssp. albopurpurea +/- E. oleosa*	Open Mallee	22,409		1
E. cladocalyx	*(5G) E. cladocalyx, E. cosmophylla, A. verticillata +/- E. fasciculosa, +/- E. leucoxylon ssp. leucoxylon*	Open Woodland	7,333		1

* This represents the original record for the species, and although the habitat has now been cleared, the location is within 100m of remnant habitat of this vegetation sub-group.

Figure 9: Extent of potential habitat of the Kangaroo Island Dunnart *Sminthopsis aitkeni* based on the vegetation associations and structural formations in which dunnarts have been recorded.

Potential habitat was determined by selecting all vegetation sub-groups and structural formations in which records of Kangaroo Island Dunnarts were located. Vegetation sub-groups and structural formations are defined in Ball and Carruthers (1998). The accuracy of pat locations is not certain, and the habitat at these locations is likely to have changed since the records were obtained (i.e. >20 years ago in some cases). Also the suitability of many of the patches highlighted as potential habitat is likely to be influenced by patch size, the state of the vegetation and the degree of isolation. However, the map provides a useful starting point for future survey work.

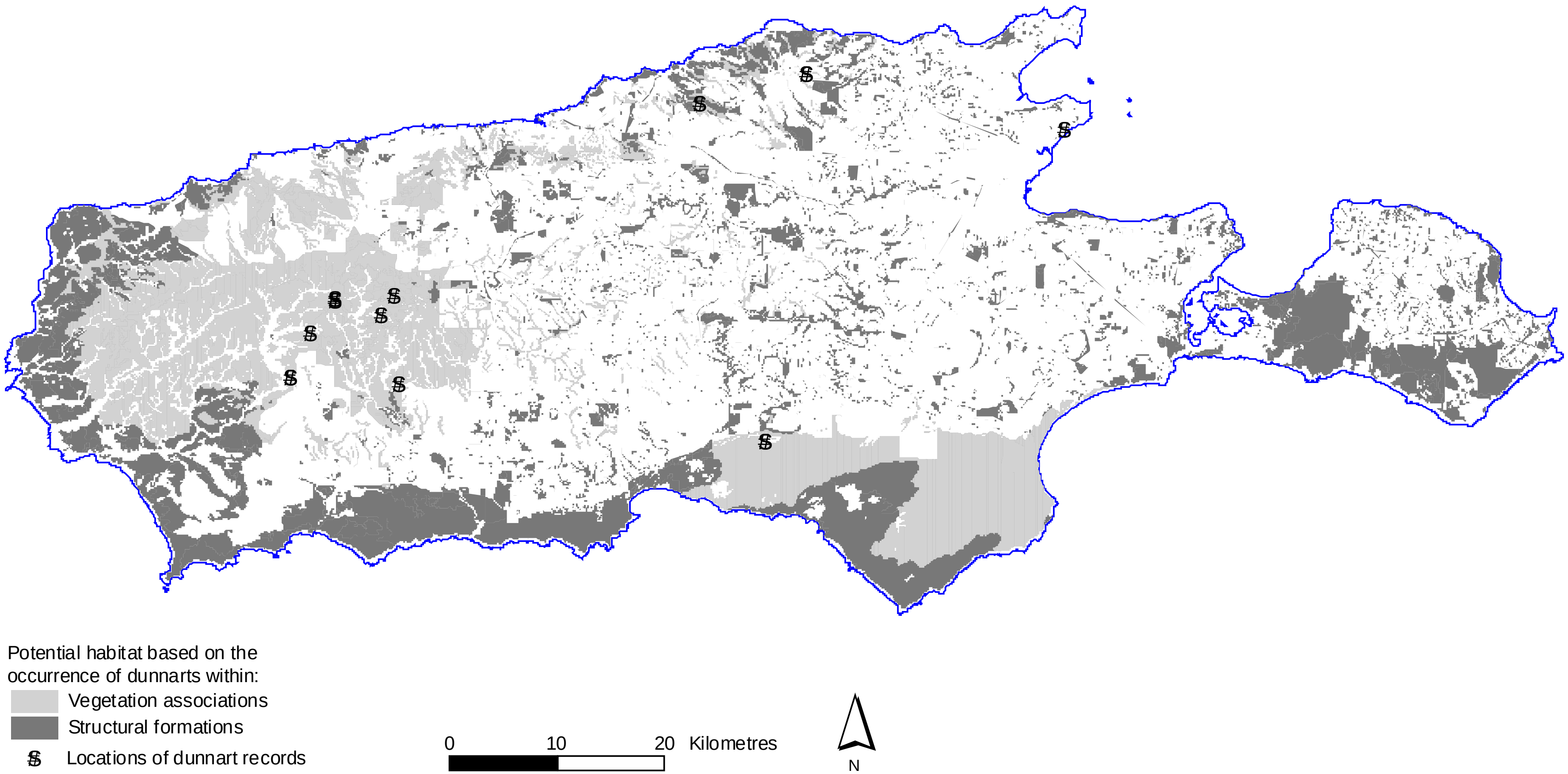


Table 10: Statistical comparison between floristics and structure of vegetation at sub-sites with and without Kangaroo Island Dunnarts *Sminthopsis aitkeni.*

Results are for Bray-Curtis analysis of similarity (ANOSIM) between 13 sub-sites with dunnarts and 92 sub-sites without dunnarts. Data were collected for 30 m by 30 m quadrats. All plant species were recorded along with the percentage cover for each lifeform/height class of vegetation following Muir's Code as outlined in Heard and Channon (1997). *significant difference at P < 0.05.

Habitat Feature	**ALL SITES**		**WEST END SITES**	
	ANOSIM R-statistic	Prob.	ANOSIM R-statistic	Prob.
All plant species	-0.083	0.91	-0.053	0.698
Understorey plant species only	-0.09	0.914	-0.034	0.627
All structure[1.]	0.071	0.182	0.079	0.143
Understorey structure only (< 2.0 m)[1.]	0.069	0.218	0.112	0.117
Lower understorey structure only (< 1.0 m)[1.]	0.133	0.067	0.175	0.038*

1. One sub-site with dunnarts was not included in the ANOSIM of vegetation structure because it was the only sub-site with ferns (bracken), and caused all other sub-sites to group tightly together.

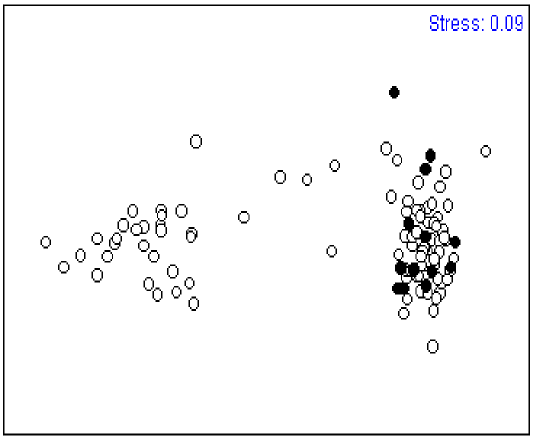
MDS and ANOSIM of the structure of vegetation of all sub-sites combined also showed no significant difference between sub-sites with and without dunnarts for: (a) all lifeform/height classes; (b) lifeform/height classes below 2.0 m; and (c) lifeform/height classes below 1.0 m (Figure 10 and Table 10). However, the ANOSIM result indicated that the sub-sites with dunnarts were only slightly different for cover of lifeform/height classes below 1.0 m (ANOSIM R = 0.175, P = 0.067; Table 10), and these sub-sites all occurred towards one side of the MDS plot (Figure 11). Similar results were obtained for only the sub-sites on the west end of the island (Figure 11 and Table 10), although here the sites with dunnarts were significantly different at P < 0.05 for the cover of lifeform/height classes below 1.0 m (ANOSIM R = 0.175, P = 0.038). Additionally, the plant species richness for each lifeform/height class was also not significantly different for the sites with and without dunnarts (ANOSIM R = 0.095, P=0.103).

Figure 10: Comparison of the floristics at sub-sites with and without the Kangaroo Island Dunnart *Sminthopsis aitkeni* using multi-dimensional scaling.

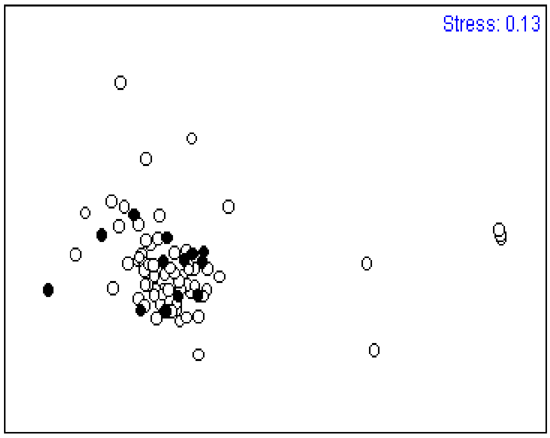
Plots are shown for all plant species and for the understorey species only for (a) all sub-sites across Kangaroo Island, and (b) sub-sites on the west end of the island only, in and around Flinders Chase National Park. Sites with dunnarts (n=13) are coloured black. Some sites are partly obscured.

All plant species

(a)

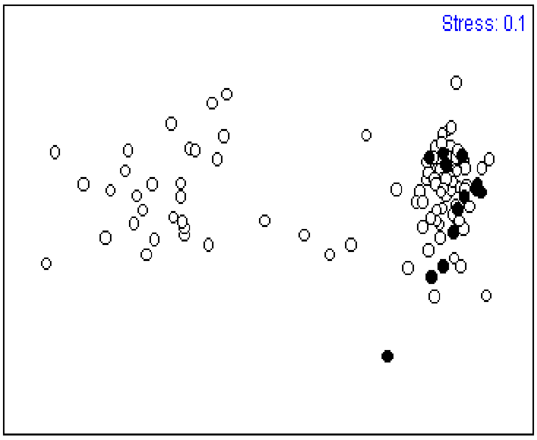


(b)



Understorey species only

(a)



(b)

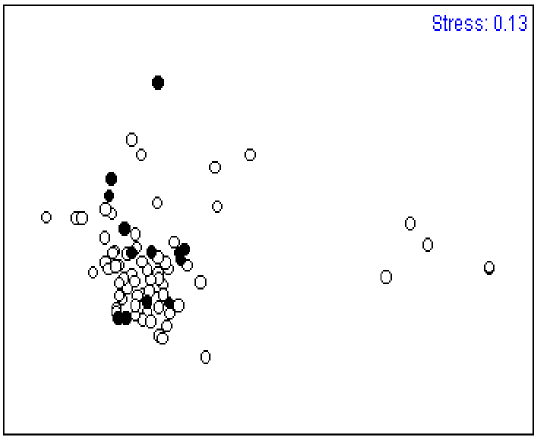
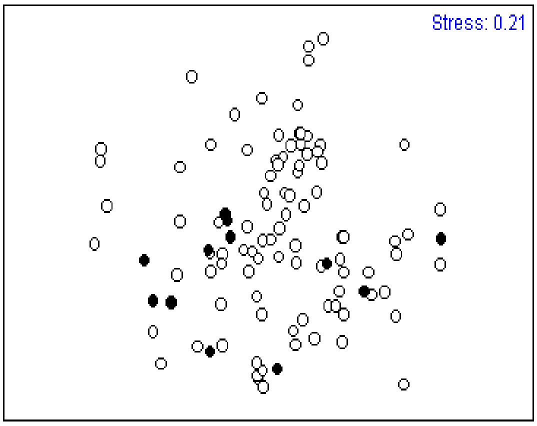


Figure 11: Comparison of the vegetation structure at sub-sites with and without the Kangaroo Island Dunnart *Sminthopsis aitkeni* using multi-dimensional scaling.

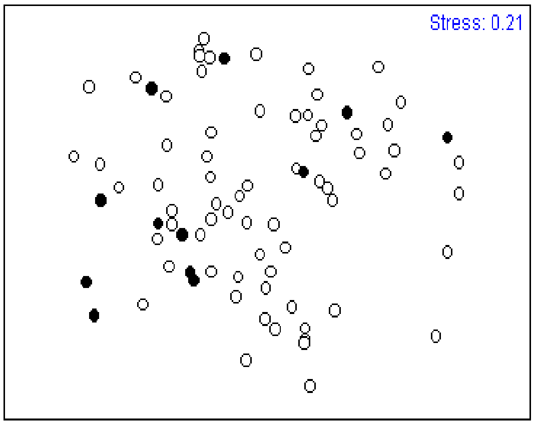
MDS plots for all sub-sites (a) and for sub-sites on the west end of the island only (b) are shown. Three analyses were undertaken - all lifeform/height (Lf/H) classes, Lf/H classes below 2.0 m only, and Lf/H classes below 1.0m only. Sites with dunnarts (n=12) are black. One sub-site was removed because it was the only site with bracken, causing all other sites to clump tightly together.

All Lifeform/Height Classes

(a)

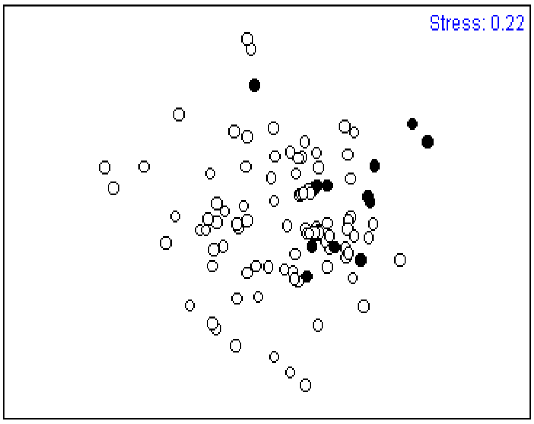


(b)

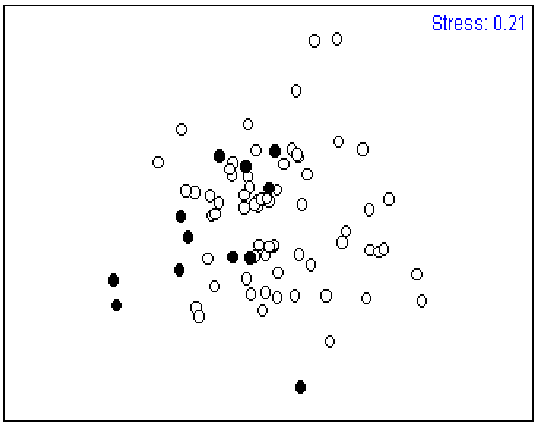


Lifeform/Height Classes below 2.0m only

(a)

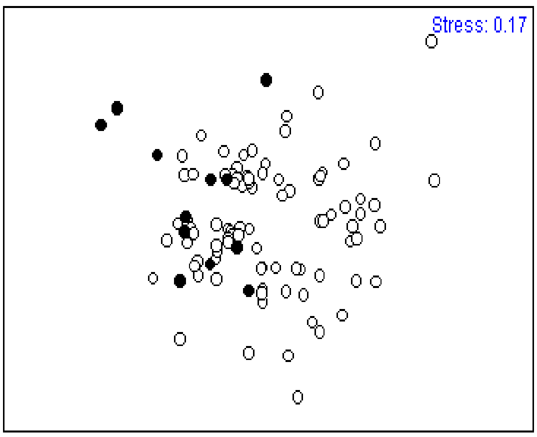


(b)

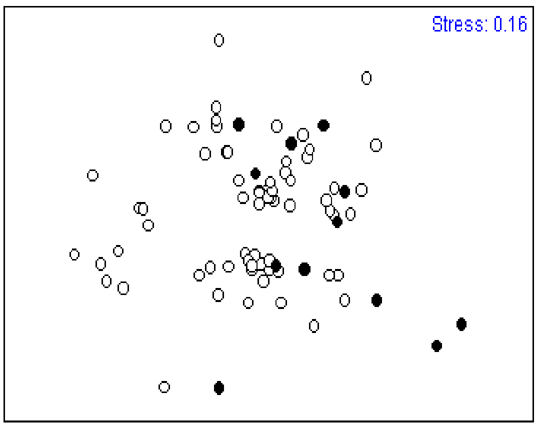


Lifeform/Height Classes below 1.0m only

(a)



(b)



Phytophthora dieback is widespread on western Kangaroo Island, and was present at seven of the 31 sites surveyed in this area, including half of the sites with dunnarts. Obviously this fungus has the potential to have a large effect on the floristics and structure of the habitat, although little is known of the effects at this stage.

4.3.3 Post fire age-classes of habitat

Unfortunately the fire history for much of Kangaroo Island is poorly understood and therefore it was not possible to undertake a complete analysis of the locations of dunnarts relative to the successional stages of habitat. However, an incomplete fire history is recorded for FCNP, and an investigation into the locations of sites with dunnarts relative to fire scars revealed some interesting patterns. All locations had not been burnt for at least 11 years, if not greater than 24 years (Table 11). Much of the Gosselands section of FCNP has not been burnt since 1986, and fire history prior to that is not recorded. All three sites in the Gosselands occurred within the boundary of the 1986 fire scar, although they were all within 200 m of unburnt remnants or the edge of the burn. Also the three sites on the West End Highway all occur on the edge of a fire scar from 1990, although the major site (WEH04) and a relatively large area around it was not burnt, and has not been burnt for at least 40 years. The other sites also appear to have escaped being burnt by this wildfire, although there is evidence of low intensity and patchy back-burns at these sites. Considering this information along with the extent and severity of the 1990 wildfire and another wildfire in 1991 (which together burnt approximately 50% of FCNP) it is possible that the relatively old age vegetation in the vicinity of the known sites (i.e. unburnt patches) provided core habitat for the species. This situation may have changes as the time since fires has increased and the vegetation has moved towards later successional stages.

4.3.3 Micro-habitat use

A total of 12 day shelters were located as a result of radio-tracking four dunnarts. All animals showed some fidelity to shelters, with up to three consecutive days spent at the same site by one animal. Tracking periods were generally too short to determine if animals subsequently returned to favoured sites.

The dunnarts sheltered under Yaccas where the fronds were continuous to ground level (n=4), in dense litter under Desert Banksias (n=4), in holes/burrows (n=3) and inside a dead Yacca trunk (n=1). At the major site there appeared to be a preference for sheltering under Yaccas,

Table 11: Estimates of time since fire at the six sites where Kangaroo Island Dunnarts *Sminthopsis aitkeni* were captured.

All figures are in years. * Although these sites occur within the mapped firescar from 1990 observations suggest that they were only subjected to low intensity backburns that did not burn far into the vegetation, and had minimal impact at these sites.

Site	Time Since Last Fire	Time Since Second to last Fire
WEH01	11*	?
WEH02	11*	?
WEH04	24	43
NS02	?	?
NS05	15?	?
WAL01	?	?

including ones that had succumbed to *Phytophthora* dieback. The dunnarts also spent periods of up to four hours using these shelters at night.

4.4 Discussion

The extent of potential habitat based on the vegetation associations and structural formations in which the dunnarts have been captured provides an indication of the potential distribution of the species. Clearly much of this habitat occurs within the large areas that have not been adequately surveyed for the species (see Figure 2), particularly within FCNP, but also on the eastern end of the island in the Seddon Plateau and Eastern Plains Regional Ecological Areas (see Figure 5). Therefore future surveys can target some of this habitat to help assess the value of such a map.

There are obvious limitations to the results of estimating potential habitat based on broad vegetation maps, particularly when very few records are available for the species. First, the inclusion of vegetation types that occur at locations of past records adds considerably to the total area of potential habitat, however, this needs to be interpreted with care. In particular, past records were obtained over 20 years ago and the accuracy of the locations is uncertain. It is likely that the habitat has undergone considerable change in this period. The vegetation mapping occurred in the mid-1990s and therefore may not reflect what was present at these sites 20+ years previously.

Second, it is likely that the dunnarts also occur within additional sub-groups of vegetation (see Ball and Carruthers 1998), which could change the extent of potential habitat considerably. Similarly, based on the structure of the habitat at the sites with dunnarts most of the remaining vegetation on the island is potentially suitable. However, this does not take into account the current state of the vegetation, patch size, or isolation, all of which would contribute significantly to the current distribution of the species.

MDS and ANOSIM showed little difference between the habitat at the sites with and without dunnarts, although these results need to be interpreted carefully because of the relatively small number of sites (n=6) and sub-sites (n=13) with dunnarts. All habitat data was collected for each sub-site, and these provided the basis for comparisons, however, it is apparent that the sub-sites from the same sites were relatively similar in many cases (pers. obs. of MDS plots). Additionally, habitat data were collected for a 30 m by 30 m quadrat surrounding the pitfall traps at each sub-site, but dunnarts were recorded using much larger areas (see Section 3.0). Therefore it is not possible to determine how representative the habitat within the quadrats was of the home ranges of the animals. However, it was felt that the habitat within the quadrat was representative of that in the broader surrounding area. Also at the sites with few captures it is not possible to determine if the dunnarts were resident in those areas, or simply passing through. Observations of breeding are therefore particularly valuable because they indicate that an area can support breeding populations. In comparison presence/absence data alone is of relatively limited value with regards to determining priorities for on-ground management.

Analyses of vegetation structural data for each sub-site produced similar results to the floristics analyses, with one exception. There was a significant difference between the vegetation cover for lifeform/height classes below 1.0 m at sub-sites with and without dunnarts when only the data for the sites on the west end of the island were considered (Figure 10 and Table 10). This result appears to reflect the relatively open nature of some of the sub-sites with dunnarts (pers. obs), and in particular those at the major site with dunnarts (WEH04), although some sites with dunnarts also had relatively high vegetation cover in the lifeform/height classes below 1.0 m. Therefore this result may reflect the relatively small sample size and bias from one relatively open site where dunnarts were caught at four sub-sites. Regardless, whilst vegetation structural cover is in part determined by the successional stage of the vegetation following fire, it is not possible to accurately map vegetation structure in a way that would allow for predictions on where the dunnarts might occur. Additionally, other factors are likely to be operating on the distribution of dunnarts, which makes it almost impossible to predict their distribution and these will be discussed below.

These results are consistent with the occurrence of dunnarts within a range of vegetation sub-groups (see Ball and Carruthers 1998), and supports the notion that the Kangaroo Island Dunnart is a habitat generalist, as suggested by Herbert (1996). Unfortunately these results confound our ability to predict the likely distribution of dunnarts based on vegetation maps above.

The presence of *Phytophthora* at half of the sites with dunnarts makes it difficult to determine the indirect effects of this fungal disease on the dunnarts. The changes to floristics and structure that result from *Phytophthora* dieback have the potential to considerably alter the habitat. Only further detailed research will assist with identifying the effects on fauna, including dunnarts.

The range of sites selected as shelters by the dunnarts was not surprising and these sites are unlikely to be limiting for the species. It was interesting that at the major known dunnart site Yaccas, including those already killed by *Phytophthora* dieback, provided the preferred day shelter. Clearly the habitat provided by these dead plants is only available in the short-term and will be removed by fires. It is possible that the loss of plants such as Yaccas from the habitat could reduce the value of that habitat to the dunnarts, although alternative shelter sites will also be available.

4.4.1 Difficulties with determining habitat preferences and implications for management

Whilst it is possible to define habitat types, such as vegetation associations, it is typically the overstorey species that provide the basis for mappable units, and this is primarily a reflection of our ability to interpret, and therefore map, broad patterns visible on aerial photographs (see Ball and Carruthers 1998). These maps are limited to broad floristic descriptions, and therefore some indication of structural habitat features can only be inferred. However, these broad habitat maps generally provide the basis for survey, monitoring and management units, with programs designed to sample each habitat type. The locations of fauna survey sites, and subsequently our understanding of patterns of fauna distribution and abundance, are therefore typically based on, and related to, these broad mappable habitat units. However, ground dwelling small mammals may not be directly reliant on the overstorey species that provide the basis for mapping habitat types (although indirectly litter fall may be important). As demonstrated, the Kangaroo Island Dunnart appears to be a habitat generalist anyway. Therefore our ability to map potential habitat in a useful way for the management of such species may be quite limited.

Determination of habitat preferences by the Kangaroo Island Dunnart within habitat such as occurs on western Kangaroo Island is likely to be confounded by the level of heterogeneity that occurs at the scale that these animals operate (i.e. several hectares or so). Heterogeneity within some of the habitat types is high, with floristics and structure often varying considerably over as short a distance as several hundred metres (pers. obs). Perturbations resulting from events such as fire, and the subsequent successional changes that occur, further complicate identification of habitat preferences. Within this context it is probably not surprising then, that the Kangaroo Island Dunnart appears to show little preference for vegetation associations, or structural features. The lack of competition from conspecifics is also likely to result in a broad habitat use. It is therefore not surprising that we find it difficult to identify the important causal factors that actually determine resource use preferences by these animals.

4.4.2 Effects of fire on habitat and implications for management

The post fire age-classes of habitat at the sites with dunnart are all relatively old, although as indicated, an incomplete fire history record for most of Kangaroo Island makes it difficult to precisely determine the effects of this process on dunnarts. It is not clear if the occurrence of all dunnart sites relative to the edge of firescars is due to the small sample size (i.e. six locations), or chance, or both. Whilst some unburnt habitat is critical for dunnarts to survive fires, the use of regenerating habitat is not known. The data suggests that part of the key to the distribution of the species may be the chance survival of populations, or individuals, within unburnt remnants within the large areas of FCNP that have burnt. Unfortunately, the lack of data, and the resolution at which some firescars have been mapped are also impediments to clearly determining the fire history at sites with dunnarts, and survey sites in general.

The effects of fire on habitat are clearly one of the most important processes that determine habitat suitability for dunnarts. Some small mammals respond well to fire, peaking in abundance in the years following fire, before declining to pre-fire levels (e.g. Monamy and Fox 2000). This pattern is evident for the Common Dunnart in the mallee heaths in Ngarkat Conservation Park (Paton 2000), and for the purposes of this discussion, it is reasonable to assume that the Kangaroo Island Dunnart responds in a similar way. Biologists often interpret such observations to mean that these species prefer early successional stages of vegetation and the ability to exploit such habitats and breed rapidly may be an important factor in the longer-term survival of a population(s). However, although rarely stated, implicit in this assumption is the fact that patches of unburnt habitat must remain to ensure that animals survive the fire event itself, and continue to survive until the habitat recovers sufficiently enough for them to exploit it. This suggests that a mosaic of successional stages of vegetation is probably required to ensure the survival of such species, and severe and extensive fires are likely to be detrimental. However, this scenario is complicated even further by rare species, or species that have a patchy distribution. The likelihood of these species occurring within any unburnt patches is relatively low, suggesting that chance plays a role in the survival of local populations.

Therefore the maintenance of a mosaic of successional stages of vegetation alone may not ensure the survival of species such as the Kangaroo Island Dunnart, and could in fact contribute to the loss of local populations. Management of populations and habitat of such species is much more complex, and in particular we need to consider the dynamics of dunnart populations in the period between fires. Clearly it is impractical and undesirable to maintain vegetation at early successional stages, and this does not occur naturally in places like FCNP. Therefore with such a rare species maintenance of relatively low 'background' levels of abundance that are typically evident in later successional stages of vegetation is in particular important (D.C. Paton pers. comm.). It is the relatively long intervening periods between fires, when populations are relatively low (based on the assumption above), that is critical to the survival of the species. The maintenance of populations relies on relatively few individuals surviving and breeding successfully. Clearly identifying the locations in the landscape where dunnarts persist, and are able to breed, (i.e. 'hotspots', see Paton 2000) and protecting these locations is at least as important as maintaining a mosaic of habitats. Given that the Kangaroo Island Dunnart appears to be a habitat generalist, in a mesic environment such as western Kangaroo Island it appears likely that the occurrence of dunnarts at these locations may simply have resulted from chance. The outcome of historical events, and in particular successive wildfires since the habitat was cleared and fragmented, quite possibly has determined the current locations of populations.

Unfortunately it is inherently difficult to identify the 'hotspots' where species such as the Kangaroo Island Dunnart persist, as indicated by this project, especially since the data indicates that there is no real preference for particular habitat features. Predictions about where the species might occur are therefore almost impossible, and in any case, as discussed above our ability to define and map habitats is limited.

Clearly conservation management must take a dual approach. 'Hotspots' need to be protected from fire at least in the short-medium term. On-going effort is also required to identify more 'hotspots'. The severity and extent of wildfires also need to be limited, whilst actively encouraging the development of a mosaic of successional stages of vegetation. Monitoring and adaptive management provides the only satisfactory approach for dealing with such complex conservation management issues.

4.4.3 Conclusions

Clearly the limited data available on the Kangaroo Island Dunnart makes it difficult to determine habitat preferences, and as indicated in Section 2.0, only further survey work will help to clarify this situation. Currently, the data suggest that the range of the dunnarts may have contracted to the western end of the island, in line with the loss of habitat on the east end. However, based on the map of potential habitat, and the apparent lack of preference for any particular habitat type (to date), most of the remaining vegetation on the island could potentially be suitable for dunnarts. Obviously the effects of fragmentation and isolation, and smaller patch sizes reduce the likelihood of the species still occurring on the eastern end of the island, however, this can not be ruled out. Only further, targeted, survey work can help to refine the habitat requirements of the species. As indicated in section 2.0, future survey site selection should be based on stratification of the habitat, starting with the Regional Ecological Areas (see Willoughby *et al*. 2001), and considering vegetation floristics and structure, post fire age-classes, and the presence and absence of other potential threats such as *Phytophthora*. Such a methodology would greatly improve our ability to determine the habitat preferences of the species, the impact of potential threats such as fire and *Phytophthora*, and would allow us to predict the extent of potential habitat with much more certainty.

5.0 DIET

5.1 Introduction and Background Information

Dunnarts are generally considered opportunistic feeders, predominantly eating a wide range of terrestrial arthropods, and occasionally small reptiles. Some information on diet has been obtained for a few conspecifics of a similar size to the Kangaroo Island Dunnart (eg. White-footed Dunnart *S. leucopus*, Lunney *et al*. 1986*;* Fat-tailed Dunnart *S. crassicaudata*, Stripe-faced Dunnart *S. macroura*, Morton *et al*. 1983; and Common Dunnart, Fox and Archer 1984). Knowledge of the diet of a species is essential for understanding its ecology and physiology, and for threatened species, is important for effective conservation and management (Chen *et al*. 1998).

The relationship between diet and habitat selection has been studied for some dunnart species, although results indicated that diet was not an important component of habitat specificity (Fox and Fox 1984, Lunney *et al*. 1986). Interspecific competition, particularly between dasyurids, has also been shown to affect the diet of individual species. As the Kangaroo Island Dunnart is the only extant dasyurid on Kangaroo Island competition of this nature does not exist. Although there may be some interspecific agonistic (eg, Bush Rat; see section 2.0) competition for food with these species is likely to be limited due to minimal dietary overlap and body size differences between the species.

Diet of mammals and birds is often determined by examining the remains of food items within faeces (e.g. mammals: Morton *et al.* 1993, Lunney *et al*. 1986, Gibson 2001; birds - Wooller and Calver 1981, Paton 1982, Danks and Calver 1993). Much has been written of the biases that potentially result from differential digestibility of various prey items, and in particular it is recognised that hard-bodied animals (e.g. beetles) are likely to be over represented compared to soft-bodied animals (e.g., Custer and Pitelka 1975, Jenni *et al*. 1990). However, studies of birds have found that faecal analysis agrees well with observations on the incidence of insectivory and the types of insects eaten (Calver and Wooller 1982). This may be further complicated with dasyurids, which may not consume all of the animals they catch (Dickman and Huang 1988). Therefore with this limitation in mind, the technique can provide a good understanding of the range of prey groups consumed without having any impact on the individual animals being studied.

This section reports on the results of a study of the diet of the Kangaroo Island Dunnart based on scat analysis.

5.2 Methods

Scats were collected opportunistically following the capture of dunnarts and subsequently examined to determine the diet. The scats were collected from five sites, with two to 12 collected from each site. All scats were collected between January and April, with three to eleven scats collected in each month. Sample sizes were too small to warrant investigation of spatial and temporal comparisons in diet. In the time required to mark, weigh, sex and measure each individual prior to release, at least one scat was usually deposited in the holding bag. Scats were stored in small snap-lock plastic bags and frozen until being analysed.

Scats were soaked in a 70% alcohol solution and then teased apart under a low power binocular microscope. Arthropod remains were sorted prior to being identified by L. Queale (Biological Survey, NPWSA). Each fragment was identified to the level of Order (referred to as food groups). The data are presented as percentage frequency of each food group occurring within scats.

5.3 Results

A total of 25 scats were collected from fourteen dunnarts caught during this survey. All scats contained the remains of at least one identifiable food group (Figure 12) with the majority having the remains of two or more groups. Spiders and ants were the most common food groups recorded within the scats, occurring within 59% and 56% of scats respectively. Beetles and scorpions were also commonly consumed, being recorded within 36% of scats (Figure 13). The remains of a centipede and grasshopper were recorded in only one scat each (Figure 13).

Comparisons between the diet of males and females shows little difference between the consumption of most food groups, except for spiders, which were recorded in the faeces of males at over twice the frequency of females (Figure 14). However, the relatively low sample size could mask differences based on size, age and locations where the dunnarts were caught.

Figure 12: The percentage frequency of the number of prey groups recorded within individual scats (n=25) of the Kangaroo Island Dunnart *Sminthopsis aitkeni* between January 2000 and April 2001.

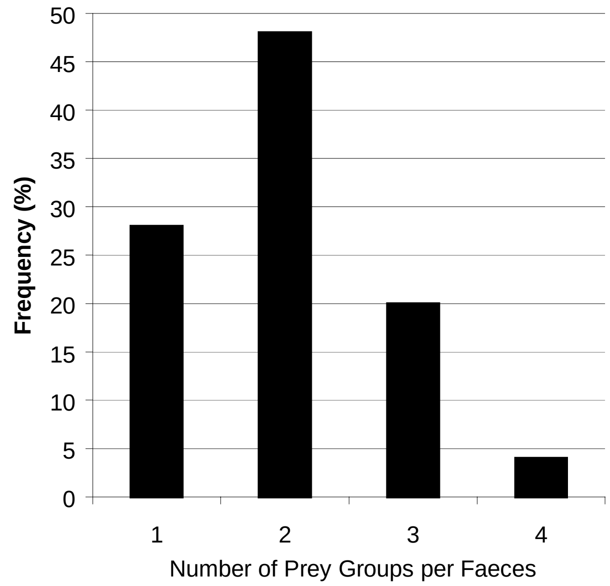


Figure 13: The percentage frequency of the occurrence of prey groups within Kangaroo Island Dunnart *Sminthopsis aitkeni* scats collected between January 2000 and April 2001.

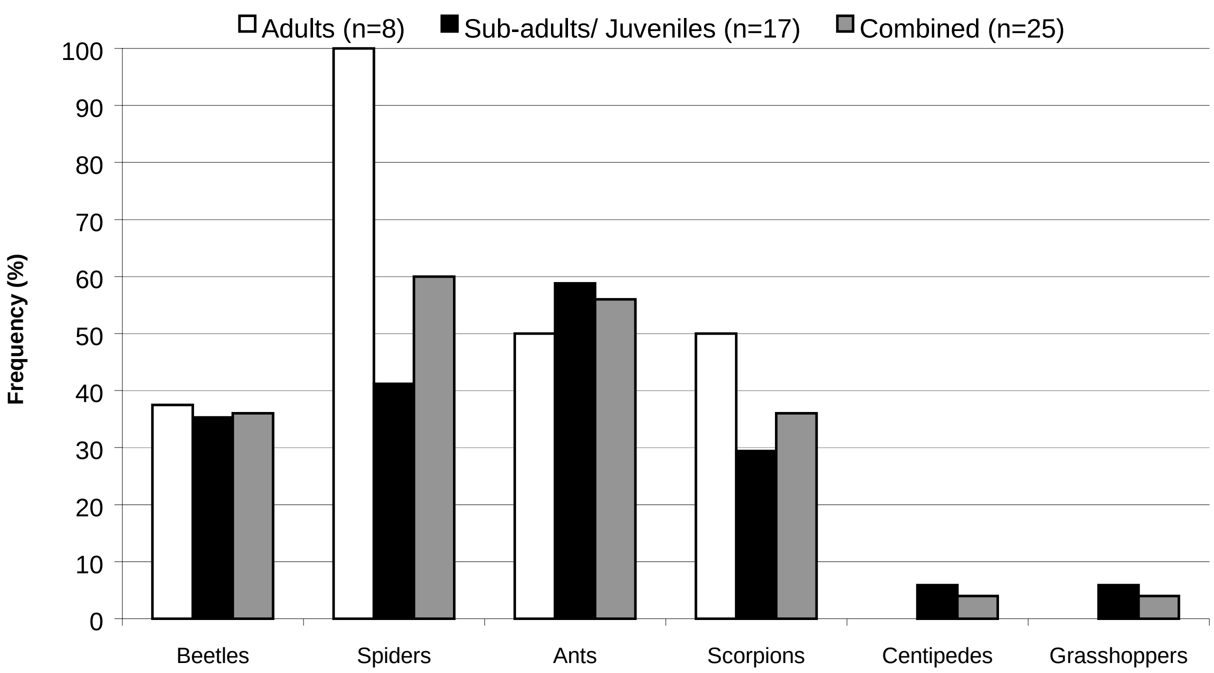
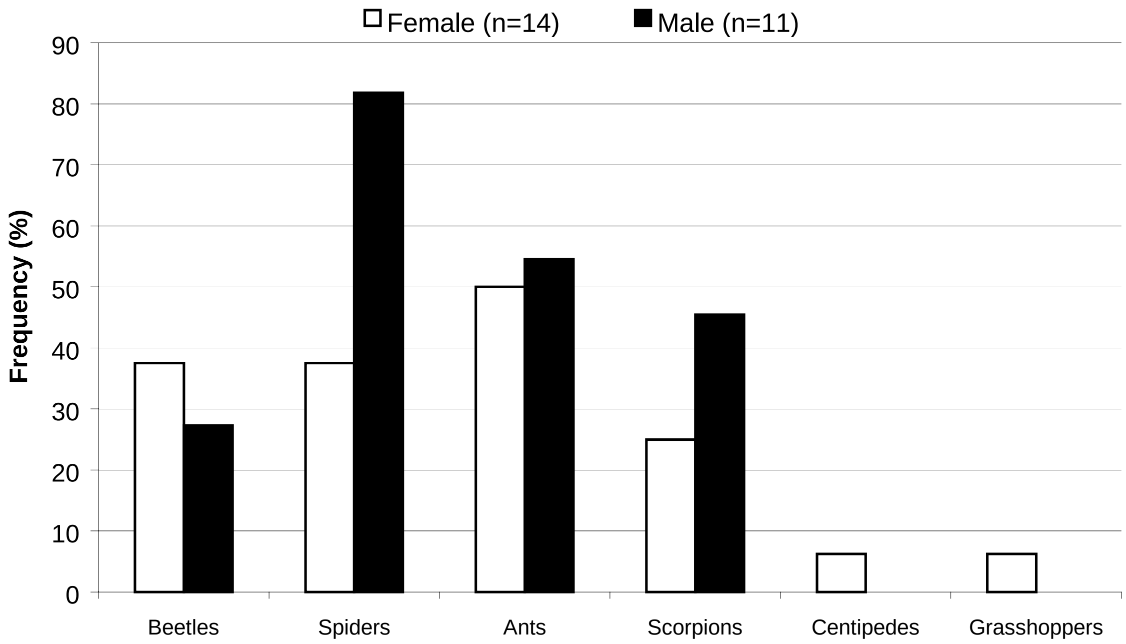


Figure 14: A comparison of the percentage frequency of the occurrence of prey groups within scats of male and female Kangaroo Island Dunnart *Sminthopsis aitkeni* collected between January 2000 and April 2001.

Data are for adults and sub-adults/juveniles combined. No adult females were captured and the number of scats collected from male sub-adults/juveniles was too small for comparisons with female sub-adults/juveniles.



Approximately one third of the faeces contained small amounts of fur and it is thought that this is simply swallowed by the animal while it is grooming itself. Small amounts of soil were recorded in a few scats.

5.4 Discussion

This investigation into the diet of the Kangaroo Island Dunnart provides a preliminary insight only. The results are indicative of the expected diet for this species, with all food groups recorded being ground-dwelling invertebrates, in particular spiders, ants, beetles and scorpions. Not surprisingly the remains predominantly originate from invertebrates with a hard exoskeleton and it is possible that soft-bodied prey, such as worms, are difficult to detect, although mandibles and legs may be present. For example, spiders are relatively soft-bodied compared to the other food groups but were readily detected. Considering the biting, cutting dentition and mobility of dasyurids they are well equipped to tackle active and hard-bodied prey, and based on other studies, it was expected that such prey would form the majority of the diet. Not surprisingly there was no apparent specialisation on a single taxonomic group (see Fisher and Dickman 1993).

Dasyurids are generally thought to favour prey taxa such as larvae, spiders, cockroaches and bugs, with less palatable or less profitable prey types identified as ants and carabid beetles (Hall 1980, Statham 1982, Fox and Archer 1984, Lunney *et al*. 1986). The Kangaroo Island Dunnart only conforms to these generalisations in part, and in particular carabid beetles formed a numerically important part of the diet based on frequency of occurrence in scats. Ants also formed an important part of the diet, and not surprisingly the nocturnal, and relatively large, *Camponotus* were consumed (pers. obs.). Carabid beetles were caught in most pitfall traps, typically in greater abundances than other invertebrate taxa (pers. obs), suggesting they were abundant, although it is not possible to determine if they were selected for or against by the dunnarts. Ants were also abundant at the survey sites (pers. obs) although relatively few ant taxa are nocturnal, and *Camponotus* in particular are much less abundant than the dominant groups such as *Iridomyrmex* (pers. obs.). Therefore given the occurrence of *Camponotus* in the diet they may not have been selected against, however, the relative abundance of nocturnal ants needs to be sampled to confirm this.

Differences in diet between the sexes might be expected if the species is sexually dimorphic, particularly with regards to size, although in this study faeces were obtained from a wide range of animals, from juveniles to adults, and the sizes of these overlapped. Therefore it is not surprising that there was little difference in diet between the sexes. The fact that only adult males were captured may possibly account for the greater consumption of spiders by this sex, possibly due to differences in foraging habits, or the size of prey taken, or other such factors.

Given the regularity of seasons on Kangaroo Island, and the lack of direct competition from conspecifics, it is thought that food resources are unlikely to be limiting for this species. However, seasonal differences in diet might be expected, simply due to changes in abundance of prey groups, or the need to meet higher energy and nutrient requirements during the breeding season (Chen *et al*. 1998). For example prey groups such as scorpions were only active during the warmer months of the year (pers. obs.) and this would be reflected in the diet of the dunnarts. Unfortunately the lack of dunnart captures during winter and spring made it impossible to examine seasonal variation in diet. A more detailed study that incorporates sampling of potential prey groups, combined with the capture of dunnarts during winter and spring is required to identify seasonal differences in diet.

This investigation was based on a moderate sample size of 25 faeces, which is considered adequate to provide a broad indication of diet of dasyurids (see Chen *et al*. 1998). As indicated more samples are required to make seasonal comparisons in diet, and to adequately compare the diet of males and females, and adults versus juveniles/sub-adults. Unfortunately, this is directly limited by the captures of dunnarts, which is not likely to ever occur in great numbers, particularly in winter/spring.

6.0 POPULATION ECOLOGY AND BREEDING BIOLOGY

6.1 Introduction and Methods

An understanding of population ecology and breeding biology is essential to determine if reproductive output is limiting the population, particularly relative to the potential effects of predation. To gain an understanding of population ecology and breeding biology a high number of animals need to be captured and/or recaptured, and therefore these aspects of the Kangaroo Island Dunnart's life history are poorly understood. This current study has contributed some information on these topics. However, it has been necessary to compare the results with information obtained from lab studies on a close relative, the Common Dunnart (Fox and Whitford 1982) and to make a few inferences based on other studies (see Lee *et al*. 1984). Information on the timing of captures, and the weight and sex of individuals were used to estimate the timing of breeding and some aspects of life histories. Clearly this section is limited to inferences made from one study on the Common Dunnart, and in particular much of this data has come from the study of one litter. This limitation must be kept in mind with regards to the information presented below.

An understanding of the longevity of individuals, population turn-over, the timing of breeding, number of pouch young, and recruitment are essential to the development and implementation of conservation measures aimed at protecting the Kangaroo Island Dunnart and its habitat.

6.2 Results and Discussion

All captures occurred between January and May and were predominantly juveniles and sub-adults (Table 3). A summary of the timeframes involved with each stage of the breeding cycle for the Common Dunnart are shown in Table 12. These data are used to estimate the timing of the breeding cycle for the Kangaroo Island Dunnart (Table 13) along with growth curves (see Fox and Whitford 1982). Both sexes weigh the same until they are 150 days old, when body weight continues to increase for almost a year. Fox and Whitford (1982) determined that body weight would appear to provide the most useful method for aging Common Dunnarts in the field (although this is based on information from one litter only).

Two cohorts of juveniles were recorded with dunnarts of less than 11 g captured during January and in March at the major site suggesting a bio-modal distribution in birth dates (WEH04, see Figure 1). This is consistent with the results for the Common Dunnart, and

Table 12: Summary of timeframes for each stage of the breeding cycle for the Common Dunnart *Sminthopsis murina* in south eastern Australia.

Source: Fox and Whitford 1982.

Stage of the breeding cycle	No. of days
Pouch develops	~10 after mating
Gestation	~12.5
Young first leave nest	~34
Young first leave the nest alone	~58
Young weaned, observed eating, have solid faeces	~60-65
Young separate from female	~69

Table 13: Dates of capture, estimated age, estimated time of mating and birth for juvenile Kangaroo Island Dunnarts *Sminthopsis aitkeni* captured at WEH04, in Flinders Chase National Park.

Estimates of age are based on growth curves for the Common Dunnart. Estimates of the timing of birth are determined based on age, and timing of mating are based on a gestation of ~12 days. (source: Fox and Whitford 1982).

Capture Date	Weight (g.)	Estimated Age (days)	Estimated Timing of Birth	Estimated Timing of Mating
11/1/00	9	90	13th October	early October
14/1/00	7	65	9th November	late October
20/1/00	9	90	22nd October	early October
13/3/00	10.5	115	20th November	early-November
13/3/00	7.5	70	5th January	late December
16/1/01	10	105	3rd October	mid-late September

suggests that Kangaroo Island Dunnarts are polyoestrous. The estimated age of the juvenile dunnarts ranged from 70 to 130 days, indicating that mating would have occurred around late September and (again) near the end of December (Table 13). The start of breeding activity therefore approximately coincides with the late winter/early spring. Unfortunately pitfall trapping is difficult to undertake at this time (see Section 2.0) making it difficult to confirm these results by capturing adult females. The fact that no adult females were captured at all during this survey also highlights the difficulties with obtaining this information in the field The estimated breeding season coincides well with the Common Dunnart's breeding season in New South Wales (Fox 1982). This may coincide with invertebrate abundance, and floral resources, although more research is required to test this.

The limited data make it difficult to determine aspects of the life history of the Kangaroo Island Dunnart. Data for other dunnart species indicate that most animals do not live much longer than one year (Menkhorst 1995). In this study all dunnarts were captured during the post-breeding season and few were adults, which supports the likelihood that few animals survive to breed in two seasons. Interestingly the two largest males that were caught in late April and early May both appeared to be unwell and stressed when captured, and did not survive more than 24 hours in captivity. This suggests that at least a proportion of adult males may die after the breeding season, although not in a single event as do *Antechinus* species. Ongoing monitoring and the recapture of known individuals is required to refine our knowledge of life history.

The lack of captures of any adult females is difficult to account for. The movements of these animals are likely to be reduced during the breeding season, although trapping only occurred at the major dunnart sites during the latter parts of the season, and for at least some of this time adult females are likely to have had no dependent young.

Based on the information available the Kangaroo Island Dunnart could tentatively be placed in life history strategy IV as defined by Woolley and Braithwaite (1982). In this strategy the breeding season is extended, but seasonal, with litters produced in winter, spring and summer. Females of these species reach sexual maturity within 6 months (within laboratory conditions) and therefore could potentially mate within their season of birth.

These results suggest that populations are primarily maintained from year to year as a result of annual recruitment. Implementation of potentially disruptive conservation measures aimed at protecting populations should avoid the breeding season to eliminate potential disturbance to females with young and/or nests.

7.0 CONSERVATION MANAGEMENT

7.1 Introduction

The information outlined in this report currently represents our complete knowledge of the Kangaroo Island Dunnart. This species is now known from only 32 records, however, the information gathered has identified directions that can be taken using an adaptive management approach, which is essential given the limitations of the data to date.

7.2 Conservation Management and Research Recommendations

Below is a list of recommended conservation management actions aimed at reducing threats to known populations, and the species in general, along with a list of research requirements for the future. This section provides the basis from which the Recovery Plan for the species has been developed and the Recovery Plan for the species includes much more detailed actions (see Gates 2001). Obviously the amount of work undertaken on the species in the future will depend on availability of resources, however, some recommendations should be implemented within existing resources.

Recommendation 1

Protect all known dunnart populations and habitat.

Only six sites with dunnarts have been located. Therefore protection of these sites is essential for conservation of the species and for facilitating ongoing monitoring and study of the species. This is essential to increase our understanding of current threats. All known populations occur within FCNP which should enhance our ability to actively protect and manage the habitat. A Kangaroo Island Dunnart management plan that details conservation management strategies for each site needs to be prepared, with particular focus on the following points.

<u>Recommendation 1.1</u>

Protect all known dunnart populations and habitat from wildfire using an adaptive management approach.

Wildfire is potentially the major threat to Kangaroo Island Dunnart populations. All known sites occur within habitat that have not been burnt for at least 11 years, and probably much longer. Small-scale patch burning (linear patches around sites with dunnarts) is required in the vicinity of the dunnart populations to reduce the likelihood of extirpation from extensive wildfires. Vehicle access lines would probably be required around known habitat to provide a control line from which burning could take place, and to prevent fires from escaping into the core dunnart habitat. The hydro-axe (a large heavy duty 'mower' attached to the front of a front-end loader) has been used to create similar control lines elsewhere in FCNP, and this machine is ideal because it causes minimal impact and does not disturb the soil, thereby allowing plants to regenerate. Implementation would need to occur outside of the normal wildfire season to ensure that fires were manageable. Given the timing of breeding of most species (i.e. late winter/spring) late autumn or early winter would be the most appropriate season to undertake such burns. Ideally burns would create a patchy break of several hundred metres wide around each area of core habitat. This would also provide a mix of fire age-classes that could be used by the dunnarts. Use of successional stages of the vegetation following fire could then be monitored and the information used to identify preferred fire age-classes.

Currently the South Australian *Native Vegetation Act 1991* and the *Wilderness Protection Act 1992* potentially include impediments to active management such as this, and this needs to be addressed in the management planning process.

<u>Recommendation 1.2</u>

Prevent the spread of Phytophthora dieback into known dunnart habitat where it does not already exist

Phytophthora dieback is relatively widespread on western Kangaroo Island and is present at the major dunnart site, and other sites. In the Brisbane Ranges (Victoria) the volume of vegetation to the structural level of 0.6 m was shown to be significantly lower at sites with *Phytophthora* dieback (Newell and Wilson 1993) and the abundance of Brown Antechinus was also significantly lower at these sites. *Phytophthora* has already caused the deaths of a large number of Yaccas and other understorey species at the dunnart site. Currently dead Yaccas are known to provide shelter for the Kangaroo Island Dunnart, however, this cover will eventually disintegrate. The indirect effects of *Phytophthora* dieback on the dunnart through habitat modification are not understood, and should be investigated. Ongoing monitoring at dunnart sites with and without *Phytophthora* needs to be undertaken to determine the effects of this disease on the species. Regardless, *Phytophthora* dieback control measures are currently a high priority and implementation needs to be continued by NPWSA and a wide range of other organisations and individuals. These measures should help to ensure that Kangaroo Island Dunnart habitat remains free of *Phytophthora* dieback.

Recommendation 2

Continue intensive survey work to clarify the distribution of the species.

Known populations all occur within one relatively small area of FCNP and are therefore at risk of extirpation from single events such as major wildfires. Targeted surveys using stratification of the habitat to select sites within each Regional Ecological Area, a range of vegetation types, structures and patch sizes, and post fire age-classes are required to clarify the habitat requirements of the species. Despite extensive survey work it is still probable that populations of dunnarts occur at other locations across the island, and particularly within FCNP and in adjacent vegetation. The identification of such populations will greatly reduce the vulnerability of the Kangaroo Island Dunnart to extinction.

To date survey work has focussed on attempting to broadly define the distribution of the species and as a result survey sites have been widely spaced and potentially suitable areas of habitat have not been surveyed. Based on the results of the previous survey the major areas of remnant vegetation on the western end of Kangaroo Island (between Western River WPA and Cape Torrens WPA; western FCNP; and Kelly Hill CP; see Figure 2) should be surveyed with a high density of trap sites. This work should be undertaken between January and April, which is when the population is probably highest following breeding, and when all recent captures occurred. Standard pitfall trapping techniques should be employed (Owens 2000). Effort should focus on only one area each year to make the program more manageable. With sites clustered around a relatively small area logistics are simplified and time required to check the traps is minimised.

Ideally the same approach should be taken at areas on the eastern end of the island (e.g. in the vicinity of Cape Cassini) in order to help confirm the absence, or otherwise, from this part of the island.

Recommendation 3

Continue monitoring of known dunnart populations to increase our understanding of ecology/biology.

Ongoing survey and research at the known dunnart sites provides the only means for increasing our understanding of this species and current threats. The major known population provides an ideal study site for this work due to its accessibility, and the relatively high density of dunnarts at this site. This information will identify whether the population is limited by predators (i.e. low survival), or limited by resources (i.e. low reproductive output).

Recommendation 3.1

Re-configure the trap lines at the major survey site and continue trapping to monitor the population

The traplines at WEH04 currently consist of a mix of standard pitfall lines and groups of four individual pits, and include pitfalls of different sizes (see Section 2.0). More dunnarts were captured in the standard traplines at this site, although habitat heterogeneity across the site may have contributed to this result. For future monitoring, however, it is recommended that 100 m pitfall lines of ten traps be established at 200 m intervals across the site, with lines running east-west. Initially four to six lines should be established, although this should be increased as resources allow. Ideally trapping should occur during each summer/autumn period to provide basic information on the population, and to facilitate detailed research, as outlined below. In addition, opportunistic trapping should also occur during late winter and spring when weather conditions allow, as this will provide critical information on the breeding biology and reproductive output of the species.

As part of this survey and research new pitfall trap designs should be trialed in an attempt to overcome the problems with flooding of traps, which occurs during winter and spring. Pitfall traps with funnels, or loosely hinged ‘lids’ would allow shorter pits to be used if successful.

All animals captured would be weighed, sexed, measured and individually marked prior to release. All captures, and especially recaptures, will contribute information to our understanding of population ecology, life history, longevity and breeding biology.

Recommendation 3.2

Undertake intensive radio-tracking to determine home range and movements and habitat use.

Micro-transmitters with refined attachment methods will allow all dunnarts, including juveniles, to contribute information on home ranges and movements, as per the methods outlined in Section 3.0. By necessity this work needs to be undertaken opportunistically whenever dunnarts are captured, which presents logistical problems. Trials of attaching the transmitters could be undertaken on other species such as House Mice or pygmy-possums, although it is recognised that this may not reflect what happens with dunnarts.

Recommendation 4

Continue education and extension work within the community.

Landholders can potentially play an important role in helping to locate new populations of dunnarts by informing NPWSA of possible sightings of this species. An increased understanding of the importance of this species may also contribute to encouraging appropriate management of vegetation remnants on private property.

Periodically articles should be written for the local newspaper and various newsletters (e.g. local NPWSA newsletter – The Warbler and Landcare newsletter). A fact sheet that provides information on identifying the range of small mammals on the island has been produced and this should also be circulated periodically to refresh landholders' memories and encourage them to keep a look-out for the species. Landholders should also be encouraged to keep and freeze unusual animals captured by their pets or otherwise.

NPWSA staff should give presentations to schools, clubs and other organisations as opportunities present themselves. In particular information on the recognition of the species needs to be promoted to help the public differentiate the species from the other small mammals on the island.

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APPENDICES

Appendix A: Status based on IUCN (2000) Red List criteria.

Based on the best available evidence the Kangaroo Island Dunnart is considered endangered under criteria B1 and B2 of the IUCN (2000) Red List Categories as follows:

B. 1. Extent of occurrence estimated to be less than 5,000 km^2, and estimates indicating…:

a. …..known to exist at less than five locations.

(the six current sites where dunnarts are known to occur are considered to occur within one location, as it is quite feasible that genetic transfer is occurring between these populations, and they could be extirpated in one severe wildfire event)

b. Continuing decline, observed, inferred or projected, in…..:

(I) EXTENT OF OCCURRENCE.

(ii) area of occupancy.

(iv) number of …subpopulations.

(*given the recent fire history in the vicinity of current sites it is probable that both extent of occurrence, and area of occupancy, have declined in the last decade, and the potential for further decline from extensive wildfires in the future is very real*)

2 Area of occupancy estimated to be less than 500 km^2, and estimates indicating….:

a. …..known to exist at no more than five locations.

(*as above*)

b. Continuing decline, observed, inferred or projected, in…..:

(I) EXTENT OF OCCURRENCE.

(ii) area of occupancy.

(iv) number of …subpopulations.

(*as above*)

Was that a Kangaroo Island Dunnart?

The Kangaroo Island dunnart is only found on Kangaroo Island. It is considered a threatened species because there are very few records, particularly from the last 20 years. The rarity of this dunnart makes any sighting very important.

This information will assist you with distinguishing the Kangaroo Island dunnart from the other small mammals common to Kangaroo Island. To make sure of your sighting compare the photos and carefully read the information. All sizes and weights are for adults, juveniles are smaller but similar in appearance.

Kangaroo Island Dunnart

Sminthopsis aitkeni - native

Main Features:

- slender pointed muzzle
- rows of small sharp pointed teeth
- females have a small pouch; males have a large scrotum
- **Colour:** dark sooty colour above and light grey below
- **Size:** (adults) body 80-90 mm long, tail 75-80 mm long
- **Weight:** (adults) approximately 20-25 gm
- **Distribution:** few widely scattered records; recent records from the western end of the Island.

House Mouse

Mus domesticus - introduced

Main Features:

- a pungent 'mousy' smell
- small beady eyes
- long front teeth
- **Colour:** brown/grey above and white/grey below
- **Size:** body 60-100 mm long; tail 75-96 mm long
- **Weight:** approximately 15 gm
- **Distribution:** widespread and common in native vegetation and agricultural areas.

Western Pygmy-possum

***Cercatetus concinnus* - native**

Main Features:

- tail is prehensile (curled) for grasping vegetation
- large eyes and ears
- females have a small pouch
- **Colour:** fawn or reddish brown above and white below
- **Size:** 50-65 mm long, tail slightly loner
- **Weight:** 10-14 gm
- **Distribution:** widespread and relatively common in native vegetation with a dense heath understorey.

Bush Rat

***Rattus fuscipes* - native**

Main Features:

- much larger than dunnarts, pygmy possums and house mice
- conspicuous rounded grey/brown ears
- **Colour:** grey-brown above, fur dense and soft
- **Size:** body approximately 150 mm long, tail slightly shorter than body
- **Weight:** 45-60 gm, occasionally 100 gm
- **Distribution:** widespread and relatively common in native vegetation with a dense understorey.

Black Rat

***Rattus rattus* - introduced**

Main Features:

- much larger than all other small mammals
- body slender and elongated
- long conspicuous tail
- **Colour:** dark grey/brown
- **Size:** body 165-205 mm long, tail much longer
- **Weight:** up to 300 gm
- **Distribution:** typically associated with human settlement, but may occur elsewhere.

If you think you have seen a KI dunnart, record the exact location and report it to your nearest NPWSA office. Remember to take photos of any live animals, or freeze any carcasses so that identification can be confirmed.

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Appendix C: Total trap effort for each survey site.

		Total Trap-nights				
Site Name	**Nights Open**	**Pitfalls**	**Elliotts**	**Stoddards**	**Hair Tubes***	**TOTAL**
WEH01	62	1808	1920	960	0	4788
WEH02	53	660	120	0	0	780
WEH03	36	432	0	0	0	432
WEH04	80	3404	1920	0	1600*	5324
BT01	15	120	120	0	0	240
BT02	21	252	180	0	0	432
NS02	45	360	240	0	0	600
NS03	15	114	120	0	0	234
NS04	15	120	120	0	0	240
NS05	42	396	300	0	0	696
BCN01	22	176	210	0	0	386
BCN02	26	208	210	0	0	418
BCN03	22	176	150	0	0	326
BCN04	21	168	195	0	0	363
DCP01	19	152	195	0	0	307
FCB01	28	224	240	0	0	464
FCB02	26	208	240	0	0	448
DEB01	17	136	210	0	0	346
CDC01	17	136	195	0	0	331
CDC02	17	136	180	0	0	316
CDC03	17	136	180	0	0	316
CDC04	17	136	195	0	0	331
CDC05	17	136	195	0	0	331
SBY01	25	200	195	0	0	395
SBY02	21	168	195	0	0	363
SBY03	21	168	195	0	0	363
CPR01	38	304	42	0	0	354
NCT01	41	328	105	0	0	433
NCT02	20	160	49	0	0	209
SPR01	6	48	0	0	0	48
WAL01	27	208	120	0	0	328
GRR01	38	304	120	0	0	424
GRR02**	4	32	0	0	0	32
GRR03**	4	16	0	0	0	16
GRR04	25	200	120	0	0	320
NS06	27	208	120	0	0	328
NS01	27	216	0	0	0	216
SCT01	6	48	15	0	0	63
SCT02	17	136	15	0	0	151
SCT03	17	136	15	0	0	151
MDR01	16	128	0	0	0	128
BER01	28	224	0	0	0	224
WRV01	28	224	0	0	0	224
SNU01	22	176	0	0	0	176
PLA01	19	76	0	0	0	76
SHA01	20	160	0	0	0	160
TOTALS	n/a	13254	8941	960	1600	23223

* hair tube effort not included in total trap effort.

** these sites were destroyed by fire suppression activities shortly after they were established.

Appendix D: Size details of all dunnarts captured.

NB. The data was measured in the field and measurements are approximate. Not all measurements were obtained for some animals.

Capture Date	Capture Site	Sex	Weight (g)	Snout-vent Length (mm)	Tail Length (mm)	Head Length (mm)	Testes Width (mm)
9/2/00	WEH01d	f	12.5	75	85	29.8	-
7/3/00	WEH01e	m	17.5	83	92	30.3	-
17/1/01	WEH01d	f	10.5	70	85	?	-
11/1/00	WEH04b	f	9	61	70	25	-
12/1/00	WEH04f	m	18	?	?	31.7	8.3
14/1/00	WEH04a	f	7	64	70	24.3	-
20/1/00	WEH04b	m	9	70	79	27.1	?
13/3/00	WEH04d	m	7.5	66	70	25.4	3
13/3/00	WEH04e	f	10.5	72	79	28.5	-
16/1/01	WEH04d	f	10	73	80	30	-
17/1/01	WEH04d	m	12	75	86	30	4
26/2/01	WEH04e	m	16	?	?	?	?
2/4/01	WEH04e	f	15	?	?	?	?
2/3/00	WEH02a	m	16.5	88	83	?	?
28/11/00*	WEH02a	-	-	-	--	-	-
4/4/00	NS02b	f	15	76	84	31.8	-
4/4/00	NS02b	m	19.5	84	90	32.3	7.7
5/5/00	NS02a	m	21	80	92	33.2	8.2
24/3/01	NS02a	f	13	73	86	27.5	-
3/2/01	NS05c	f	13	75	80	28	-
8/2/01	NS05b	f	12	72	81	29	-
27/4/01	WAL01b	m	18	82	96	31.3	9.4

* skeletal remains only.

Appendix E: Summary of the vertebrates captured at all survey sites.

Numbers are total numbers of captures.

Mammals

Site Name	*Cercartetus concinnus*	*Cercartetus lepidus*	*Isoodon obesulus*	*Mus musculus*	*Rattus fuscipes*	*Rattus lutreolus*	*Sminthopsis aitkeni*
WEH01	36	10	5	32	872	17	3
WEH02	22	5		4	33		2
WEH03	11	4		3	3		
WEH04	119	10		96	10		10
BT01	23	1			53		
BT02	9			1	25		
NS02	23	2		2	15		4
NS03	1	2		1	96		
NS04		1		5	54		
NS05	15	14		4	142		2
BCN01	1			5	30		
BCN02	6				28		
BCN03	3			9			
BCN04	3			1			
DCP01				9			
FCB01	2						
FCB02	1						
DEB01				1			
CDC01	9			1	9		
CDC02	10	1			30		
CDC03	5	4			56		
CDC04	4				33		
CDC05	1	2		9	43		
SBY01				12			
SBY02				4			
SBY03				7			
CPR01	3			3	5		
NCT01	7			29			
NCT02	4			2	3		
SPR01					2		
WAL01	6	1		3	24		1
GRR01	3			8	28		
GRR02							
GRR03							

Site Name	***Cercartetus concinnus***	***Cercartetus lepidus***	***Isoodon obesulus***	***Mus musculus***	***Rattus fuscipes***	***Rattus lutreolus***	***Sminthopsis aitkeni***
GRR04		1		2	24		
NS06	5	9		2	34		
NS01		1	2		23		
SCT01				4			
SCT02	4			2			
SCT03	3	1		4			
MDR01	4						
BER01	3			3	15		
WRV01	5	2		13			
SNU01	1	1		2	4		
PLA01	2				4		
SHA01	4				2		
TOTALS	358	72	7	283	1700	17	

Reptiles

Site Name	***Aprasia striolata***	***Austrelaps labialis***	***Bassiana duperreyi***	***Egernia multiscutata***	***Egernia whitii***	***Hemiergis peronii***	***Lampropholis guichenoti***	***Lerista bougainvillii***	***Nephurus milii***	***Pseudemoia entrecasteauxii***	***Varanus rosenbergi***
WEH01	2	2	54		6	30	84			1	1
WEH02	2	1	9		2	20	38				3
WEH03	5					16	7				1
WEH04	5		11		10	26	105	1			7
BT01					2		9				
BT02	3					4	11				
NS02			1			4	17				
NS03			1			1	1				
NS04						1					
NS05	2		1			1	12				
BCN01					1	3	5				
BCN02					8	4	8		2		
BCN03					1	3	10		1		
BCN04				1			2		2		
DCP01					1	2	2		4		
FCB01						1	1				1
FCB02			1			2	6		1		
DEB01							2				
CDC01			3		9	1			1		
CDC02			2		1		2				

Site Name	*Aprasia striolata*	*Austrelaps labialis*	*Bassiana duperreyi*	*Egernia multiscutata*	*Egernia whitii*	*Hemiergis peronii*	*Lampropholis guichenoti*	*Lerista bougainvillii*	*Nephurus milii*	*Pseudemoia entrecasteauxii*	*Varanus rosenbergi*
CDC03							2				
CDC04						1	2				
CDC05	1				1	1					
SBY01						3	1		3		
SBY02					1		1		1		1
SBY03			1		2		1				
CPR01			4				46				
NCT01	1					3	30	2			1
NCT02						1	5				2
SPR01						3	6				
WAL01						1	16				
GRR01			4			2	12			1	
GRR02											
GRR03											
GRR04			3				10				1
NS06			1		1	1	6				1
NS01	1		1				1				
SCT01				12	2		3		2		
SCT02							1				
SCT03					1		2				
MDR01						1	10				
BER01						1	5				1
WRV01						1	10				
PLA01			1			1	2				
SHA01							4				
SNU01						1	6				
TOTALS	22	3	97	13	49	140	504	3	17	2	20

Amphibians

Site Name	*Crinia signifera*	*Limnodynastes dumerilii*	*Limnodynastes tasmaniensis*	*Litoria ewingi*	*Neobatrachus pictus*	*Pseudophryne bibroni*
WEH01	183			25	61	17
WEH02	6				1	8
WEH03	42	1				2
WEH04	110				2	1
BT01	6					
BT02	2	2				
NS02	30	7				
NS03	23					1
NS04	35				1	14
NS05	64	1				4
BCN01						
BCN02						
BCN03						
BCN04						
DCP01						
FCB01						
FCB02					1	
DEB01		2	1		1	
CDC01	1	1	2			
CDC02						
CDC03						
CDC04						
CDC05					1	
SBY01		5			2	
SBY02						
SBY03		1				
CPR01		3				
NCT01	2	2				
NCT02	6	1		1	1	
SPR01		1				
WAL01	2					
GRR01	22	17			1	
GRR02						
GRR03						

Site Name	***Crinia signifera***	***Limnodynastes dumerilii***	***Limnodynastes tasmaniensis***	***Litoria ewingi***	***Neobatrachus pictus***	***Pseudophryne bibroni***
GRR04						1
NS06	1				1	
NS01	23					
SCT01					1	
SCT02		2				
SCT03	1	4			2	
MDR01	5	6				
BER01	1					
WRV01						
SNU01					1	
PLA01	3					
SHA01						
TOTALS	568	56	3	26	67	48

Appendix F: Lifeform/height classes of vegetation used to record structural details are survey sites.

Source: Heard and Channon (1997).

Code	Definition
T	Trees > 30 m
M	Trees 15 - 30 m
LA	Trees 5 - 15 m
LB	Trees < 5 m
KT	Mallee > 3 m
KS	Low mallee < 3 m
S	Shrubs > 2 m
SA	Shrubs 1.5 - 2.0 m
SB	Shrubs 1.0 - 1.5 m
SC	Shrubs 0.5 - 1.0 m
SD	Shrubs 0 - 0.5 m
P	Matt Plants (single plant)
H	Hummock grass
GT	Grass > 0.5 m
GL	Grass < 0.5 m
J	Herbaceous species
VT	Sedges > 0.5 m
VL	Sedges < 0.5 m
V	Vines (twiners)
MI	Mistletoes
X	Ferns
MO	Mosses, liverwort
LI	Lichens