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Melinda A. Norton
mn813@uow.edu.au

Kristine O. French
University of Wollongong, kris@uow.edu.au

Andrew W. Claridge
University of NSW

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Keywords

long, nosed, potoroo, potorous, habitat, associations, tridactylus, scales, spatial, multiple

Disciplines

Life Sciences | Physical Sciences and Mathematics | Social and Behavioral Sciences

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Habitat associations of the long-nosed potoroo (*Potorous tridactylus*) at multiple spatial scales

Melinda A. Norton[A,B,E], *Kris French*[B] *and Andrew W. Claridge*[C,D]

[A]Department of Environment, Climate Change and Water, Parks and Wildlife Division, Highlands Area, Nowra Road, Fitzroy Falls, NSW 2577, Australia.
[B]Department of Biological Sciences, University of Wollongong, NSW 2522, Australia.
[C]Department of Environment, Climate Change and Water, Parks and Wildlife Division, Planning and Assessment Team, Southern Ranges Region, PO Box 733, Queanbeyan, NSW 2620, Australia.
[D]School of Physical, Environmental and Mathematical Sciences, University of New South Wales, Australian Defence Force Academy, ACT 2600, Australia.
[E]Corresponding author. Email: melinda.norton@environment.nsw.gov.au

Abstract. This study examined the coarse- and fine-scale habitat preferences of the long-nosed potoroo (*Potorous tridactylus*) in the Southern Highlands of New South Wales, in order to inform the management of this threatened species. Live-trapping was conducted in autumn and spring, from 2005 to 2008, at two sites. Macrohabitat preferences were examined by comparing trap success with numerous habitat attributes at each trap site. In spring 2007 and autumn 2008, microhabitat use was also examined, using the spool-and-line technique and forage digging assessments. While potoroos were trapped in a wide range of macrohabitats, they displayed some preference for greater canopy and shrub cover, and ground cover with lower floristic diversity. While most individuals also displayed preferences for various microhabitat attributes, no clear trends were evident across all individuals. Potoroos displayed some foraging preference for microhabitats with higher shrub cover densities and more open ground cover. Despite extensive fox predation risks, individual potoroos did not all preferentially utilise dense ground cover. Future management of known and potential potoroo habitat should aim to provide effective introduced predator control and enhance the diversity of vegetation attributes while avoiding practices that simplify the habitat.

Introduction

At any scale of resolution, natural landscapes can be viewed as mosaics of ‘patches’ (Wiens 1995). When a patch is large relative to the movements of an individual, and the individual can fulfil all of its resource requirements within it, the environment is termed ‘coarse-grained’ (Levins 1968; Morris 1984; Kozakiewicz 1995; Law and Dickman 1998). This contrasts with a fine-grained environment, where patch size is small relative to the movements of an individual and a mosaic of patches is used in order to fulfil resource requirements. The examination of a species’ use of a coarse-grained patch can be termed macrohabitat use while fine-grained patch use would then be termed microhabitat use.

The ecological attributes of an organism, such as geographical range, home range and daily movements, determine the appropriate scales at which to examine habitat selection (Morris 1987). For example, the geographic range of a species may be associated with certain vegetation communities. At a finer scale, the home range of individuals may be associated with certain components of some vegetation communities.

The habitat preferences of many medium-sized marsupials, including the Australian rat-kangaroo family (Potoroidae), are poorly understood, due to their small size and cryptic nature making direct observational studies difficult. The long-nosed potoroo (*Potorous tridactylus*), weighing between 660 and 1640 g (Johnston 2008), is one of the smallest members of this family. It is also solitary and largely nocturnal (Claridge *et al*. 2007). The species is primarily mycophagous (fungus-feeding) and most fungal materials consumed are hypogeous (underground-fruiting) in origin and form mycorrhizal associations with some native plants, most notably *Eucalyptus* sp. (Warcup 1980; Bennett and Baxter 1989; Claridge *et al*. 1993*b*; Tory *et al*. 1997). Previous ecological studies of the species have examined forage-digging locations and live-capture data to discern habitat preferences (Guiler 1958; Bennett 1993; Claridge *et al*. 1993*a*; Mason 1997; Claridge and Barry 2000).

Coarse-scale habitat-use studies of long-nosed potoroo have found that the species occurs in a large variety of vegetation communities, particularly coastal sandy wet heathlands and inland moist woodland and forests along plateaus and associated slopes and gullies (Claridge *et al*. 2007). Its coastal habitats are

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typically on sandy, shallow, nutrient-poor soils with a dominant stratum of small trees or large shrubs while inland habitats are mostly on poorly drained areas in a variety of forest, woodland, wet heath and rainforest vegetation communities (Schlager 1981; Bennett 1987; Seebeck *et al*. 1989). Despite this, little information is available on the species' habitat preferences at finer scales, other than the general presence of a dense vegetative cover, provided by either the ground layer (e.g. sedges, ferns, heaths) or shrub layer (e.g. *Leptospermum* spp., *Melaleuca* spp.) (Schlager 1981; Seebeck 1981; Bennett 1987; Johnston 2008). Thus, while broad habitat types can be conserved as areas for the long-nosed potoroo, information on finer-scaled requirements are needed to provide an understanding of how these broad areas could be managed to maintain populations.

The long-nosed potoroo, like many of the rat-kangaroo species, has undergone both distributional and population-level declines since European settlement (Claridge *et al*. 2007). It is listed as a vulnerable species in New South Wales (under the *Threatened Species Conservation Act 1995*) and at the Commonwealth level (under the *Environment Protection and Biodiversity Conservation Act 1999*). Predation by foxes and habitat loss and modification, due to inappropriate fire regimes and/or clearing of native vegetation, are believed to be the major causes of the decline of the species (Seebeck *et al*. 1989; Claridge and Barry 2000). The long-nosed potoroo fits within the category of medium-sized (450–5000 g) ground-dwelling mammals upon which the impact of fox predation is suggested to be substantial (Dickman 1996) and it is listed as a priority species in the NSW Fox Threat Abatement Plan (NSW DECCW 2010).

In order to conserve the long-nosed potoroo, the important habitat elements for the species at both the coarse and fine scale need to be identified and managed appropriately. However, caution must be used when identifying the important habitat elements by comparing usage and availability data, particularly for threatened species (Partridge 1978; Johnson 1980). For species with reduced population densities, certain habitats may be unoccupied because they are truly unacceptable or because the population density of the species is too low to enable all preferred habitats to be filled (Partridge 1978). Alternatively, the habitat use of a species may simply be a reflection of the habitat least amenable to the agent of its decline and the habitats now apparently favoured may simply be acting as refuges from predation. For example, the quokka (*Setonix brachyurus*) is now restricted to dense swampy vegetation in the presence of foxes, although previously they were persecuted as pests of forestry plantations several kilometres from swamps (Hayward *et al*. 2005). A simple comparison of habitat usage and availability in such instances may lead to the conservation and management of only part of a threatened species' habitat. A good understanding of a threatened species' habitat use is obviously of particular management importance (Vernes 2003).

This study aimed to examine whether trap success was influenced by broad vegetation communities, and structural or floristic attributes at the macro- and microhabitat scale. We were interested in determining whether these patterns were consistent between two populations within the Southern Highlands of New South Wales. The ecology of the long-nosed potoroo in this geographic locality is poorly understood, making this study both timely and critical. More specifically, we hypothesised that potoroos would be most likely associated with high levels of cover across a range of strata, providing protection from aerial and ground predators, and with particular plant species that have mycorrhizal associations with hypogeous fungi. The potoroo's macrohabitat preferences were defined as habitat choices at the scale of individuals' home ranges within the species range and were assessed using trapping. Microhabitat preferences were defined as habitat choices at the scale of individuals' movements within their home ranges and were assessed using spool-and-line tracking and examination of forage-diggings.

Materials and methods

Study areas

The study was conducted within Barren Grounds Nature Reserve (hereafter Barren Grounds) and nearby Budderoo National Park (hereafter Budderoo), ~100 km south of Sydney (34°40′55″S, 150°43′58″E). Barren Grounds and Budderoo contain distinctive highland, plateau and escarpment landscapes, over 600 m above sea level, on underlying sandstone. Both reserves contain a complex range of vegetation types and their ecotones, including cool temperate rainforest, open forests, woodlands, heaths and sedge-lands on the plateaux and tall open forests, warm temperate rainforest and subtropical rainforest on the slopes, gullies and ridges below the escarpment (NPWS 1998). From east to west, across the highland/plateau sections of the reserves, the rainfall and soil moisture decreases and the soil depth increases (NPWS 1998), resulting in the predominance of heath in Barren Grounds and diverse woodlands and forests in Budderoo (NPWS 1998). Both study areas had not had any fires or land clearing/logging for over 25 years.

Potoroo live-trapping

Long-nosed potoroos were live-trapped at Barren Grounds and Budderoo. With the closest trap site between study areas being 5.7 km and the largest home range ever recorded for the species being 34.4 ha (Kitchener 1973), no individual was captured at both study areas. Following an initial trapping session at Barren Grounds in March 2004, regular trapping at both areas was conducted twice-yearly (over four consecutive nights each autumn and spring) between March 2005 and March 2008 to assess habitat use. A total of 40 trap sites at Budderoo and between 40 and 63 trap sites at Barren Grounds were set adjacent to walking tracks and fire trails, with trap sites located ~100 m apart.

At each trap site a wire mesh cage trap (200 × 200 × 400 mm, R.E. Sinclair, Melbourne, Australia) and two Elliott aluminium box traps (Elliott Scientific Equipment, Upwey, Victoria, Australia) were set, baited with peanut butter, rolled oats and honey mix. Elliott traps were used to reduce the probability of small mammals being cage-trapped. The date, trap site and identity of each potoroo capture were recorded: individual potoroos were implanted with Trovan microchips.

Potoroo trapping data was used in the examination of their macrohabitat use at both study areas. Each trap site was retrospectively identified as either a 'potoroo' trap site or a 'nil' trap site based on whether a long-nosed potoroo was ever captured at it during any of the trapping sessions. To examine macrohabitat use in more detail, 'potoroo' trap sites were arbitrarily split into 'poor' sites (with potoroo captures between zero and 25% of the trapping sessions) and 'good' sites (with more frequent potoroo captures).

Trap-site attributes

Five broad vegetation communities were present within the Barren Grounds and Budderoo study areas (Tindall *et al*. 2005). The broad vegetation community in which each trap site was situated was recorded (Table 1) to compare with trap success.

At each trap site, general site details were recorded as well as attributes of the vegetation formation and floristics within a 20×20 m quadrat. These macroscale attributes, identified between March and May 2007, are detailed in Table 2. The percentage open ground was defined as the percentage of the ground cover layer that was not sufficiently dense to obscure a potoroo.

A habitat complexity score, based on that used by Catling and Burt (1995) and Catling *et al*. (2001), was calculated for each trap site using the relative abundance scores of several macrohabitat attributes (Table 3). However, a moisture rating was not assessed at trap sites in this study and so was not included in the calculation of this score. Therefore the formula for the Macrohabitat Complexity Score (MacroHCS) was:

$$\text{MacroHCS} = \text{tree crown cover score} + \text{shrub cover score} + \text{open ground score} + (\text{leaf litter score} + \text{rock score} + \text{coarse woody debris score})/3.$$

Spool-and-line tracking

The spool-and-line technique (Miles *et al*. 1981; Boonstra and Craine 1986) was used to examine microhabitat use of potoroos. In using this technique it is acknowledged that subsequent pathways of movement by animals will contain a mixture of foraging and non-foraging responses, the precise delimitation of which is impossible to quantify. Each spool package consisted of a $12\,\text{mm} \times 32\,\text{mm}$ cocoon bobbin (Danfield Limited, Lancashire, England) containing ~140 m of 2-ply nylon thread, in a black heat-shrink plastic casing. The package was attached to fur on the animal's rump, using cyanoacrylate ('Super Glue'). The free end of the thread was tied off to a fixed point and the animal left at the point of capture, in an open capture bag, allowing the animal to leave the bag when ready. This was to assist in reducing the flight response of the animal and maximising the amount of spool path laid out during 'normal' activity, althought habitat use during any flight response was considered to be an acceptable part of their overall nightly habitat use.

Spooling was conducted at both study areas in September/October 2007 and March/April 2008. Additional trapping sessions within these periods were conducted where necessary to trap sufficient potoroos for the spooling component of this study. All spooling was conducted after sunset, when potoroos were thought to be most active, and spool paths were assessed the following day.

Spool path microhabitat attributes

Many of the habitat attributes examined at the macrohabitat scale were examined at this microhabitat scale, but across a smaller area (Table 2). The relative abundance of the microhabitat attributes were examined at ~5-m intervals, paced out along the course of each spool path. This resulted in the total number of sample points per completed spool path varying from 28 to 35. Average scores for each attribute were then calculated for the entire spool length by aggregating the values at each point and dividing by the number of sample points at which measurements were taken.

In some instances, a spool event was not completed. This was due either to the spool package being removed by the study animal prematurely, the thread snapping with no sign of the rest of the thread or the spool path being lost due to the density/structure of ground vegetation. Unless a minimum of 25 sample points were recorded, these spools were not considered 'full' spools and were not used in the analysis. Data from a minimum of five 'full' spools from five individual potoroos were collected per study area per season.

The abandoning of spooling attempts due to the spool path being lost in dense vegetation may have had an impact on the results by either under-representing the use of dense vegetation or the proportion of individuals using their habitat in proportion to its availability. However, only 12% of spooling attempts were abandoned for this reason and thus this is not considered likely to have had a serious effect on the conclusions drawn regarding microhabitat use.

Table 1. Five dominant vegetation communities and the number of trap sites within each at the Barren Grounds NR and Budderoo NP study areas

Vegetation community	Study site	No. of trap sites	Description of community	No. of trap-nights	No. of potoroo captures
Budderoo–Morton Plateau Forest	Barren Grounds Budderoo	31 20	Low eucalypt forest with a dense sclerophyll shrub stratum and open groundcover dominated by sedges	1316	182
Blue Mountains–Shoalhaven Hanging Swamps	Barren Grounds Budderoo	1 0	Open canopy of tall shrubs and a dense groundcover of sedges and forbs	32	0
Coastal Sandstone Plateau Heath	Barren Grounds Budderoo	28 0	Open to dense shrub canopy with emergent mallees and groundcover of sedges and forbs	627	20
Escarpment Foothills Wet Forest	Barren Grounds Budderoo	3 11	Eucalypt forest with a mesophyll shrub/small tree stratum and an understorey of vines and ferns	324	21
Shoalhaven Sandstone Forest	Barren Grounds Budderoo	0 9	Eucalypt woodland with an abundant sclerophyll shrub stratum and a groundcover dominated by sedges	252	0

Table 2. Habitat attributes and their relative abundance categories recorded at macro- and microscales

Scale	Attribute	Relative abundance categories	Details
Macro-scale[A]	% tree crown cover % shrub cover (>2 m) % open ground (≤2 m)	0%, >0–20%, >20–50%, >50–80% or >80%	
	% leaf litter cover % rock cover % coarse woody debris (>20 cm diameter) cover	0%, >0–5%, >5–25%, >25–50%, >50–75% or >75%	
	Dominant ground cover vegetation type(s) (<2 m)	Fern, sedge, tall sedge, grass, rush, shrub, heath and mixed	
	Position in the landscape	Gully, slope or flat	
	Dominant plant genera	Maximum of three genera	In each stratum: tree canopy, >2 m shrub, 1–2 m vegetation, 0.2–1 m vegetation and <0.2 m vegetation
	Estimated no. of species present	1–3, 4–6, 7–10, 11–20 or >20 species	
Micro-scale	% tree crown cover[B] % shrub cover (>2 m)[B]	0%, >0–20%, >20–50%, >50–80% or >80%	Within a 5-m radius of sample point
	Woody plant genera present[C]	*Eucalyptus*, *Acacia*, *Melaleuca*, *Callistemon*, *Leptospermum*, *Baeckea*, *Hakea* and *Banksia*	
	Dominant shrub genera[C]		
	Ground cover[B]	Open (0–25%), Mid (>25–75%) or Closed (>75%)	Within a 2-m radius of sample point
	Average ground cover height[B]	<0.5 m, 0.5–1 m or >1–2 m	
	Ground cover patchiness[B]	Heterogeneous or homogeneous	
	Dominant ground vegetation type (<2 m)[B]	Fern, sedge, tall sedge, grass, rush, shrub, heath, mixed and suspended plant debris	
	Dominant ground cover genera (<2 m)[C]		
	Fresh or old forage-diggings[B]	Presence or absence	Within 1-m radius of sample point
	Position in the landscape[C]	Gully, slope or flat	

[A]Within 20 × 20 m quadrat around cage trap.
[B]Examined at both spool sample points and microhabitat-availability sample points.
[C]Examined at microhabitat-availability sample points only, to identify foraging microhabitat preferences.

Table 3. Scores for the relative abundance categories of the macrohabitat attributes used to calculate Macrohabitat Complexity Scores

MacroHCS	Relative abundance categories					
	Tree crown cover (%)	Shrub cover (%)	Open ground (%)	Leaf litter cover (%)	Rock cover (%)	Coarse woody debris cover (%)
0	0	0	–	0	0	0
1	>0–20	>0–20	>80	>0–5	>0–5	>0–5
2	>20–50	>20–50	>50–80	>5–25	>5–25	>5–25
3	>50–80	>50–80	>20–50	>25–50	>25–50	>25–50
4	>80	>80	0–20	–	–	–
5	–	–	0	–	–	–

Microhabitat availability

The relative abundance of the same microhabitat attributes examined during spooling (Table 2) were assessed at each of several sample points in a grid pattern centred at each trap site at which spooling was conducted. The grid pattern comprised a series of transects of sample points and each transect comprised 10 sample points, ~25 m apart. At Barren Grounds transects were ~50 m apart while at Budderoo transects were ~100 m apart, due to the greater area targeted for spooling at this site due to the site's lower trap success observed during our study.

Microhabitat availability was scored only once during this study (January/February 2008) as it was not believed that the vegetation changed significantly during the period in which spooling was undertaken. To determine habitat preferences, the data collected for each 'full' spool were compared with the microhabitat availability data from sample points within a

200 × 200 m grid around the trap site at which the spooling event started.

Microhabitat foraging preferences

During the assessment of microhabitat availability, some additional microhabitat attributes were examined at each sample point (Table 2) to identify microhabitat preferences specifically during foraging activities. The sample points were split into those with and without potoroo forage-diggings present and a comparison made of the microhabitat attributes at each. It is noted that potoroo and bandicoot diggings can be difficult to tell apart (Claridge and Barry 2000) and that long-nosed bandicoots (*Perameles nasuta*) were present at both study areas. However, only three individual bandicoots (on a total of five occasions) were ever caught during the years of trapping, compared with the vastly greater numbers of potoroo individuals and captures (Norton 2009). As there were also no typical 'diagnostic' bandicoot diggings observed at any of the sample points, it was assumed that the vast majority of diggings observed were from potoroos.

Statistical analysis

To examine whether there was a relationship between trap success and broad vegetation community type, a Chi-square contingency test (JMP ver. 5.1) compared trap site success ('potoroo' or 'nil') in each broad vegetation community.

Differences in the macrohabitat attributes at 'potoroo' and 'nil' trap sites were compared using analysis of similarity (ANOSIM; PRIMER ver. 5). Macrohabitat attributes were grouped to form the following categories for analysis: general site information (% canopy cover, % shrub cover, % open ground and position in the landscape), dominant ground vegetation types (heath, sedge, tall sedge, grass, fern, rush shrub and mix), number of species present in each layer and the dominant genera in each of the 0–0.2 m, 0.2–1 m, 1–2 m, >2 m shrub and tree layers. A Bray–Curtis Similarity Matrix was developed for each group of macrohabitat attributes except the 'general site information' group for which a Normalised Euclidean Distance Matrix was developed, as the group used variables with a range of different units of measurement. Two-way crossed ANOSIMs (a randomised permutation analysis) were run on each matrix using study areas (Barren Grounds and Budderoo) and trap success ratings ('potoroo' or 'nil') as the two factors. Where significant global *r* values were obtained for either factor, a SIMPER analysis was then conducted to identify which attributes were contributing most to the significant results.

For each study area, Chi-square contingency tests (JMP ver. 5.1) were run for each macrohabitat attribute to identify whether the categories for each attribute at 'nil' and 'potoroo' trap sites were used in similar proportions to those expected. To identify whether any cover-related macrohabitat attributes (% canopy cover, % shrub cover, % open ground, ground cover patchiness and dominant ground vegetation type) were associated with lower or higher trap success a second set of Chi-square contingency tests was run for 'nil', 'poor' and 'good' trap sites across both study areas.

An analysis of variance (ANOVA; JMP ver. 5.1) was run to identify whether macrohabitat complexity scores for either study area were significantly different between 'potoroo' and 'nil' trap sites. The macrohabitat complexity scores within each of the broad vegetation communities across both study areas were also compared using ANOVA.

To assess microhabitat preferences for each individual, a goodness-of-fit test (Zar 1996) was used to compare spooling data proportions for each microhabitat attribute with the relevant set of microhabitat availability data proportions. To account for low sample size, a P value of ≤ 0.01 was used as significant for any habitat attribute where more than one-fifth of the expected categories values were less than 5. For the assessment of foraging microhabitat preferences, Chi-square contingency tests were used to compare microhabitat attributes at 'dig' and 'non-dig' sites at the two study areas.

For all Chi-square contingency tests Pearson's P values were used ($P \leq 0.05$) except when one-fifth or more of the expected categories' values for any attribute were less than 5. Where this occurred a 2-tailed Fisher's Exact Test P value was used if provided by JMP and when no such value was provided a P value of ≤ 0.01 was used as significant to account for low sample sizes.

Results

Potoroo occurrence

Of the total number of trap sites across both study areas, 53% yielded no potoroo captures in any trapping sessions ('nil' sites), while 17% yielded potoroo captures in less than 25% of trapping sessions ('poor' sites) and 30% yielded potoroo captures more frequently ('good' sites). Both study areas had similar proportions of 'nil', 'poor' and 'good' trap sites. The 'good' trap sites at Barren Grounds actually averaged potoroo captures in 75% of sessions compared with only 36% at Budderoo.

Potoroos were captured in three of the five broad vegetation communities present at the two study sites (Table 1). 'Potoroo' trap sites were more likely to be in the Budderoo–Morton Plateau Forest community and less likely to be in the Coastal Sandstone Plateau Heath Forest community ($\chi^2_8 = 20.94$, $P = 0.007$) than expected on the basis of chance (Fig. 1). However, only 60% of potoroo captures were in the Budderoo–Morton Plateau Forest community in Budderoo while 88% were in this community type in Barren Grounds.

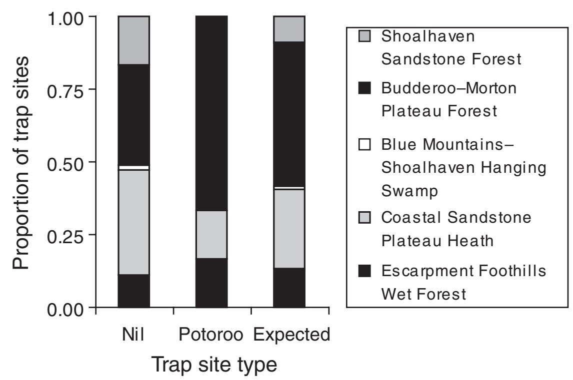

Fig. 1. Proportions of 'nil' and 'potoroo' trap sites with each dominant vegetation community (≥20% of expected counts were less than 5).

Macrohabitat use

Potoroos were captured in all categories of canopy cover, shrub cover and ground cover present in the local environment with the exception of 0% shrub cover. They were also caught in all dominant ground cover vegetation types present with the exception of grasses and heath.

Trap sites with potoroo captures were found to have greater levels of canopy cover (mostly *Eucalyptus sieberi*) and >2 m shrub cover (mostly *Banksia* and *Hakea* sp.) than 'nil' trap sites (Table 4). They were also more likely to have ferns (mostly *Gleichenia* sp.) as a dominant ground cover type, than 'nil' trap sites. Alternatively, the 'nil' trap sites were more likely to have greater numbers of plant species present within the 0–0.2-m vegetation layer, and often sedges, and to have *Banksia* sp. as a dominant genus in the 0.2–1-m layer and *Leptospermum* sp. as a dominant genus in the >2-m shrub layer. However, the relatively low Global *r* values and Dissimilarity/s.d. ratios for most of the data suggest reasonable variation within 'potoroo' and 'nil' sites and therefore a weakened explanatory power of these variables.

ANOSIM also revealed significant differences between the two study areas for all macrohabitat attribute groupings with the exception of the 'dominant ground vegetation types' group (Table 4). In particular, trap sites at Budderoo had more tree species compared with Barren Grounds and a greater likelihood of *Eucalyptus piperita* as a dominant tree species. The level of canopy cover and likelihood of having *Gleichenia dicarpa* as a dominant species below 1 m, *Banksia* sp. as a dominant genus in the 1–2-m layer and *Hakea* sp. as a dominant genus in the >2.0-m layer also appear greater at Budderoo and the likelihood of sedges in the 0–0.2-m layer and *Banksia* sp. as a dominant genus in the 0.2–1-m layer greater at Barren Grounds, although again there were low Global *r* values and Dissimilarity/s.d. ratios for these comparisons.

The observed and expected relative abundances of each macrohabitat attribute at 'potoroo' and 'nil' sites revealed varied potoroo preferences at the two study areas (Table 5). 'Potoroo' trap sites were more likely to have particular levels of canopy cover, greater shrub cover and more open ground than expected at Barren Grounds while no such preferences were observed at Budderoo. Barren Grounds 'potoroo' trap sites were also more likely to have rushes and less likely to have heath as dominant ground vegetation types than expected. No such preferences were observed at Budderoo, although no heath was present at this study area. Most dominant genera below 1 m were used in proportion to their availability at both study areas; however, *Lomandra* sp. was preferred at Barren Grounds whereas bracken was preferred at Budderoo and sedges were used in lower proportions than their availability. Banksias (>1 m tall) were preferred at Barren Grounds but selected against at Budderoo in the 1–2-m layer. Melaleucas (>2 m) were also preferred at Barren Grounds while at Budderoo all shrub species >2 m were used in proportion to their availability.

At Barren Grounds the macrohabitat complexity score was significantly higher ($F_{1,61} = 5.439$, $P = 0.023$) at 'potoroo' trap sites (average score 7.7 ± 1.3) than at 'nil' trap sites (6.6 ± 2.2) while at Budderoo there was no significant difference ($F_{1,38} = 0.326$, $P = 0.572$) between the 'potoroo' (9.0 ± 0.9) and 'nil' (9.1 ± 0.9) trap site scores. The average score across all trap sites was lower at Barren Grounds than at Budderoo. There was a significant difference between the macrohabitat complexity scores among the broad vegetation communities across both study areas ($F_{4,98} = 12.179$, $P < 0.0001$) despite score overlap between some vegetation communities present. The three broad vegetation communities with potoroo captures had mid-range average complexity scores (8.1 ± 1.7 for Budderoo–Morton Plateau Forest, 6.4 ± 1.7 for Coastal Sandstone Plateau Heath, and 8.7 ± 1.1 for Escarpment Foothills Wet Forest) compared with the two broad vegetation communities with no potoroo captures (9.7 ± 0.7 for Shoalhaven Sandstone Forest and 5 for Blue Mountains–Shoalhaven Hanging Swamps).

Canopy cover was more likely to be 20–50% at 'poor' trap sites and 50–80% at 'good' trap sites, compared with 0% at 'nil' trap sites ($\chi^2_6 = 18.37$, $P = 0.005$) (Fig. 2*a–d*). There was no heath at any 'good' or 'poor' trap sites. The dominant ground vegetation types were more likely to be ferns ($\chi^2_2 = 7.07$, $P = 0.03$) and/or rushes ($\chi^2_2 = 12.17$, $P = 0.002$) at 'good' trap sites while the dominant ground vegetation types at 'poor' trap sites and 'nil' were in similar proportions to what was available. No other significant differences were observed between 'nil', 'poor' and 'good' trap sites for macrohabitat attributes relating to cover.

Microhabitat use

Between five and eight full spools were achieved per study area per season (Table 6), with a small number of spooling attempts failing due to spool packages being dropped and spool paths being lost in thick vegetation. In either season, full spools were achieved at six trap sites at Barren Grounds, five of which yielded full spools in both seasons, and all of which were classed as 'good' trap sites. At Budderoo, full spools were achieved at five trap sites in either season, with only two trap sites yielding full spools in both seasons and with three of the overall trap sites being classed as 'poor'. The individuals from which full spools were achieved at Budderoo in either season were all different, while at Barren Grounds, of the 10 individuals providing full spools, five provided in both seasons.

In thick ground vegetation, the spool paths generally passed through small runways, not much larger than the size of a potoroo. A few spool paths crossed tracks in either study area although none travelled along the tracks. No spool paths were followed to squats, suggesting that all spooled individuals continued their evening activities after the spool package was exhausted. The use of coarse woody debris along spool paths was fairly low, with logs generally crossed rather than travelled along. However, in two instances at Budderoo hollow logs were travelled through, providing cover in otherwise quite open habitat patches.

Most potoroo spooling sample points had 0–50% canopy cover and shrub cover at the microhabitat level. The ground cover densities and distributions varied while the average ground cover height was up to 1 m. Of the most common dominant ground vegetation types, ferns were at 50% of sample points, suspended plant debris at 45% and sedges at 27%.

A comparison of the proportions of microhabitat attributes available with those utilised by potoroos during spooling revealed that most potoroos showed significant preferences for certain categories of cover densities, distributions and heights (Table 7); however, the specific categories selected varied widely

Table 4. ANOSIM results for study areas and trap success ratings for each vegetation attribute group analysed

Habitat attribute groups	Factor	Global *r*	*P*	SIMPER dissimilarity Average dissimilarity	Most contributing variable	% contribution	Dissimilarity/s.d.	Greatest variable at
General site information (% canopy cover, % shrub cover, % open ground, position in the landscape)	Trap success rating	0.094	0.001	26.29	Tree canopy cover	29.96	1.14	Potoroo sites
					>2-m shrub cover	28.06	1.08	Potoroo sites
	Study areas	0.115	0.001	26.09	Tree canopy cover	34.19	1.23	Budderoo
Dominant ground vegetation types (heath, sedge, tall sedge, grass, fern, rush, shrub and mix)	Trap success rating	0.062	0.012	62.6	Ferns	21.85	0.86	Potoroo sites
					Sedges	19.35	0.86	Nil sites
	Study areas	0.047	0.06					
Dominant genus in the 0–0.2-m layer	Trap success rating	0.04	0.038	71.86	Sedges	18.11	0.98	Nil sites
					Gleichenia sp.	17.43	0.92	Potoroo sites
	Study areas	0.175	0.001	76.00	Sedges	19.19	1.12	Barren Grounds
					Gleichenia sp.	17.14	0.91	Budderoo
Dominant genus in the 0.2–1-m layer	Trap success rating	0.051	0.021	73.87	*Gleichenia* sp.	13.91	10.28	Potoroo sites
					Banksia sp.	13.2	0.91	Nil sites
	Study areas	0.133	0.002	76.01	*Gleichenia* sp.	13.94	0.92	Budderoo
					Banksia sp.	13.21	0.93	Barren Grounds
Dominant genus in the 1–2-m layer	Trap success rating	0.032	0.058					
	Study areas	0.131	0.001	82.04	*Banksia* sp.	13.27	0.98	Budderoo
Dominant shrub genus in the >2-m layer	Trap success rating	0.034	0.035	73.66	*Banksia* sp.	16.76	0.89	Potoroo sites
					Hakea sp.	16.7	0.92	Potoroo sites
					Leptospermum sp.	16.01	0.89	Nil sites
	Study areas	0.055	0.041	74.23	*Hakea* sp.	20.38	1.11	Budderoo
Dominant tree species	Trap success rating	0.056	0.018	61.93	*Eucalyptus seiberi*	28.23	0.88	Potoroo sites
	Study areas	0.295	0.001	69.78	*Eucalyptus piperita*	32.36	1.41	Budderoo
No. of species present in each layer	Trap success rating	0.08	0.001	25.18	0–0.2-m layer	26.43	1.24	Nil sites
	Study areas	0.228	0.001	26.37	Tree canopy	28.71	1.59	Budderoo

Table 5. Chi-square results for Barren Grounds and Budderoo comparing observed and expected relative abundances of several macrohabitat attributes at 'potoroo' and 'nil' trap sites

Study area	Macrohabitat attribute	Specific attribute	χ^2	d.f.	*P*	'Nil' trap sites	'Potoroo' trap sites
Barren Grounds	% canopy cover		9.48	3	0.0235	More likely to have nil	More likely to have >0–25% or >50–80%
	% shrub cover		15.737	4	0.0034[A]	More likely to have <50%	More likely to have >50%
	% open ground		12.203	3	0.0067[A]	More likely to have ≤20%	More likely to have >20%
	Dominant ground vegetation type	Rushes	10.705	1	0.0015[B]	Less common	More common
		Heath	11.859	1	0.0006[B]	More common	Less common
	Dominant genera in 0.2–1-m layer	*Lomandra*	8.490	1	0.0054[B]	Less common	More common
	Dominant genera in 1–2-m layer	*Banksia*	5.403	1	0.0244[B]	Less common	More common
	Dominant genera in >2-m shrub layer	*Banksia*	9.258	1	0.0036[B]	Less common	More common
		Melaleuca	5.308	1	0.0323[B]	Less common	More common
Budderoo	Dominant genera in 0–0.2-m layer	Sedge	10.000	1	0.0033[B]	More common	Less common
	Dominant genera in 0.2–1-m layer	Sedge	5.714	1	0.0471[B]	More common	Less common
		Bracken	7.059	1	0.0202[B]	Less common	More common
	Dominant genera in 1–2-m layer	*Banksia*	5.227	1	0.0484[B]	More common	Less common

[A] ≥20% of expected counts were less than 5 and so a $P \leq 0.01$ was considered significant.
[B] *P* value from two-tailed Fisher's exact test.

between individuals across study areas and seasons. While some individuals preferred high densities of cover, others showed significant preferences for low cover densities. Individuals showing no significant preferences for any particular microhabitat attribute were always in the minority of animals spooled.

Microhabitat preferences for particular dominant ground cover types also varied widely between individuals, study areas and seasons. Overall, potoroos were found to use fern and heath microhabitats less than, or in similar proportions to, their availability (Table 8), although heath was never a large component of the available habitat where potoroos occurred. Shrub, rush and mixed microhabitats were generally either preferred or used in similar proportions to their availability. Grasses were used in similar proportions to their availability, while the use of sedges, tall sedges and suspended plant debris varied widely.

Potoroo forage-diggings occurred in all categories of tree, shrub and ground cover present in the landscapes of both study areas. In relation to foraging microhabitat preferences (Fig. 3*a–f*), sample points with diggings were more likely to be in >50% shrub cover and less likely to be in 0–20% shrub cover ($\chi^2_3 = 11.42$, $P = 0.0097$) than expected. Sample points with forage-diggings were also more likely to be in open ground cover ($\chi^2_2 = 8.90$, $P = 0.0117$), and have sedges ($\chi^2_1 = 11.25$, $P = 0.0009$) and suspended plant debris ($\chi^2_1 = 6.09$, $P = 0.0145$) as dominant ground cover types, and less likely to have heath as a dominant ground cover type ($\chi^2_1 = 5.97$, $P = 0.0158$) and *Acacias* present within a 5-m radius ($\chi^2_1 = 6.95$, $P = 0.0112$).

Discussion

Macrohabitat use

Across the eastern seaboard of Australia and Tasmania, long-nosed potoroos occupy a variety of habitats including rainforest, dry and wet sclerophyll open-forests, woodland, shrublands and heath vegetation communities and their ecotones (Claridge *et al*. 2007). Our study also revealed usage of a range of vegetation communities across the two study areas. Potoroos were captured in three of the five major vegetation communities mapped by Tindall *et al*. (2005) in the study areas (plateau forest, wet forest and plateau heath). Each of these communities is described as having dense shrub and/or ground cover strata, a common feature of potoroo habitat (Seebeck *et al*. 1989). A comparison of the proportion of trap sites in each vegetation community with potoroo captures, revealed a preference for the Budderoo–Morton Plateau Forest vegetation community.

At the macrohabitat level, long-nosed potoroos were caught in sites with a broad range of ground cover vegetation densities, types and levels of floristic diversity, as well as canopy and shrub cover levels. However, some of these categories were used in greater proportions than others and in greater proportions than their availability, suggesting preferential utilisation. Despite there being some degree of variability and overlap in the attributes of trap sites with and without captures, potoroos had a weak preference for sites with greater levels of canopy and shrub cover, for ferns as a dominant ground cover type and for lower levels of floristic diversity in ground cover. Macrohabitat attributes at trap sites were also found to be significantly different between study areas. Trap sites at Budderoo were found to have more tree canopy

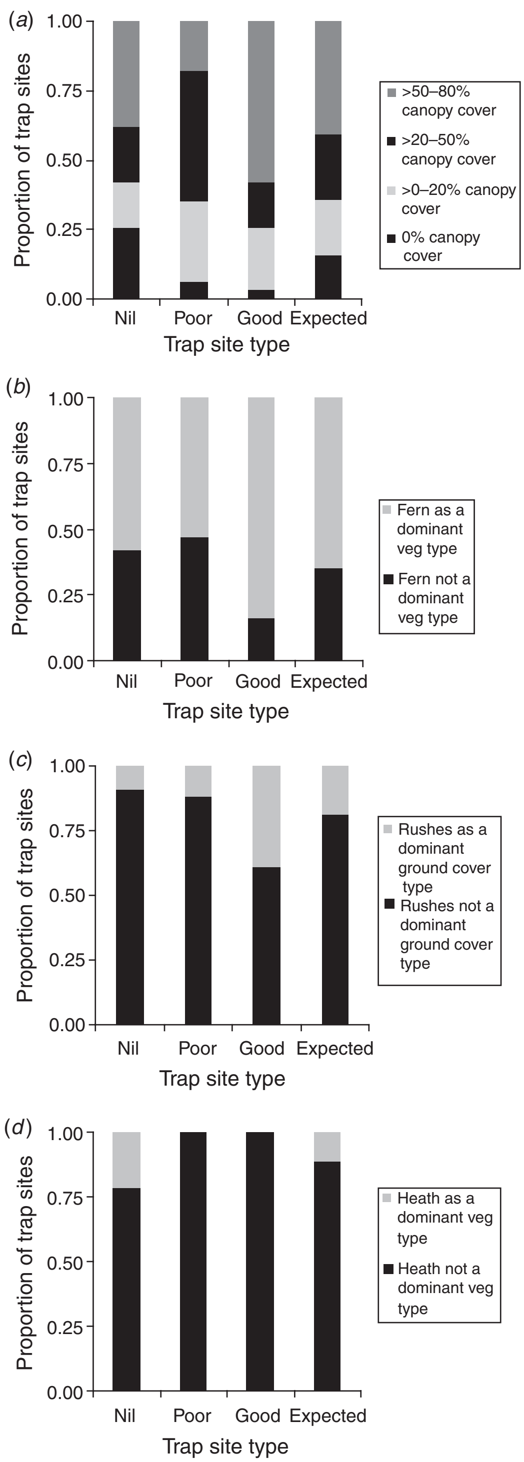

Fig. 2. Proportions of 'nil', 'poor' and 'good' trap sites with: (*a*) each tree canopy cover percentage group ($\chi^2_6 = 18.369$, $P = 0.0054^A$), (*b*) ferns as a dominant ground cover type ($\chi^2_2 = 7.067$, $P = 0.0292$), (*c*) rushes as a dominant ground cover type ($\chi^2_2 = 12.165$, $P = 0.0023$), and (*d*) heath as a dominant ground cover type ($\chi^2_2 = 11.854$, $P = 0.0027^A$), compared with expected. $^A \geq 20\%$ of expected counts were less than 5 and a $P \leq 0.01$ was considered significant.

species, including *E. piperita*, and possibly more canopy cover overall, more chance of a coral fern ground cover and less chance of a sedge ground cover than at Barren Grounds.

A comparison between study areas of macrohabitat attributes at trap sites with and without potoroos revealed that at Barren Grounds potoroos were found to be preferentially utilising several structural and floristic macrohabitat attributes, including greater canopy and shrub cover, while at Budderoo most macrohabitat attributes were used in proportion to their availability.

Collectively, our results imply that while the species used a range of macrohabitats within its local environment, it did display macrohabitat preferences, particularly where there was greater habitat variety to choose from. For example, the selection for canopy cover at Barren Grounds was probably related to the lower overall level of canopy at this study area, due to the presence of patches of treeless heath, compared with Budderoo where canopy cover was used in proportion to its availability.

To assess whether there were differences in the structurally related macrohabitat attributes at trap sites with low or high trap success regardless of location, data from both study areas were pooled. While several significant macrohabitat preferences were observed across all trap sites with frequent potoroo captures, there were few significant differences between available habitat and either the sites with few or no potoroos. Trap sites with frequent potoroo captures were found to have greater canopy cover, and to be associated with ferns as a dominant ground vegetation type. As was observed by Seebeck (1981) in coastal Victoria, the species was absent from treeless heath and was more likely to be absent in other areas with no canopy cover. This may indicate that canopy cover was an additional stratum contributing to the dense vegetative cover with which the species is associated, although its canopy cover preferences may also be due to the fungal diversity many canopy species support. A similar dual benefit of canopy cover was noted for another mycophagous small mammal, the brush-tailed bettong (*Bettongia penicillata*), by Pizzuto *et al.* (2007).

Because of the potential threats of aerial and ground predation faced by this small mammal, it was considered that total cover may be more important to a potoroo than cover at any one particular layer. Habitat complexity scores calculated for each trap site provided a means of assessing cover across the three major layers combined (ground, shrub and canopy). At Barren Grounds trap sites with potoroo captures were significantly more complex at the macrohabitat scale than trap sites at which no potoroos were captured over the course of the study. In contrast, at Budderoo there appeared to be no difference in macrohabitat complexity between trap sites with and without potoroo captures. Again, this difference may be related to Budderoo having very high complexity scores associated which included significant canopy cover and Barren Grounds having greater habitat variety to choose from, including areas of low heath with very low complexity scores associated.

Catling *et al.* (2001) found that the expected abundance of potoroos decreased with lower habitat complexity scores. They suggested that, owing to the species' preference for high general cover in landscapes, areas with higher complexity scores will be likely to have more potoroos. While this was the case within Barren Grounds, overall Barren Grounds trap sites had significantly lower 'macrohabitat complexity' than those at

Table 6. Spooling success at Barren Grounds and Budderoo
The ratio of males (M) to females (F) from which full spools were achieved is also shown

	Barren Grounds		Budderoo	
	Spring 2007	Autumn 2008	Spring 2007	Autumn 2008
Spooling attempts	10	10	7	6
Full spools achieved	7 (5M : 2F)	8 (6M : 2F)	5 (5M)	5 (3M : 2F)
Spool packages dropped	1	1	1	1
Spool paths lost in thick vegetation	2	1	1	0
Full spools with fresh diggings	6	8	5	4

Table 7. Potoroo preferences and avoidances of microhabitat features at Barren Grounds and Budderoo

Microhabitat features	Categories	% of individuals with significant[A] preference for:				% of individuals with significant[A] avoidance of:				% of individuals using habitat in proportion to availability:			
		Barren Grounds		Budderoo		Barren Grounds		Budderoo		Barren Grounds		Budderoo	
		Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08
% canopy cover	0	–	–	20	–	57	88	20	40	0	13	0	40
	>0–20	43	50	80	–	14	–	–	60				
	>20–50	57	63	–	60	14	–	80	–				
	>50–80	–	–	20	–	–	–	–	–				
	>80	–	–	–	–	–	–	–	–				
% shrub cover	0	–		–	–	–	13	–	–	29	13	20	0
	>0–20	29	13	80	20	–	25	–	60				
	>20–50	14	38	–	60	29	13	80	20				
	>50–80	–	13	–	20	29	25	20	20				
	>80	–	–	–	–	–	–	–	–				
Ground cover	Open	43	13	60	20	14	25	–	20	14	13	0	40
	Mid	14	75	–	–	–	–	60	40				
	Closed	–	13	–	40	43	63	20	20				
Ground cover height	0	29	–	20	–	–	–	–	–	29	13	20	20
	>0–0.5 m	29	75	40	20	29	–	20	–				
	>0.5–1 m	14	–	20	–	29	50	60	20				
	>1–2 m	14	–	–	–	14	50	–	40				
Ground cover patchiness	Homogenous	14	–	80	20					14	13	0	20
	Heterogeneous	71	88	20	60								

[A]Significant when either $P < 0.05$ with <1/5th of expected values of <5 or $P < 0.01$ with >1/5th of expected values of <5.

Budderoo and yet more potoroos were trapped there (Norton 2009). Three possibilities may explain this result. First, there may be a limited range within the habitat complexity scale that is suitable for potoroo habitats. The broad vegetation community, Budderoo–Morton Plateau Forest, had a mid-range average macrohabitat complexity score compared with the other communities available and yet had the highest trap success rate. Second, the complexity index may have included characteristics, or combinations of characteristics, that were unfavourable for potoroos. Third, there are likely to be factors other than habitat complexity that influenced habitat usage.

The use of the term 'habitat complexity' can be misleading when considering favourable potoroo habitat in terms of a habitat complexity score. The more dense the layers of cover, the more complex the habitat is considered. However, both Bennett (1993) and Claridge and Barry (2000) suggest that habitat 'patchiness' may actually be more important for the species. In the present study potoroos were captured in all canopy cover, shrub cover and ground cover macrohabitat categories except 0% shrub cover. Further, numerous individuals were each captured at several trap sites with varying levels of cover. These results suggest that potoroos were utilising habitat patchiness at the scale at which the macrohabitat was assessed in this study. However, the potential importance of habitat patchiness is not taken into account in the habitat complexity assessment used by Catling and Burt (1995) and Catling *et al*. (2001). Consideration of habitat patchiness as an essential part of potoroo habitat would make the term 'habitat complexity' imply more about varying levels of cover than maximised cover.

As a threatened and declining species, the long-nosed potoroo may be absent from certain macrohabitats because these habitats are truly unacceptable, because its population density is too low to allow all of its preferred habitats to be filled (Partridge 1978), or because predators are move successful in hunting it there. In an

Table 8. Potoroo microhabitat preferences and avoidances of dominant ground cover types at Barren Grounds and Budderoo

Dominant ground cover type	% of trap sites at which each type was present:				% of individuals with significant[A] preference for:				% of individuals with significant[A] avoidance of:				% of individuals using habitat in proportion to availability:			
	Barren Grounds		Budderoo		Barren Grounds		Budderoo		Barren Grounds		Budderoo		Barren Grounds		Budderoo	
	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08	Spr 07	Aut 08
Fern	100	100	100	100	0	0	0	0	43	25	60	40	57	75	40	60
Sedge	100	100	100	100	14	0	20	40	29	50	40	0	57	50	40	60
Tall sedge	100	100	80	100	0	13	0	20	86	38	0	0	14	50	100	80
Rush	100	100	60	40	14	63	0	0	0	0	33	0	86	38	67	100
Grass	57	63	40	20	0	0	0	0	0	0	0	0	100	100	100	100
Shrub	100	100	100	100	14	25	20	20	0	0	0	0	86	75	80	80
Heath	43	50	0	0	0	0	0	0	33	50	0	0	67	50	0	0
Mix	57	63	100	80	50	20	20	0	0	0	0	0	50	80	80	100
Plant debris	86	100	100	100	17	88	0	40	33	0	100	20	50	13	0	40

[A]Significant when either $P < 0.05$ with <1/5th of expected values of <5 or $P < 0.01$ with >1/5th of expected values of <5.

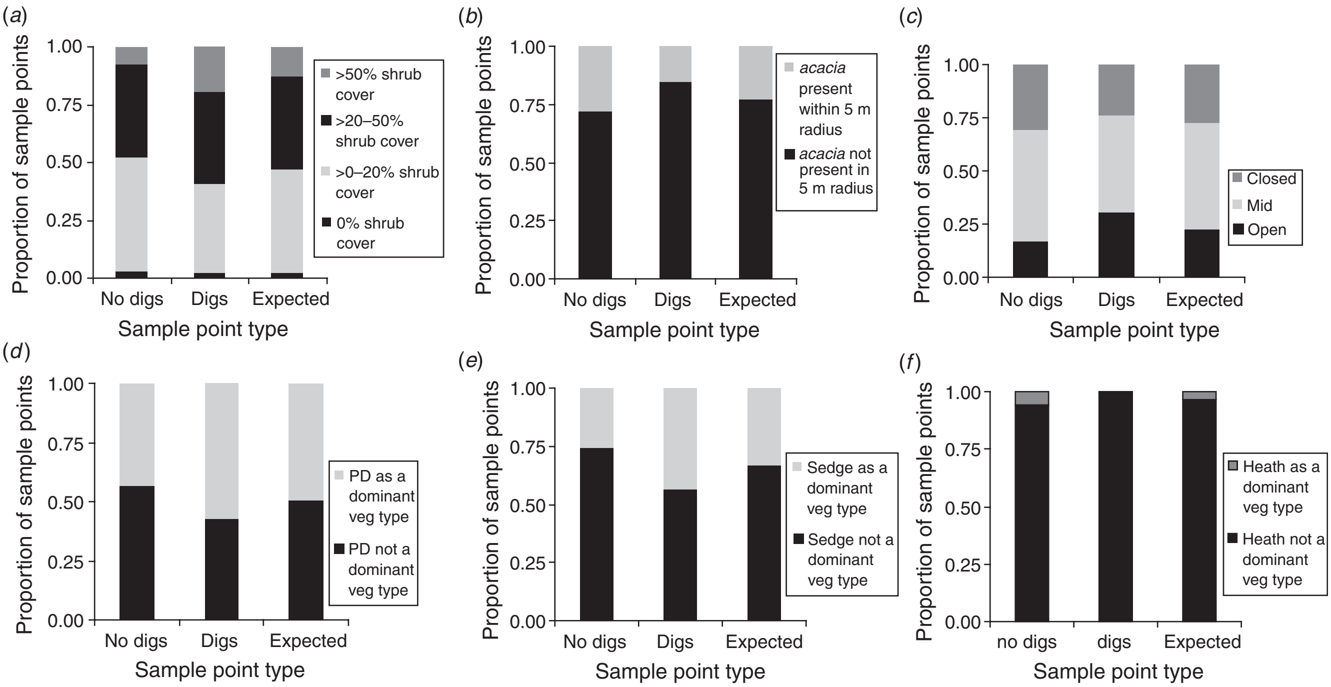

Fig. 3. Proportions of 'dig' and 'no dig' background vegetation sample points with: (*a*) each % shrub cover group ($\chi^2_3 = 11.418, P = 0.0097^A$), (*b*) *acacia* within a 5-m radius ($\chi^2_1 = 5.966, P = 0.0112^B$), (*c*) each ground cover density group ($\chi^2_2 = 8.896, P = 0.0117$), (*d*) plant debris (PD) ($\chi^2_1 = 11.252, P = 0.0145^B$), (*e*) sedges ($\chi^2_1 = 11.252, P = 0.0009^B$), and (*f*) heath ($\chi^2_1 = 5.966, P = 0.0158^B$), as a dominant ground cover type. $^A\geq$20% of expected counts were less than 5 and a $P \leq 0.01$ was considered significant. $^B P$ value from two-tailed Fisher's exact test.

examination of habitat use, this may lead to some macrohabitat preferences not being identified or being under-represented. In the current study, long-nosed potoroos were found to be absent from some trap sites at which the macrohabitats matched those at trap sites at which potoroos were present. This may suggest that habitat availability is not the limiting factor for this species; rather that other factors determine the habitation of locations. However, the patterns of potoroo habitat use and preferences at macrohabitat level may be directly influenced by the microhabitat features available to them within each macrohabitat.

Microhabitat use

An examination of habitat preferences at the microhabitat scale found that most potoroos in each of the study areas preferentially utilised some microhabitat components available to them during evening activities. However, the specific patterns of microhabitat use varied between individuals, sites and seasons. A similar lack of overall microhabitat preferences for the species was observed by Bennett (1993) in south-western Victoria, using live-capture data. Likewise, a spool-and-line study on the closely related Gilbert's potoroo (*Potorous gilbertii*) in Western Australia by Vetten (1996) found that microhabitat use by this species was also not clearly associated with any particular floristic group or strongly correlated with any particular density of vegetation cover.

Bennett (1993) suggested that microhabitat preferences of the long-nosed potoroo, in regard to structural and floristic diversity, vary during different activities, resulting in the utilisation of habitat patchiness. This habitat patchiness, provided by vegetation mosaics and ecotones, allowed individuals, within their relatively small home ranges, access to the different kinds of resources they required: dense, structurally complex patches for shelter and predator avoidance and relatively open, floristically diverse patches for foraging activity.

Bennett (1993) also found that potoroo diggings were negatively correlated with total vegetation density under 3 m and there was a positive correlation between digging abundance and floristic richness. He suggested that the fungal food resources of potoroos were more abundant and accessible where there was more open ground vegetation and light penetration. Similarly, our examination of habitat use during foraging activity revealed that potoroos foraged in all levels of tree, shrub and ground cover present in the landscape but showed preferences for locations with higher shrub cover and more open ground cover, generally with sedges and plant debris.

Methodological challenges

Spool paths may be laid out during a range of evening activities and so are likely to represent varying mixes of foraging and non-foraging movements, including interaction with other individuals, travelling between foraging sites and sheltering. Therefore, due to the species' varying microhabitat preferences during foraging and non-foraging activities (Bennett 1993), the ability to draw meaningful conclusions on microhabitat preferences from spool and line data such as ours is reduced. The various activities each individual was undertaking during its spooling event may well have caused the varying individual microhabitat preferences we observed.

Nearly all spool paths in our study had indications of fresh foraging activities at points along them, but it is not known what proportions of the spool paths were laid out during non-foraging activities. A comparison of the fairly specific habitat preferences we observed during foraging activities, with the varying habitat preferences displayed by individuals during spooling, may indicate that the proportion of foraging to non-foraging activities during spooling varied substantially between individuals. Microhabitat preferences during trapping were also found by Claridge *et al*. (1993*a*) to vary compared with those indicated by the presence of forage diggings.

Synopsis

In our study, patterns of habitat use by long-nosed potoroos differed at the two scales of investigation. Some habitat attributes were important at the macrohabitat scale, but did not appear as important at the microhabitat scale, and *vice versa*. Overall, this suggests that the species' habitat use is influenced by both macro- and microscale preferences and highlights the importance of examining habitat associations at multiple scales. In fact, our data suggest that variation in habitat attributes at a range of scales may be the important feature of potoroo habitat.

From a management perspective, areas where long-nosed potoroos occur should ideally be perpetuated as a mosaic of habitat types with variable floristic and structural diversity at both the macro- and microscale. Activities that result in the simplification of habitat attributes, particularly the frequent use of prescribed fire (Catling 1991; Claridge and Barry 2000), should be avoided. Frequent low-intensity fires lead to the elimination of dense understorey and thus increased predation risks. However, the total suppression of fire from the species habitat will prevent the continued development of the habitat mosaics the species requires (Mason 1997). Occasional higher-intensity fires encourage dense understorey growth in the long term.

Claridge and Barry (2000) suggest that the species is more likely to be found in habitats long unburnt (>20 years) due primarily to the availability of increased 0.5–2-m ground cover. Trapping by Baker and Clarke (1991) in a portion of our Barren Grounds study area, eight years after the last fire event, resulted in no potoroo captures. Alternatively, our trap success in the same area as that used by Baker and Clarke was particularly high (Norton 2009), suggesting that the absence of fire for over 25 years may have assisted in the recovery of the local population. Kenny *et al.* (2004) recommends that the broad fire interval for heath vegetation types is a minimum of 7 years (based on the minimum maturity requirements of associated species) and a maximum of 30 years (a general estimate of post-fire age at which species may be lost due to senescence). However, these intervals are the average values across all heath community types and the true maximum may be much greater for many species/communities. Therefore, if using prescribed fire as a management tool in potoroo habitat, to promote regeneration and create habitat age mosaics, at any one time most mosaic patches should be long unburnt, while the amount or area of recently burnt habitat should be minimised.

Given the availability of abundant habitat in our study areas, sometimes without evidence of potoroo usage, there is the possibility that the population is being controlled by factors other than habitat availability. It is apparent that even in the good-quality potoroo habitat offered at both study areas the species may be facing serious predation risk due to its use of patches of open ground cover, particularly during foraging. The effective control of introduced predators, especially foxes, in and around potoroo habitat is also likely to assist in the conservation of the species, particularly following disturbances such as fire (Dexter and Murray 2009).

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