Government of South Australia

South Australian Arid Lands Natural Resources Management Board

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An expansion of Dusky Hopping Mouse *Notomyus fuscus* distribution inside the Dog Fence in northern South Australia

Richard Southgate & Katherine Moseby

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Landholder summary

The dusky hopping mouse is a small native rodent which inhabits sandy areas in the South Australian pastoral zone. Numbers have significantly declined over the past 200 years probably due in part to the introduction of feral cats and foxes. Rabbits and domestic stock are also thought to reduce plant cover lowering food resources for the dusky hopping mice which feeds mainly on seed and plant material. The Department for Environment and Natural Resources has been monitoring key populations of the dusky hopping mice since 1993 and found their numbers fluctuate depending on seasonal conditions. After large rainfall events, hopping mice can breed rapidly, building up in numbers and dispersing out into surrounding sandy areas. During these good seasons dusky hopping mice can be relatively easy to find, leading many people to believe they are a common species rather than one of our most threatened mammals. During dry times they are only found in a few core areas in the Strzelecki desert region north of the dog fence. During these dry times populations are very small and vulnerable to extinction through low food resources and predation from cats and foxes. High grazing pressure from rabbits or stock during these dry times may further reduce food and plant cover making them more susceptible to local extinction. Dusky hopping mice have disappeared from many of these key areas so the remaining refugia areas are vital for securing the long term conservation of this species.

The introduction of calicivirus in 1995 drastically reduced rabbit numbers in many areas of the pastoral zone and is thought to have improved life for this native rodent. There are now less predators and more plant cover in many areas where dusky hopping mice are found. The recent excellent rainfall conditions have also helped the species to breed up and disperse across large areas of the pastoral zone. This study was conducted to determine how far dusky hopping mice have spread and how abundant they are. When conditions become dry we can see if the dusky hopping mice contract back to known key areas or establish new ones. By understanding what makes these key areas special we can hopefully determine if any management actions are needed to prevent extinction and return this species to its former distribution.

We visited 14 pastoral stations situated south of the dog fence during May 2011 and looked for sign of dusky hopping mice. We used a number of techniques including spotlighting, trapping and searching for hopping mice tracks and burrows. Hopping mice were recorded on the western, southern and southeastern side of Lake Frome as far south as Wirrealpa, Curnamona, Kalabity and Boolcoomata Stations, and near Cockburn. To the northwest of Lake Frome, sign extended from Moolawatana to Muloorina Stations including Mundowdna. Hopping mice were found in sandy areas such as creeklines, sand dunes and sandy rises on gibber plains. Sign was most abundant in northern areas close to the dog fence with less dusky hopping mice in southern areas. More hopping mice were recorded in areas of continuous dune systems with less in patches of isolated dunes. Despite the good conditions, rabbit numbers were quite low and grass seed was plentiful. Trapping at Wooltana recorded the highest density of dusky hopping mice per hectare (10) since trapping records began in South Australia in 1993.

Although we don't yet know what detailed actions are needed to conserve the dusky hopping mouse we can make broad management suggestions that will benefit the species. Increasing the number of key refugia areas is needed to minimize the risk of extinction. This can be done in a number of ways:

- by maintaining good vegetation cover, particularly of grasses. This will help both stabilize the sand dunes where they live and provide hopping mice with food. This is particularly important during droughts when hopping mice populations are low. Stable sand dunes are needed to enable hopping mice to build their permanent burrow systems.
- by reducing rabbit abundance through ripping warrens or deliberately releasing the rabbit calicivirus at key times (usually during autumn before young rabbits are present). This will reduce competition for food and lower predator numbers.
- by controlling foxes and cats. This will also help reduce pressure from predation. Control could include long term sustained fox baiting programs or encouraging kangaroo shooters to shoot any cats or foxes encountered during kangaroo harvesting.

- Finally, reporting any sightings of hopping mice tracks or forwarding any dead specimens to Reece Pedler at DENR (phone 86711083), particularly as conditions become dry. This will help us determine which management practices are working and inform future decision making.

We hope to resample sites during dry conditions to locate key areas and understand what makes these refugia areas special. We would like to thank all the pastoralists who assisted with this study through providing specimens, allowing property access, sharing their knowledge and assisting with surveys. By working together we hope to ensure the dusky hopping mouse survives in the South Australian arid zone well into the future. If you are interested in more information on the dusky hopping mouse or the management practices that can help conserve it please contact your SAAL NRM board office in Pt Augusta.

Executive Summary

A survey was conducted during May 2011 to investigate the distribution of the dusky hopping mouse *Notomys fuscus* in northern eastern South Australia south of the Dog Fence. The survey used spotlighting, track-based monitoring and trapping to determine the current distribution and abundance of the species in this region. Past surveys have recorded dusky hopping mice from sandy deserts in the north east of South Australia (Strzelecki and Tirari Deserts) with only scattered records from arid areas south of the Dog Fence. The report briefly discusses the expansion of *N. fuscus* range in response to the rabbit calicvirus and the period of exceptional rainfall beginning in 2010 following several years of drought.

The survey found *N. fuscus* sign on the western, southern and southeastern side of Lake Frome extending to Wirrealpa, Curnamona, Kalabity and Boolcoomata Stations and near Cockburn in the south. Sign extended to a southerly latitude of around 32^{o} S. To the northwest of Lake Frome, sign extended from Moolawatana to Muloorina Stations including Mundowdna. A series of voucher specimens were collected during the survey or supplied by pastoralists (from animals found dead) to verify the identity of *N. fuscus*. This extends the previously known distribution of *N. fuscus* south of the Dog Fence by over 70 kms. Sign was more abundant close to the dog fence and diminished further to the south. Trapping and the use of track-based monitoring provided an opportunity to collect information on introduced and native species associated with the occurrence of *N. fuscus*. There was no obvious negative association at the scale of investigation with the distribution of introduced predators or herbivores. A southward extension in range was recorded for the crest-tailed mulgara (or Ampurta), *Dasycercus cristicauda* the long- haired rat *Rattus villosissimus* and the sandy inland mouse *Pseudomys hermannsburgensis*. The introduced house mouse *Mus musculus* was extremely abundant at all trap sites. Range extensions of native rodents are associated with above average rainfall recorded over the last 12-24 months and are expected to contract when conditions become dry. Resampling of track and trap sites during dry conditions may allow the influence of calcivirus and rainfall to be differentiated.

Recommendations

1. Resample monitoring sites during dry conditions to determine the following:

   - whether the recent range extension of *N. fuscus* is sustained
   - the location of any key refugia sites south of the dog fence
   - the strength of association between habitat characteristics (eg. type, size of sandy patch, distance from continuous sandy habitat) and resilience of *N. fuscus* populations.
   - the strength of association between predator abundance and abundance of *N. fuscus* during periods of nutritional stress.

2. Compare hopping mouse abundance and competitor/predator levels in continuous sand dunes north and immediately south of the dog fence. This will improve our understanding of why *N. fuscus* is rarely recorded south of the dog fence during dry conditions. This action could include comparing track plots and trap grids on either side of the fence.

3. Determine the influence of rabbit and stock levels on *N.fuscus* occupancy and abundance through the erection of rabbit/stock proof exclosures and resampling track plots when rabbit abundance is high.

Introduction

This document reports on a survey conducted in South Australia to define the southerly distribution of the dusky hopping mouse *N. fuscus* in a study region extending from the Barrier Hwy in the southeast to Lake Eyre South in the northwest. *Notomys fuscus* was formerly widespread and early records show the species once occurred in the southern parts of the Northern Territory, southwest Queensland to Ooldea on the Nullarbor Plain and as far west as Rawlina in Western Australia. The range of the species has declined in the last 50 years and is mainly restricted to the Strzelecki Desert region of arid South Australia.

Four extant species of *Notomys* occur in arid Australia and all are around 35 g in weight. Along with dusky hopping mouse, the fawn hopping mouse *N. cervinus* was once known from the study area. The spinifex hopping mouse *N. alexis* occurs to the north and west and Mitchell's hopping mouse *N. mitchelli* occurs to the south and west inhabiting mallee country. Three other large hopping mice, each around 100 g in weight once occurred in the study area. The remains of the broad-cheeked hopping mouse *N. robustus*, long-tailed hopping mouse *N. longicaudatus* and short-tailed hopping mouse *N. amplus* have been recorded from owl pellets found in caves along the Flinders Ranges. None of these species have been recorded alive for over 100 years (Watts and Aslin 1981).

N. fuscus and *N. cervinus* can be found in close proximity but *N. fuscus* is found mainly on sandy substrates including dunes with sand hill canegrass *Zygochloa paradoxa* whereas the *N. cervinus* is mainly restricted to claypans and gibber plains. *Notomys fuscus* lives communally in complex warren systems. Warrens are often associated with sand hummocks or rabbit warrens and contain a number of vertical shafts (popholes) which they use to escape predators. Both species underwent a contraction in range following the establishment of pastoralism and expansion of rabbits, cats and foxes. By the 1970s *N. fuscus* had become restricted to localities in south-western Queensland and parts of northern South Australia. Extensive surveys in the 1990s recorded *N. fuscus* populations consistently only from within the Strzelecki Regional Reserve and in south-western Queensland near Betoota. The species was also occasionally reported from a number of other sites in the northern and southern Strzelecki Desert, as far south as Quinyambie Station (Moseby *et al*. 1999; Moseby *et al.* 2006).

Notomys fuscus is similar to *N. alexis* in appearance and general biology and unlike *N. cervinus* which has a slower rate of reproduction (Watts and Aslin 1981). *N. alexis* is known to show large fluctuations in population numbers in the wild and 'boom-bust' cycles have been reported in some populations of *N. fuscus* but not others (Owens *et al.* 2008).

Concerns about the conservation status of the dusky hopping mouse *N. fuscus* have led to its listing as a species of ***Conservation Priority*** in the South Australian Arid Lands NRM Region and as *Vulnerable* under the national ***EPBC Act 1999*.** The species is also listed as *Vulnerable* in Schedule 9 of the ***SA National Parks & Wildlife Act 1972*** – *Schedule 7* and *9,* amended September 2000.

In 2006, a study using track-based monitoring suggested that the range of *Notomys* spp. had expanded with sign recorded at a large number of sites between Muloorina and Mungeranie Stations on the Birdsville Track (Southgate, 2006). Subsequent trapping confirmed the identity of *N. fuscus* (Bellchambers 2007) in this region and on Kalamurina Station (R. Paltridge, pers. com.). The species was also rediscovered in the Sturt Desert National Park in western New South Wales. Anecdotal reports during 2007 and 2008 indicated hopping mouse numbers had become extremely abundant across the southern parts of the Strzelecki Dunefields and the species was confirmed as *N. fuscus* (Waudby and How 2008; R. Pedler, unpublished data).

In an effort to provide more security for the conservation of this and other threatened species, the SA Arid Lands Draft Biodiversity Strategy (2009) was developed. The relevant 5-year actions identified for the dusky hopping mouse were to:

- determine area of occupancy and relationship between habitat and distribution and abundance of the dusky hopping-mouse in the Strzelecki Desert.
- identify and, where possible, quantify the disruption, and sources of disruption, of key ecological processes supporting individual populations of the Dusky Hopping-mouse in the Strzelecki Desert.
- identify potential habitats within the Strzelecki Desert for the Dusky Hopping-mouse.
- rank populations of the Dusky Hopping-mouse within IBRA subregions for viability, based on size, threats and landscape context.

We carried out work to help address the questions outlined above. Primarily, we focused on

- investigating the southern distribution of *N. fuscus* from the Barrier Hwy in the southeast to Lake Eyre South in the northwest.
- documenting the range of habitats associated with the occurrence of *N. fuscus*
- collecting information on introduced and native species associated with the occurrence of the *N. fuscus*.
- Undertaking trapping to record relative abundance of the species at three sites across its southerly range and collect voucher specimens.

Methods

The survey used a combination of tracking and trapping to identify and verify the occurrence of the *N. fuscus*. The survey was conducted 5-18 April 2011 and extended from Mulyungarie Station near Olary in the southeast to Muloorina near Marree in the northwest. Existing roads and station tracks were used to reach the location of survey plots and most were situated more than 5 km apart. A GPS was used to record the position of each plot in UTMs (datum: WGS84).

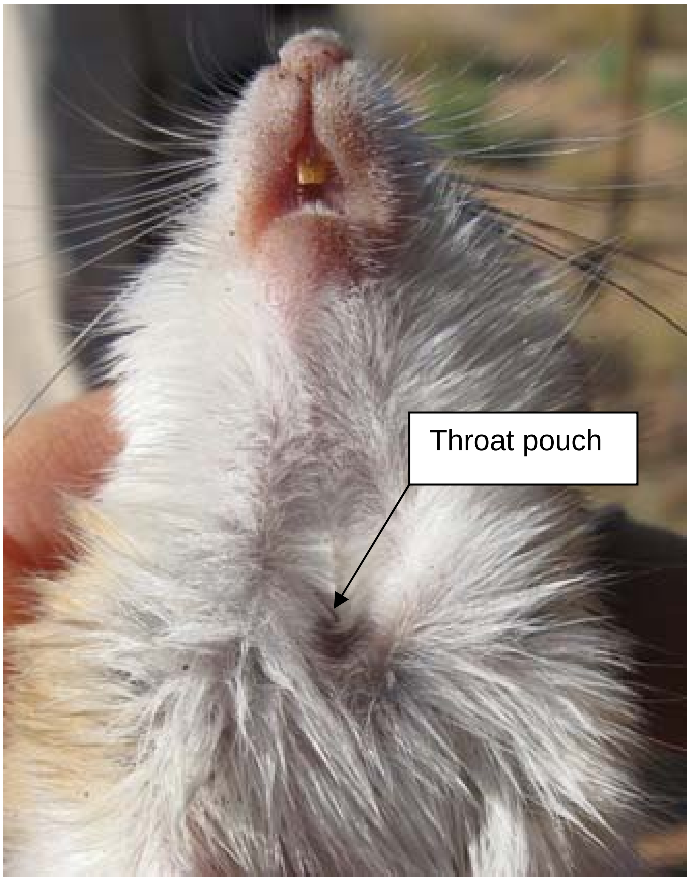
Trapping of animals was conducted at three locations: Mulyungarie, Wooltana and Mundowdna Stations (**Appendix 1**). Grids were designed to complement the two established *N. fuscus* monitoring grids north of the dingo fence at Montecollina Bore (S.A.) and Pelican Waterhole (Qld). These original grids covered 8 ha and were established by DENR and trapped from 1993 to 2000 (Moseby *et al.* 2006). The grids established during the current survey were half the size and each was approximately 100 m x 400 m. Ninety Elliott traps were baited with peanut butter and oats and each trap was set 20 m apart with three central trap lines of 20 Elliotts and a line of 15 Elliotts on either side. A set of pitfall traps was set on the grid at five locations spaced along Elliott trap lines. Each set of pitfall traps consisted of one wide pit (200 mm diameter x 600 mm deep) and one narrow pit (150 mm diameter pit x 600 mm deep) set 10 m apart and dug in flush with the ground surface. Fly wire was placed between the pitfall traps in each set with a 3 m tail on either side. Elliott and pit fall traps were sprinkled with Coopex insecticide to prevent ant attack on captured animals. Peanut butter and oat bait was also placed in pitfall traps to reduce house mice attacking other species. Elliott and pitfall traps were set for two consecutive days at each site. Voucher specimens were euthanised using a portable CO_2 chamber. *Notomys fuscus* is characterized by the presence of a well developed throat pouch in both sexes (**Figure 1**). The colour of the dorsal fur is pale orange and ventral surface is white. Ears are long and delicate and tail is long with brush at the end. All house mice *Mus domesticus* captured on the first night of trapping were euthanized.

Spotlight counts were conducted at several localities during the study, including each trap grid. Each count involved the driver recording animals seen in the vehicle spotlights and an observer in the left-hand passenger seat recording animals seen with a handheld spotlight. A 5 km transect was sampled with animals recorded on the outward and return legs (10 km in total) with the vehicle traveling at about 10 km/hr. At other sites, opportunistic transects were conducted using only the car headlights, usually when on route to another location at night. In these instances, vehicle speed ranged between 50-70 km/hr.

Track-based monitoring using the occurrence of animal track imprints was the main method used to document the distribution of *N. fuscus* and a range of other native and introduced species. Although it is not feasible to distinguish among extant *Notomys* using only track and gait characteristics, this sign can be used to identify them from other genera. Presence on a plot was recorded if at least three consecutive gait imprints were observed. The presence of pop holes and runways was used as confirmatory sign. A track-based monitoring protocol similar to that outlined in Moseby *et al*. (2009) was used. A visual search of a 100m x 200m plot for a period of 25-30 minutes was conducted to determine the occurrence of species including feral cats, foxes, dingoes, cattle, camels, goats, rabbits, red kangaroos, mulgara, small dasyurids, mice and sleepy lizards. The identity of species was assigned on the basis of gait pattern and foot imprint size (**Figure 2**). The age (days) of the most recent track imprint or activity for each species was estimated based on track clarity and antecedent wind conditions. Data for tracks aged two nights or less are presented.

The conditions that affected animal imprint detection at each plot were recorded. This included the intensity of light, sun angle, area of plot with a sandy trackable surface and continuity or size of the sand lenses. Each attribute was scored between 1 and 3, with 1 indicating good response and 3 a poor response. An ordinal detection score was derived for each plot by adding the score for the five attributes. This produced a minimum score of 5 (very good) and 15 (very poor). On each the plot, the composition of dominant ground and shrub vegetation was also recorded and the vegetation cover of each layer was estimated visually. The habitat type was categorised as creek line, sand plain, sand rise and sand dune and the geological characteristics were derived from 1:250 k geological map sheets.

a)



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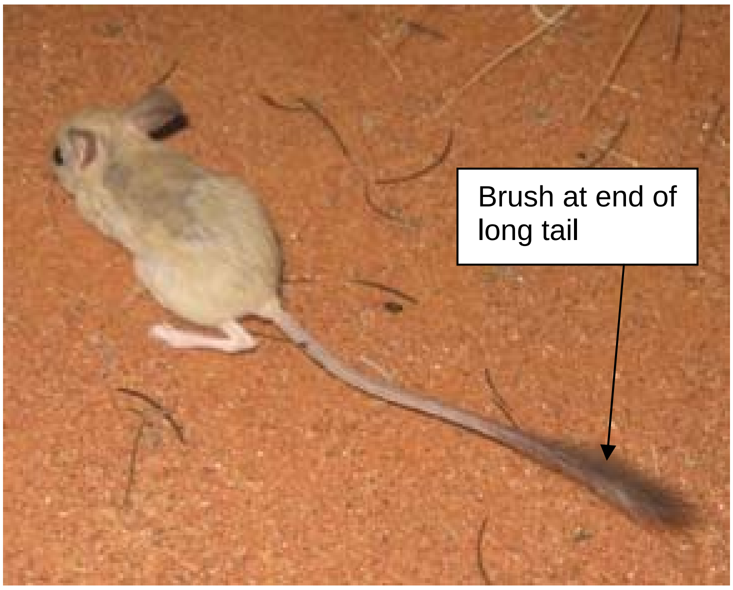


c)

Figure 1. Photos of dusky hopping mice. a) animal found dead on side of road on Kalabity Station - note long back legs b) the distinctive throat pouch and c) dusky hopping mouse photo showing brush on end of tail, body form and pale colour. Arrows indicate distinguishing features

Results

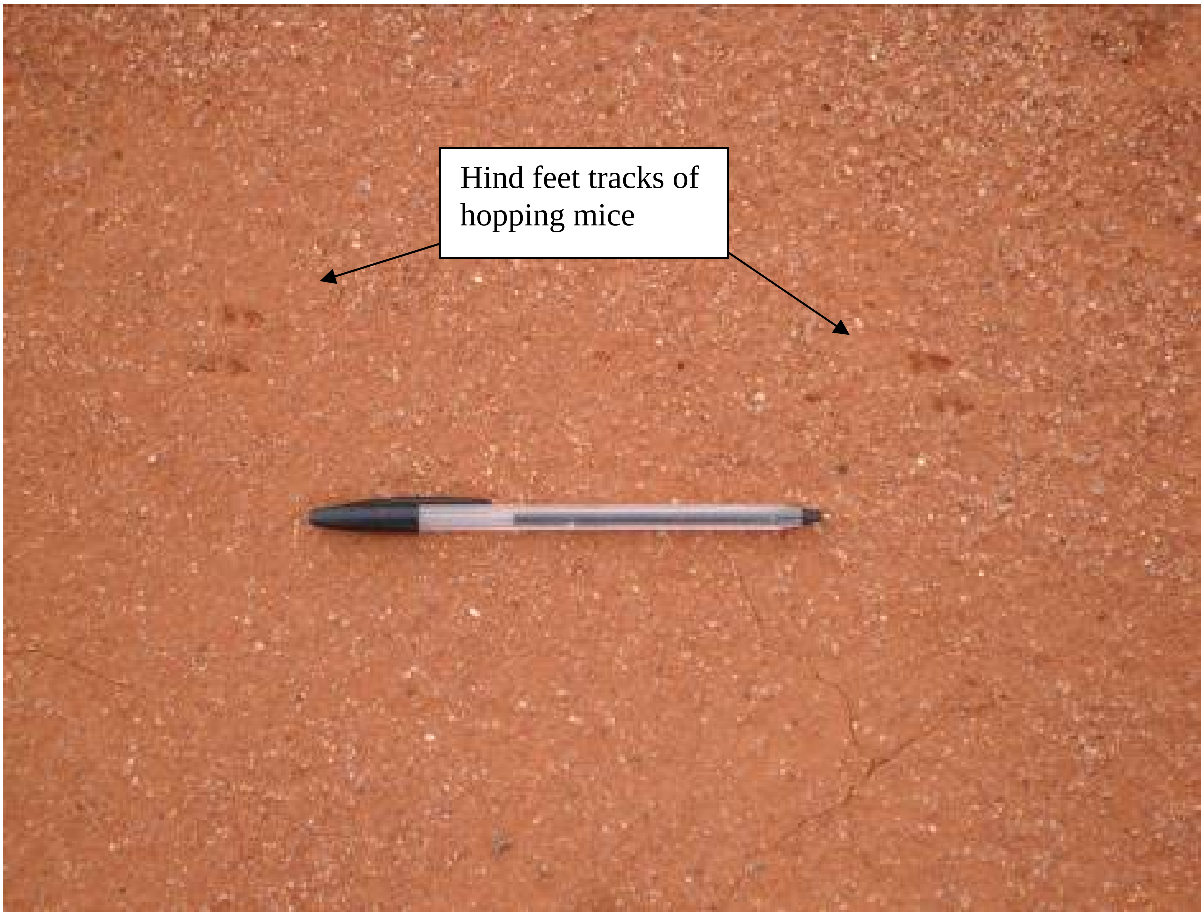
Trapping and spotlighting

Elliotts and pitfall traps

A total of 71 *N. fuscus* individuals were captured at the three trapping grids (**Table 1**). Trap success ranged from 1 % to 21 % with the highest dusky hopping mouse captures recorded at the Wooltana grid followed by Mulyungarie Station and only low abundance recorded at the Mundownda grid. Pregnant females and/or subadult hopping mice were captured at all three trap grids. The introduced house mouse *Mus musculus* was the most abundant small mammal captured with 278 individuals caught. Juvenile and/or pregnant *Mus* were recorded at each site and the site with the highest hopping mice captures corresponded with the lowest house mouse capture rate. The sandy inland mouse (*Pseudomys hermannsburgensis)* was present in low numbers at each trapping grid. One stripe-faced dunnart (*Sminthopsis macroura*) was captured in a pitfall trap on the Mundowdna grid and a short-tailed mouse (*Leggadina forresti*) was captured in an Elliott trap on the Mulyungarie grid.

Spotlighting

The abundance of *N.* fuscus seen during spotlight transects in the vicinity of trap grids reflected trapping data. More than 9 hopping mice were recorded per kilometre along transects at Wooltana, 1-1.5 on Mulyungarie and none on Mundowdna Station (**Table 2**). In general, both slow and fast speed spotlight transects indicated a decline in *Notomys* abundance toward the southern, southwest and northwest of the study area. The same trend was not apparent for house mice or rabbits.



a)


b)

c)


d)

e) 

f)

g) 

Figure 2.Tracks of some of the focal animals encountered during the survey. a) single hopping mouse set of imprints,b) tracks showing bipedal hop c) hopping mice popholes on Kalabity Stn, d) hopping mice (arrow), rodent/dasyurid and crested pigeon tracks on Wirrealpa Stn, e) long-haired rat in dried mud f) long haired rat on Mundowdna Stn and g) mulgara tracks on Muloorina Stn

Track-based monitoring

Hopping mice

In total, 78 plots were sampled. The plots were mostly located on sand plains with undifferentiated alluvial/fluvial sediments (63%) or sand dunes with aeolian sediments (26%) with the remainder on clays, siltstones, shale or carbonates (11%).
Hopping mouse sign was recorded at 70% of the 78 track monitoring plots (Fig. 3). Chance of hopping mouse detection was 0.76 and 0.75 for plots with an ODS<8 and ODS8-10 but reduced to 0.25 when the ODS>11 (n=8).

To the south of Lake Frome, hopping mice sign extended to latitude 32^{o} S or close to the Barrier Hwy. Sign was found on Wirrealpa, Curnamona, Kalabity Boolcoomata Stations and a kangaroo shooter we interviewed reported one near his house at Dismal Swamp in the vicinity of Cockburn. To the northwest of Lake Frome, sign extended from Moolawatana to Muloorina including Mundowdna Station. More hopping mice sign was encountered on sand dunes (85%) with less on sand plains (69%) and least on other geological formations (44%).

Table 1 Individuals captured in Elliott and pitfall traps at each trap grid. Total trap nights per grid for Elliott traps = 180 and pitfalls = 20

Trap grid	***N. fuscus***			***M. musculus***			***P. hermansburgensis***		
	Pit	Elliott	Total	Pit	Elliott	Total	Pit	Elliott	Total
Mulyungarie	22	6	28 (14%)	41	105	146 (73%)	2	1	3 (1.5%
Wooltana	25	16	41 (21%)	6	28	34 (17%)	0	1	1 (0.5%)
Mundowdna	0	2	2 (1%)	7	121	128 (64%)	2	3	5 (2.5%)

Table 2 Observations from spotlight transects conducted during the survey. Results are expressed as the number of animals seen per km with the total animals seen in brackets. Sites are listed in order from East to West. a) vehicle speed 10 km/hr: head lights plus hand held spot by passenger; b) speed 60-80 km/hr: headlights only

Property	**Trans**	***Notomys***	**Mice**	**Rabbits**	**Locality notes**
a)					
Mulyungarie Stn	10 km	1.5 (15)	0.4 (4)	0.3 (3)	5 km S homestead
Kalabity Stn	16 km	0.44 (7)	0	0.44 (7)	54J 430619 6470116
Curnamona Stn	25 km	0.08 (2)	0.08 (2)	0.08 (2)	Mulga Dam-Swamp Dam
Wooltana Stn	10 km	2.8 (28)	-		Trap Grid-Mulga Bore
Wooltana Stn	10km	9 (90)	0.5 (5)	0.3 (3)	Trap Grid-Pipeline return
Mt Lyndhurst Stn	10 km	0	0.2 (2)	0.5 (5)	5 km N homestead
Mundowdna Stn	20 km	0	1.5 (30)	0.4 (8)	Within 10km of trap grid
b)					
Mulyungarie Stn	64 km	0.125 (8)	0.015 (1)	0.030 (2)	Barrier Hwy-homestead
Mulyungarie Stn	50 km	1.04 (52)	0.04 (2)	0.12 (6)	Homestead-Billeroo Bore
Curnamona Stn	50 km	0.04 (2)	0	0.08 (4)	Homestead-Koonamore
Wirrealpa Stn	8 km	0	0	0.125	Homestead-camp site
Mundowdna Stn	10 km	0	0	0.6 (6)	Woolshed-trap grid

Relative abundance of track sign was greater at plots in the vicinity of Lake Frome and on the southern edge of the Strzelecki Desert and sign diminished to the south west and north of these locations (**Fig. 3**).

Hopping mouse sign was recorded from a range of habitats including sand dunes, sand plains and sandy creek lines and aeolian deposits among the foot hills of the Flinders Ranges (**Fig. 4**). Within stony gibber habitat, hopping mice sign was usually restricted to narrow sandy creeks or drainage lines that bisected the gibber plains. Hopping mice sign was even recorded in small patches of sand or isolated sandy rises/dunes within otherwise hard stony substrate. Spotlighting also recorded *dusky hopping mice* sightings in the vicinity of sandy patches within areas of harder substrate.

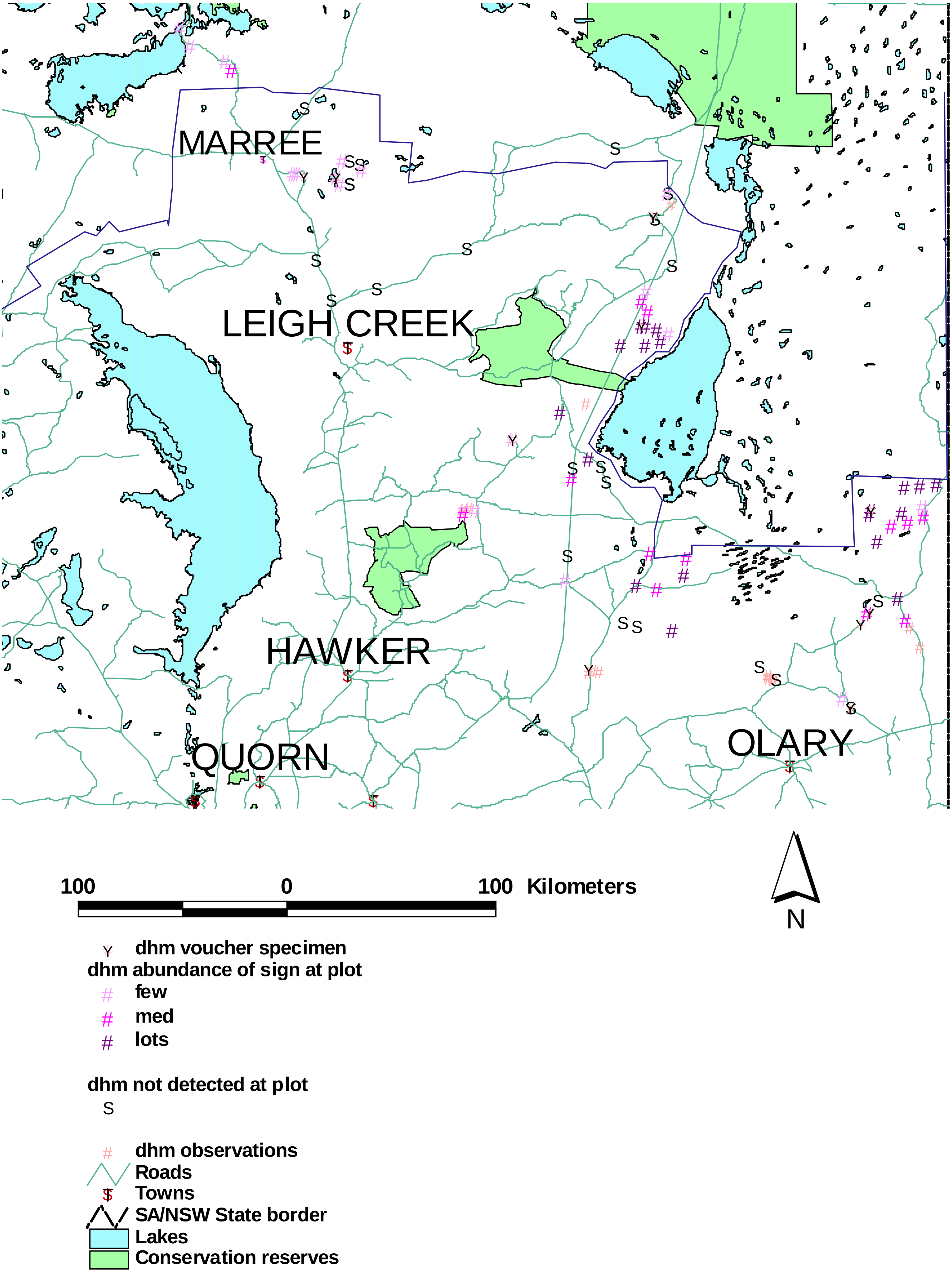


Figure 3. Relative abundance of *N. fuscus* (dhm) track sign at monitoring plots, location of voucher specimens and additional opportunistic observations from tracking or spotlighting


a)


b)


c)


d)

e)

f)

Figure 4. Habitat used by N. fuscus in the study area a) Kalabity Stn b) Kalabity Stn c) Wirrealpa Stn d) Wirrealpa Stn e) Wooltana Stn and f) Mundowdna Stn

Tracking conditions

The tracking condition at 34 plots was good to very good with an ordinal detection score (ODS) <8. Tracking condition was reasonable at 36 plots with ODS from 8-10 and eight plots received an ordinal detection score >10 indicating that tracking conditions were poor (**Fig 5**). We encountered rain during two nights of the survey but weather conditions for track-based monitoring were good for the remainder of survey with little cloud cover and no periods of strong wind. Plot tracking conditions with an ODS<8 were more frequently encountered on sand dunes and with mixed geology (60% and 67%, respectively) and less commonly encountered on sand plains (33%).

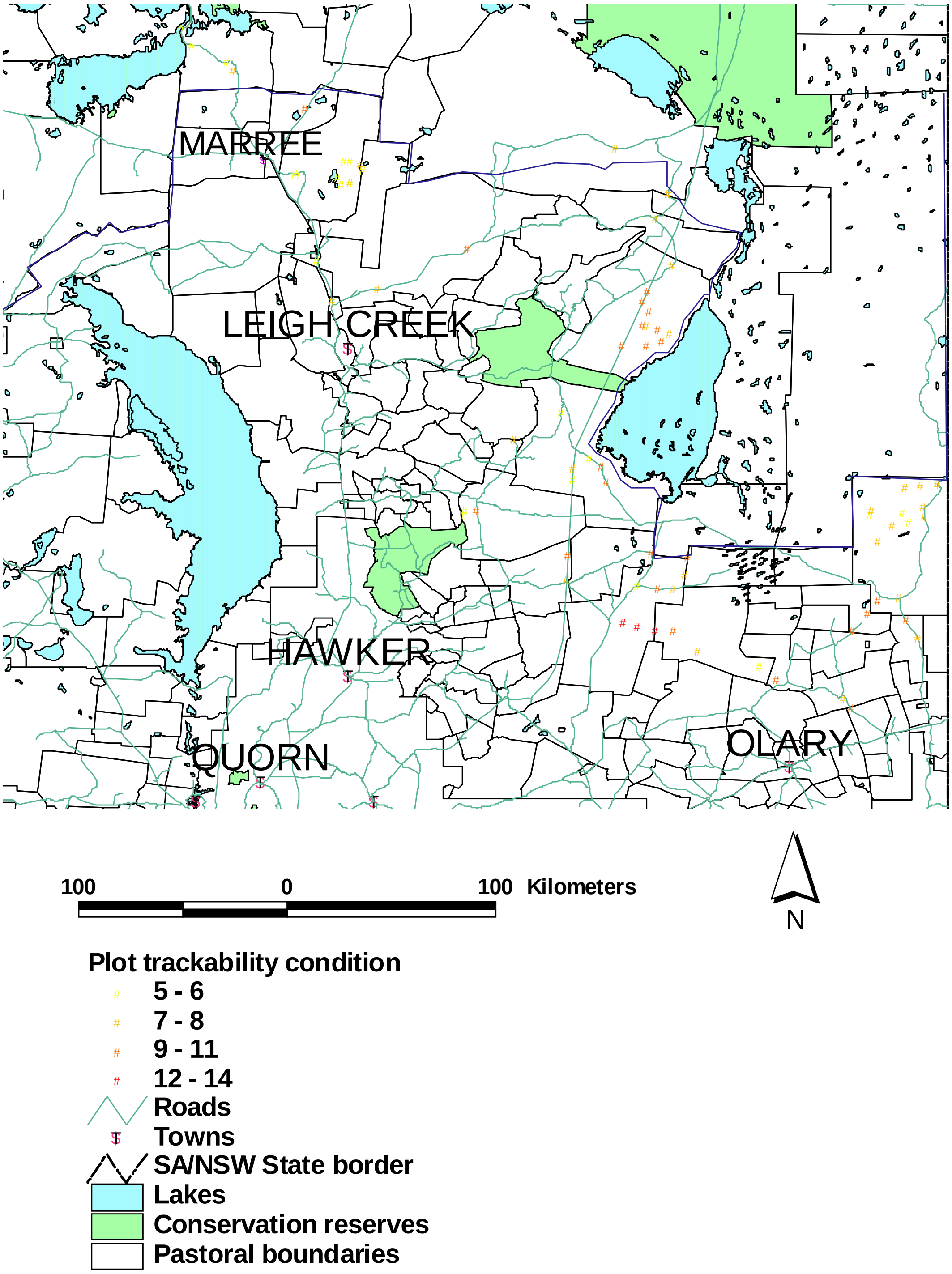


Figure 5. Study area and plot trackability conditions at monitoring plots. Larger scores indicated poorer trackability conditions. Blue line shows location of Dog Fence.

Other native species

Mulgara and long-haired rat

Of the 76 plots sampled, 3 (4%) had putative crest-tailed mulgara (or ampurta) *Dasycercus cristicauda* sign present (**Table 3**) and clear sign was recorded on Muloorina Station near Goyder Channel between Lake Eyre North and Lake Eyre South. Older indistinct tracks of a mulgara or rat size animal showing typical gait pattern was also recorded near the trapping site at Mundowdna Stn. Fresh tracks consistent with those of long-haired rat *Rattus villosissimus* were later recorded at this location. More definitive sign of putative long-haired rat tracks were recorded at five plot locations (mainly in creeklines) and two dry specimens were collected on Muloorina Sation near Goyder Channel and Mundowdna Station. A *R. villosissimus* specimen was also recently captured at Mundowdna homestead (Stuart Crombie, pers com.).

Small rodent/ dasyurid

Small rodent or dasyurid (Dunnarts etc) sign was recorded at 65% of plots. It was not feasible to distinguish among species and much of the sign was probably attributable to house mouse *Mus musculus*.

Kangaroo and emu

Emu sign was relatively common and recorded on 28% of plots. More red kangaroo sign (26%) was recorded than grey kangaroo (4%). All these species were widely distributed in the study area (**Fig. 6**).

Predators

The red fox was the most frequently detected predator and sign was recorded on 23% of plots. (**Table 4**). Feral cats were the next most commonly detected species (14%) and dingoes/dogs the least commonly detected species (6%). Each of the predator species was broadly distributed in the study area (**Fig. 7)**. Feral cat sign was observed frequently in association with the larger creek lines with free standing water

Introduced herbivores

Fresh (1-2 day) rabbit tracks were detected on 76% of plots and sign was detected throughout the study area. Some plots had relatively little fresh track sign and no old evidence of diggings or scats indicating a site transience or recent colonization. Plots with abundant rabbit sign were generally least prevalent on the eastern side of the study area. Many rabbit warrens were inactive or had only one or two active holes. (**Fig. 8**) Cattle and/or sheep were present on all of the stations visited but fresh track sign was infrequently detected on plots (2.6% and 5.2%, respectively) (**Table 4**). Pig sign was detected on Mulyungarie Station but not on plots and no camel sign was detected.

Table 3 Percentage of 78 plots with recent imprint sign (< 2 days) of native species

Species	Hopping mouse	Dasyurids & rodents	Rat	Mulgara	Emu	Red kang	Grey kangaroo
	70.5%	65.4	5.1	3.8	28.2	25.6	3.8

Table 4 Proportion of 78 plots with recent imprint sign (< 2 days) of introduced species

Species	Dingo/ Dog	Red fox	Feral cat	European rabbit	Cattle	Sheep	Pig
	0.064	0.231	0.141	0.756	0.026	0.051	0.000

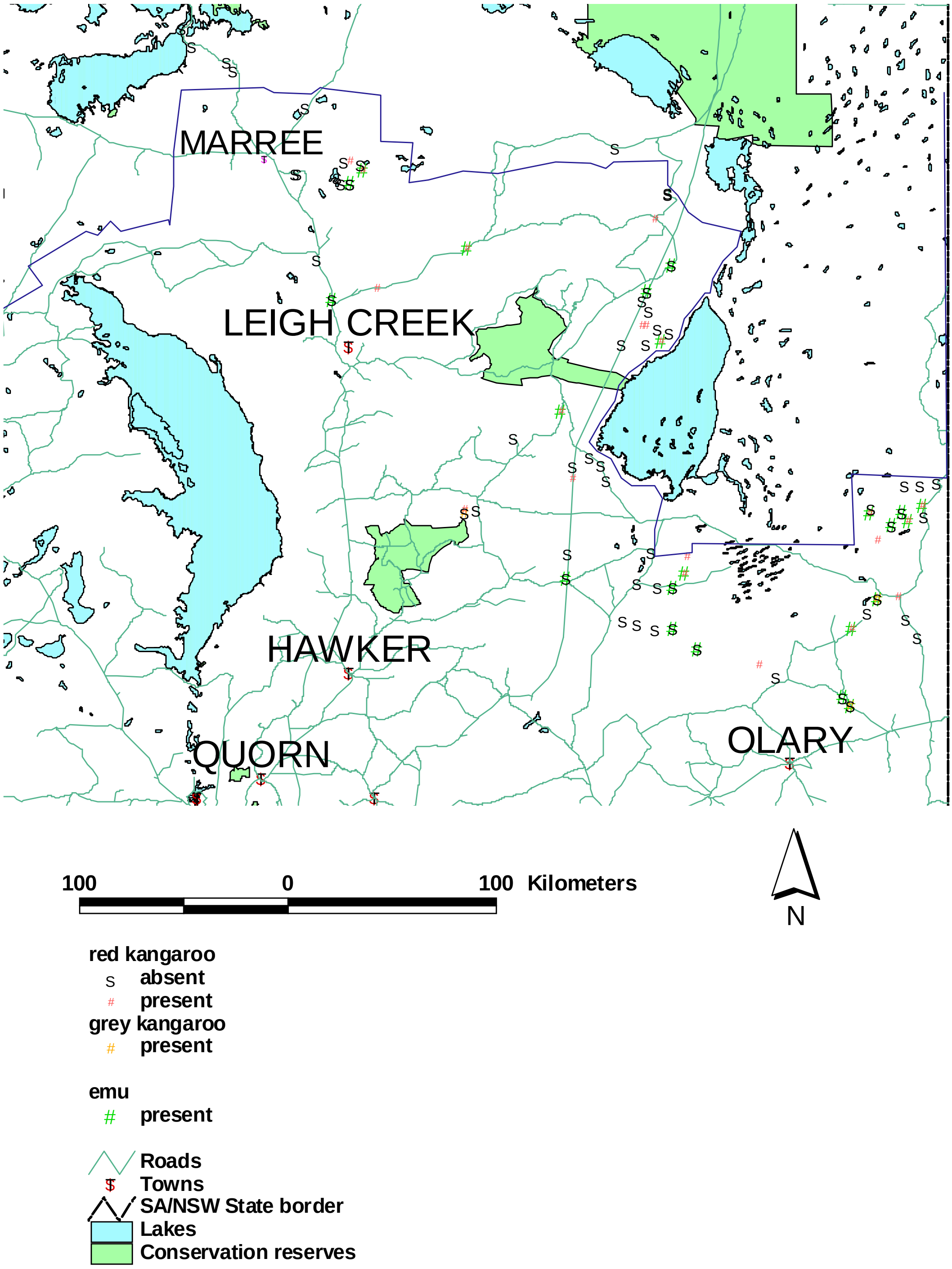


Figure 6. Fresh (1-2 day) emu and red and grey kangaroo track sign at monitoring plots. Blue line shows the location of the Dog Fence.

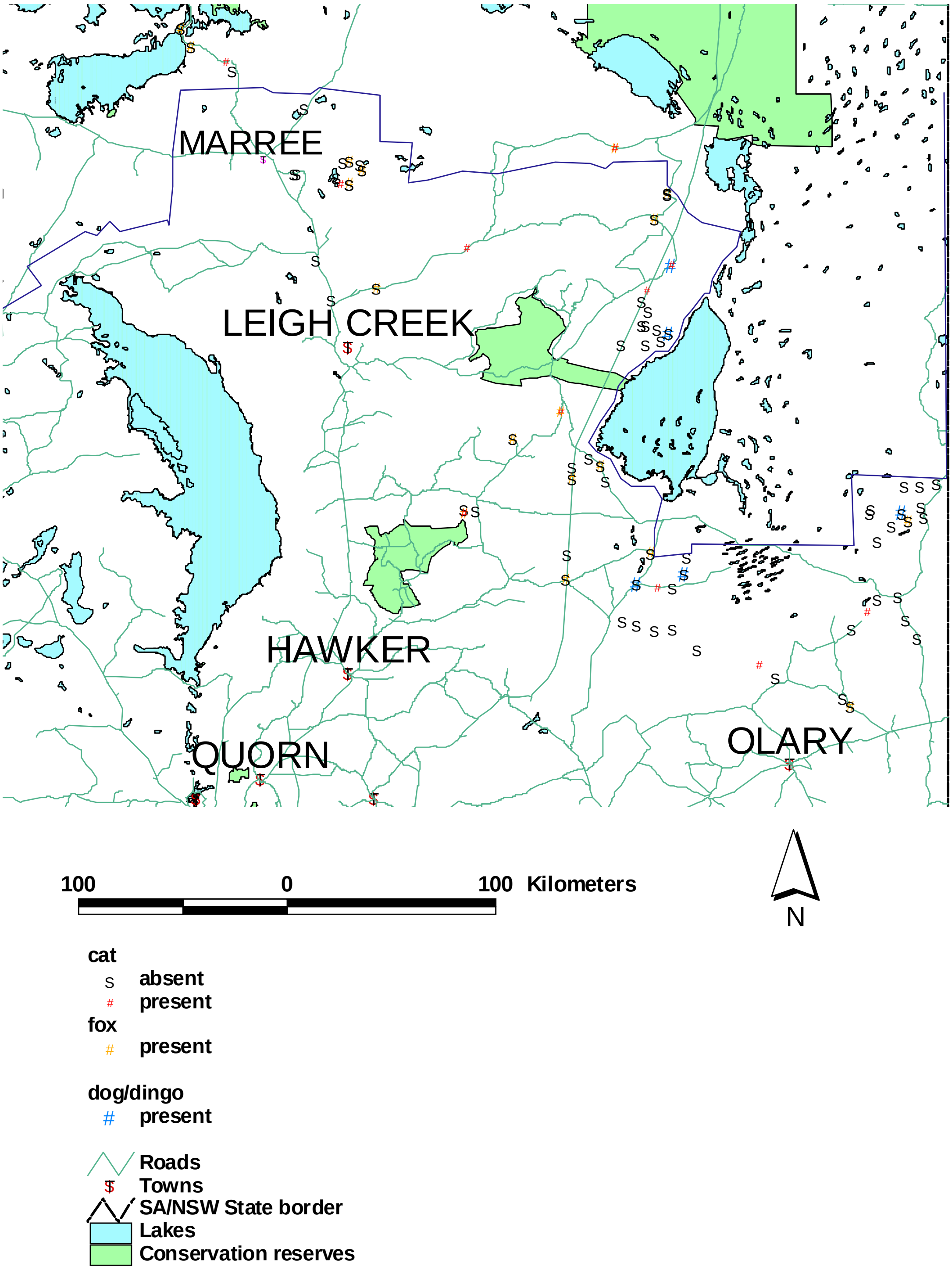


Figure 7. Fresh (1-2 day) feral cat, red fox and dog/dingo track sign at monitoring plots

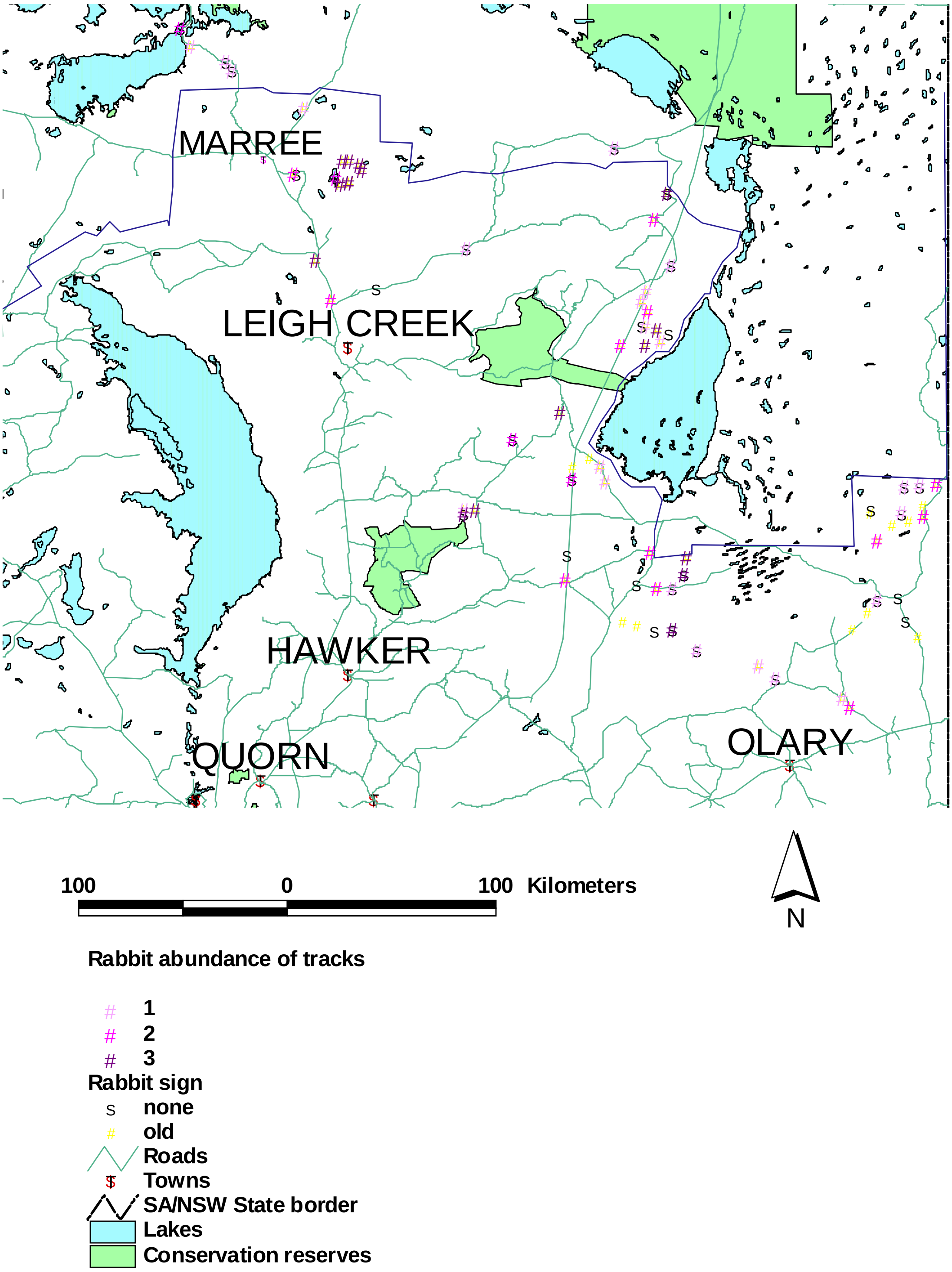


Figure 8. Rabbit: abundance of fresh track sign (1-2 day) and occurrence of old scat or digging and burrow sign at monitoring plots.

Discussion

Distribution and abundance of *N. fuscus*

Trapping, spotlighting and track-based monitoring indicated that hopping mice were very common in parts of the study area particularly closer to Lake Frome and the southern edge of the Strzelecki Desert. *Notomys fuscus* was the only species of hopping mouse recorded during the study, either as captures, live observations or specimens provided by landholders. Similarly *N. fuscus* was also the only species of hopping mouse captured during recent surveys by DENR staff in the Gammon Ranges National Park (de Preu, pers. comm.) and by environmental consultants near the Beverly Uranium Mine (Sue Carter, pers. comm.). Hence, it is reasonable to assume that all hopping mouse track sign encountered by us and similarly, all the hopping mice observed by spotlight can be attributed to *N. fuscus.* Our survey extended the known current distribution of the *N. fuscus* southward almost to the Barrier Hwy and westward to the Flinders Ranges. This represents a substantial expansion in range for the species from its known distribution in the late 1990s. At this time the species could be consistently captured at a few colonies and all of these were north of the Dog Fence. We found the species at some locations over 70 km south and west of the Dog Fence.

The density of *N. fuscus* at the Wooltana and Mulyungarie grids was high at 10 and 7 individuals per ha respectively, but much lower further west on the Mundownda grid, and the species was not recorded on Farina Station. Recent surveys on adjacent Witchelina Station have also failed to record the species (G. Medlin, pers. comm.). It is possible that the large areas of unsuitable rocky habitat between isolated patches of sandy habitat have limited the range and abundance of the species in this region. In contrast, grids at Wooltana and Mulyungarie were present in extensive areas of sand dunes located close to the Strzelecki Desert dunefields facilitating easier colonization.

The density of *N. fuscus* at the Wooltana grid is the highest ever recorded on a trapping grid for this species. In comparison, the highest density recorded at DENR northern trapping grids at Montecollina and SW Queensland between 1993 and 2000 was 8 and 2 individuals per ha, respectively. However, caution is required when comparing the density of *Notomys* and other species with among trap grids and with previous studies. House mice probably impacted significantly on the rate of capture of *Notomys* and other native species reported in our study. *Mus* showed a willingness to enter Elliott traps, were aggressive toward native rodents and small dasyuid species and were extremely abundant. They dominated Elliott trap captures (57%) particularly at Mulyungarie (73%) and this would have displaced native species from being trapped. The greatest number of *Notomys* was captured in Elliotts and pitfall traps at Wooltana Station where *Mus* were least abundant. Elsewhere it has also been shown that high trap success using Elliott traps can be achieved for *N. alexis* (eg. 24%) and *P. hermannsburgensis* (eg. 29%) when *Mus* numbers are low (4%) (Southgate and Masters 1996).

Habitats associated with the occurrence of *N. fuscus*

Seasonal conditions at the time of our survey were described by many landholders as similar to the exceptional rainfall years of 1956 and 1974. Vegetative cover was high throughout the study area including the three trap sites and many perennial and short-lived plant species showed recent sign of fruiting and seeding. Prolific seeders such as Button Grass *Dacyloctenium radulans* were common in all habitats supporting a range of species including little button quail *Turnix* velox and large flocks of budgies *Melopsittacus undulatus*. Pregnant and/or subadult *N. fuscus* were recorded at all three trapping grids suggesting that the population was still breeding and food resources had not yet become limiting. The presence of breeding individuals and popholes and burrows also indicates that suitable habitat was present at all three trap grids.

The study demonstrated that *N. fuscus* was capable of occupying a range of habitats much broader than previously characterized by Watts and Aslin (1981) and Owens *et al*. (2006). The species was previously reported as restricted to sand dunes and ridges. We found them occupying a wide range of habitat types (rocky ranges, gibber plains, sand dunes, sand plains) but nearly always in association with patches of sand. Where individuals were observed in hard gibber or rocky habitat, sandy drainage lines, creeklines or rises were present. Sandy habitat is needed for *N. fuscus* to build the burrow systems it requires to live communally and breed. Isolated sand dunes or rises were also inhabited despite being separated by several kilometers of hard substrate. It is apparent that *N. fuscus,* like other arid zone mammal species*,* are capable of dispersing over large distances and colonizing small patches of suitable habitat.

The long-term resilience of populations occupying these atypical and remote sandy habitat patches will become clearer once drier conditions return and food availability declines. It is possible that *N. fuscus* distribution will again contract northwards to areas with more continuous sandy habitat.

Introduced and native species associated with *N. fuscus*

Saunders and Giles (1975) argued that a rodent irruption requires not only a flush of food stimulated by rain but also a dry period prior to rain. Under these conditions the abundance of parasites, pathogens, competitors, predators are reduced and this allows the rodent population to quickly boom in response to flourishing food resources. The numbers of predators and large competitors often lag behind because of their slower rates of reproduction. The conditions in the region during the study exhibited a number of these characteristics. A drought of almost a decade preceded the exceptional rainfall. Stock numbers were low and the high price/low availability of sheep and cattle was largely preventing the broadscale restocking in the region. Fresh sign of cattle and sheep tracks was recorded from less than 8% of plots compared to 34% of plots during a study on the eastern and western side of Lake Eyre North in 2006 (Southgate 2006). Rabbits were found to be ubiquitous but in relatively low abundance with more rabbits evident in the western part of the study area and less in the east. Landholders reported that a recurrence of calicivirus had recently struck the eastern part but had not yet reached the western part of the survey area. Fresh rabbit sign was recorded from 76% of plots compared to 92% of plots around Lake Eyre in 2006 (Southgate 2006). Less than 1 rabbit per km of spotlight transect was recorded, considerably lower than pre-calicivirus levels. The common occurrence of regenerating perennial species such as mulga *Acacia aneura* also indicated that a reduction in grazing pressure had occurred in the study area.

Dingo/dog numbers were comparatively low in the study area because of ongoing control efforts and the influence of the Dog Fence. Fresh tracks were recorded at 6% of plots compared to 75% of the plots sampled around Lake Eyre North (and above the Dog Fence) in 2006 (Southgate 2006). Red fox occurrence was similarly low because of control efforts through baiting and shooting and prior drought conditions. During the study fresh fox sign occurred on 23% of plots compared to 75% of plots in the study further north conducted in 2006. Feral cat sign was recorded relatively infrequently (14%) during the study and this was a similar rate of occurrence compared to the 2006 study.

While irruption of *N. fuscus* in the study area fits well with the 'drought-plague' model it does not adequately explain why a similar irruption did not occur following exception rainfall in 1974 (P. Absolm and J. McIntee, pers comm.). Nor does it explain why a number of other rodent and small dasyurid species had begun to expand their range prior to 2010. A southward expansion in the range of the spinifex hopping mouse *N. alexis,* the plains rat *P. australis* and the kultarr *Antechinomys langier* has been documented to the west of the study area (K. Moseby, unpublished; R. Pedler, unpublished). Similarly, the expansion of *N. fuscus* and the crest-tailed mulgara *Dasycercus cristicauda* was documented around Lake Eyre North in 2006 (Southgate 2006). The most likely 'game-changer' has been the release of the rabbit calcivirus in 1995. The subsequent decline in rabbit populations has most probably lowered predator abundance and reduced grazing pressure sufficiently to allow vegetation and associated invertebrate communities to recover. The expansion of several native species is beginning to reflect subtle but broad-scale changes in the landscape brought about by the calicivirus. This conclusion provides support for the hypothesis proposed by Morton (1990) suggesting that invading herbivores can cause habitat degradation and disrupt food resources thus negatively affecting native mammals in arid Australia.

Biodiversity Strategy Actions

Four, five year actions were outlined in the SAAL Board biodiversity strategies for the dusky hopping mouse. This present study has contributed to these actions in the following ways;

- ACTION: Determine area of occupancy and relationship between habitat and distribution and abundance of the dusky hopping-mouse in the Strzelecki Desert.

The area of occupancy during good seasons has now been quantified with regards to the southern limit of the species. This serves as a baseline for future surveys after significant rainfall events allowing changes in distribution to be determined over the long term. This comparison is needed to determine if the species listing of Vulnerable is appropriate or whether the population is stable or increasing.

The range of habitats utilized by the species during these good seasons has also been documented. To determine the relationship between habitats, distribution and abundance, these sites need to be revisited when conditions become dry. In this way, the location of any refugia areas south of the dog fence can be identified and the relationship with habitat features such as sandy patch size, proximity to continuous sand dunes, presence of feral species etc can be determined.

- ACTION: Identify and, where possible, quantify the disruption, and sources of disruption, of key ecological processes supporting individual populations of the Dusky Hopping-mouse in the Strzelecki Desert.

No relationship was found between hopping mice occupancy and presence or absence of rabbits, cats or foxes. However, rabbit, cat and fox abundance was considered to be low during the survey. This action requires revisiting sites during dry conditions as outlined previously. Occupancy can then be compared with ecological parameters during times of nutritional stress and when populations are low and vulnerable to extinction. Sites should also be revisited when rabbit numbers are high to determine their impact on hopping mice or rabbit proof exclosures could be used to compare population parameters with and without rabbits or stock.

- ACTION: Identify potential habitats within the Strzelecki Desert for the Dusky Hopping-mouse.

Dusky hopping mice were found in a range of sandy habitats and were able to live and breed in very small patches of isolated sandy substrate. These included sandy creeklines, sand sheets on gibber plains and isolated dunes adjacent to rocky ranges. However, the highest density of hopping mice was found in areas of continuous sand dune habitat close to the dog fence. These larger continuous areas are the most likely to support populations of dusky hopping mice during dry times and should be revisited at this time to identify key refugia. The influence of the dog fence is not known and requires comparing distribution and abundance of dusky hopping mice in continuous areas of sand dune both north and immediately south of the dog fence during dry conditions.

- ACTION: Rank populations of the Dusky Hopping-mouse within IBRA subregions for viability, based on size, threats and landscape context.

Populations were not ranked but the highest density of dusky hopping mice south of the dog fence were recorded on Wooltana and Mulyungerie Station, suggesting they may support important populations of the species.

Recommendations

1) Resample monitoring sites during dry conditions to determine the following:
- whether the recent range extension of *N. fuscus* is sustained
- the location of any key refugia sites south of the dog fence
- the strength of association between habitat characteristics (eg. type, size of sandy patch, distance from continuous sandy habitat) and resilience of *N. fuscus* populations.
- the strength of association between predator abundance and abundance of *N. fuscus* during periods of nutritional stress.

2) Compare hopping mouse abundance and competitor/predator levels in continuous sand dunes north and immediately south of the dog fence. This will improve our understanding of why *N. fuscus* is rarely recorded south of the dog fence during dry conditions. This action could include comparing track plots and trap grids on either side of the fence.

3) Determine the influence of rabbit and stock levels on *N.fuscus* occupancy and abundance through the erection of rabbit/stock proof exclosures and resampling track plots when rabbit abundance is high.

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Appendix 1. Location and habitat features of each trapping grid.

Grid Location	Northing	Easting	Habitat
Mulyungarie Station	54J 469211	6551138	Callitrus glaucophylla pale orange dune adjacent to Eucalyptus coolabah creekline. Abundant grasses and understorey of *Sida*, *Abutilon*, *Salsola kali* and *Enneapogon*
Wooltana Station	54J 375736	6638345	Linear orange dune vegetated with sandhill canegrass *Zygochloa paradoxa, Sida*, Rhagodia and *Crotolaria eremea*. Dunes separated by 500m-1km of grassy clay swale.
Mundowdna Station	54J 245572	6706734	Pale dune located within 1 km of permanent spring and salt pans. Vegetated with *Z. paradoxa* and *Crotolaria* as well as overstorey of *Acacia ligulata*.

Appendix 2. Details of native species captured. R=regressed, D=distended,B=button, I=imperforate, P=perforate

Location	*Date*	*Species*	*Sex*	*Wt*	*Testes*	*Teats*	*Vag.*	*Elliott or Pitfall*	Comments
Mulyungarie	8/4/11	N. fuscus	M	34	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	M	30	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	M	27	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	M	35	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	M	33	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	M	31	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	M	30	Scrotal			Pit	Specimen MY-12
Mulyungarie	8/4/11	N. fuscus	M	28	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	M	27	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	F	36		R	I	Pit	
Mulyungarie	8/4/11	N. fuscus	M	36	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	M	36	Scrotal			Pit	
Mulyungarie	8/4/11	N. fuscus	F	52		D	P	Pit	Pregnant
Mulyungarie	8/4/11	N. fuscus	F	66		D	P	Elliott	Pregnant
Mulyungarie	8/4/11	N. fuscus	F	44		D	P	Elliott	Pregnant
Mulyungarie	8/4/11	N. fuscus	M	35	Scrotal			Elliott	
Mulyungarie	8/4/11	N. fuscus	F	47		D	P	Elliott	Pregnant
Mulyungarie	9/4/11	N. fuscus	M	23	Scrotal			Pit	
Mulyungarie	9/4/11	N. fuscus	M	34	Scrotal			Pit	
Mulyungarie	9/4/11	N. fuscus	F	32		R	P	Pit	
Mulyungarie	9/4/11	N. fuscus	M	33				Pit	
Mulyungarie	9/4/11	N. fuscus	M	32				Pit	
Mulyungarie	9/4/11	N. fuscus	F	37		R	I	Pit	Post-lactating
Mulyungarie	9/4/11	N. fuscus	F	31		R	P	Pit	
Mulyungarie	9/4/11	N. fuscus	M	27	Abdominal			Pit	
Mulyungarie	9/4/11	N. fuscus	M	-	Abdominal			Pit	
Mulyungarie	9/4/11	N. fuscus	F	19		B	I	Elliott	
Mulyungarie	9/4/11	N. fuscus	F	-		D	P	Elliott	
Mulyungarie	9/4/11	P. hermansburgensis	F	12		R	I	Pit	Specimen MY-12
Mulyungarie	9/4/11	P. hermansburgensis	F	11		D	P	Pit	
Mulyungarie	9/4/11	P. hermansburgensis	-	-		-	-	Elliott	
Mulyungerie	9/4/11	L. forresti	-	-					Specimen MY-12
Wooltana	13/4/11	N. fuscus	M	24	Scrotal			Pit	Narrow pit
Wooltana	13/4/11	N. fuscus	M	24	Scrotal			Pit	Wide pit
Wooltana	13/4/11	N. fuscus	F	28		B	I	Pit	Wide pit
Wooltana	13/4/11	N. fuscus	F	31		B	I	Pit	Wide pit
Wooltana	13/4/11	N. fuscus	M	29	Scrotal			Pit	Small pit
Wooltana	13/4/11	N. fuscus	F	28		B	I	Pit	Wide pit
Wooltana	13/4/11	N. fuscus	M	32	Scrotal			Pit	Wide Pit
Wooltana	13/4/11	N. fuscus	M	34	Scrotal			Pit	Wide Pit
Wooltana	13/4/11	N. fuscus	M	34	Scrotal			Pit	Wide Pit
Wooltana	13/4/11	N. fuscus	F	29		B	I	Pit	Wide pit
Wooltana	13/4/11	N. fuscus	M	28	Scrotal			Elliott	
Wooltana	13/4/11	N. fuscus	F	31		B	I	Elliott	
Wooltana	13/4/11	N. fuscus	M	31	Scrotal			Elliott	
Wooltana	13/4/11	N. fuscus	M	20	Scrotal			Pit	Wide pit
Wooltana	13/4/11	N. fuscus	F	15		B	I	Pit	Subadult Wide pit
Wooltana	13/4/11	N. fuscus	M	31	Scrotal			Pit	Wide pit
Wooltana	13/4/11	N. fuscus	M	31	Scrotal			Elliott	

Wooltana	13/4/11	N. fuscus	M	33	Scrotal			Pit	Narrow pit
Wooltana	13/4/11	N. fuscus	F	30		R	P	Pit	Narrow pit
Wooltana	13/4/11	N. fuscus	M	18	Abdominal			Pit	Subadult Narrow pit
Wooltana	13/4/11	N. fuscus	F	21		B	I	Pit	Narrow pit
Wooltana	13/4/11	N. fuscus	F	15		B	I	Pit	Subadult Narrow pit
Wooltana	13/4/11	N. fuscus	F	23		B	I	Pit	Wide pit
Wooltana	13/4/11	N. fuscus	M	20	Abdominal			Pit	Wide pit
Wooltana	13/4/11	N. fuscus	F	16		B	I	Pit	Subadult Narrow pit
Wooltana	13/4/11	N. fuscus	M	35	Scrotal			Elliott	
Wooltana	13/4/11	N. fuscus	-	23				Elliott	
Wooltana	13/4/11	P. hermansburgensis	M	12	Scrotal			Elliott	Specimen WO-06
Wooltana	14/4/11	N. fuscus	M	28	Scrotal			Pit	Wide pit
Wooltana	14/4/11	N. fuscus	M	29	Scrotal				Narrow pit
Wooltana	14/4/11	N. fuscus	F	27		B	I	Pit	Narrow pit
Wooltana	14/4/11	N. fuscus	M	33	Scrotal			Elliott	
Wooltana	14/4/11	N. fuscus	F	20		B	I	Elliott	Subadult
Wooltana	14/4/11	N. fuscus	F	45		D	P	Pit	Pregnant narrow pit
Wooltana	14/4/11	N. fuscus	F	30		B	P	Elliott	
Wooltana	14/4/11	N. fuscus	F	32		B	I	Elliott	
Wooltana	14/4/11	N. fuscus	F	40		D	P	Elliott	Pregnant
Wooltana	14/4/11	N. fuscus	F	52		D	P	Elliott	Pregnant
Wooltana	14/4/11	N. fuscus	M	24	Scrotal			Elliott	
Wooltana	14/4/11	N. fuscus	F	46		D	P	Elliott	Pregnant
Wooltana	14/4/11	N. fuscus	M	31	Scrotal			Elliott	Specimen WO-06
Wooltana	14/4/11	N. fuscus	F	36		R	P	Pit	Specimen WO-06
Mundownda	16/4/11	N. fuscus	F	42		D	P	Elliott	Pregnant
Mundownda	16/4/11	N. fuscus	M	30	Scrotal			Elliott	Specimen MU-03
Mundownda	16/4/11	P. hermansburgensis	F	11		B	I	Pit	Narrow pit
Mundownda	16/4/11	P. hermansburgensis	M	13	Scrotal			Elliott	
Mundownda	16/4/11	P. hermansburgensis	F	12		B	I	Elliott	
Mundownda	17/4/11	P. hermansburgensis	M	14	Scrotal			Pit	
Mundownda	17/4/11	P. hermansburgensis	F	15		R	I	Elliott	
Mundownda	17/4/11	S. macroura	F	17				Pit	Developed pouch

Appendix 3. The location details of plots sampled and opportunistic records during the survey

Name	Date	Zone			Easting	Northing	Lat_dd	Long_dd	Location	Type	dhm
MY01	6-Apr-11	54	J	481914	6549557	-31.18791	140.81018	Mulyungarie	plot	1	
MY02	6-Apr-11	54	J	489976	6552607	-31.16049	140.89483	Mulyungarie	plot	1	
MY03	6-Apr-11	54	J	484512	6545704	-31.22272	140.83738	Mulyungarie	plot	1	
MY04	6-Apr-11	54	J	477527	6543344	-31.2439	140.76399	Mulyungarie	plot	1	
MY05	6-Apr-11	54	J	468817	6549367	-31.18935	140.67272	Mulyungarie	plot	1	
MY06	6-Apr-11	54	J	471790	6535907	-31.31087	140.70354	Mulyungarie	plot	1	
MY07	7-Apr-11	54	J	480071	6509242	-31.20497	140.90182	Mulyungarie	plot	1	
MY08	7-Apr-11	54	J	490648	6547678	-31.55163	140.79002	Mulyungarie	plot	1	
MY09	7-Apr-11	54	J	495813	6563208	-31.06487	140.95611	Mulyungarie	plot	1	
MY10	7-Apr-11	54	J	489213	6562494	-31.07127	140.88693	Mulyungarie	plot	1	
MY11	7-Apr-11	54	J	483008	6561923	-31.07635	140.82187	Mulyungarie	plot	1	
MY13	8-Apr-11	54	J	483338	6498385	-31.64964	140.82426	Mulyungarie	plot	1	
MY14	8-Apr-11	54	J	488215	6489777	-31.72736	140.87559	Mulyungarie	plot	1	
MY15	8-Apr-11	54	H	460812	6456963	-32.02279	140.58502	Boolcoomata	plot	0	
MY16	8-Apr-11	54	J	458019	6460895	-31.98722	140.55561	Boolcoomata	plot	1	
KL01	9-Apr-11	54	J	430612	6470103	-31.9028	140.26617	Kalabity	plot	0	
MY12	9-Apr-11	54	J	469209	6551147	-31.17335	140.67682	Mulyungarie	plot+trap grid	1	
MY17	9-Apr-11	54	J	471977	6507864	-31.56389	140.70471	Mulyungarie	plot	0	
MY18	9-Apr-11	54	J	467557	6501523	-31.62099	140.65793	Mulyungarie	plot	1	
YM01	9-Apr-11	54	J	461528	6493836	-31.69015	140.59406	Yarramba	plot	1	
CM01	10-Apr-11	54	J	373685	6494968	-31.67362	139.66745	Curnamona	plot	0	
CM02	10-Apr-11	54	J	367718	6496861	-31.65588	139.60478	Curnamona	plot	0	
KL02	10-Apr-11	54	J	423834	6476244	-31.84697	140.19498	Kalabity	plot	0	
KL03	10-Apr-11	54	J	398537	6483308	-31.78128	139.92837	Kalabity	plot	1	
KL04	10-Apr-11	54	J	388306	6493241	-31.69072	139.82147	Kalabity	plot	1	
KL05	10-Apr-11	54	J	380719	6492892	-31.69311	139.74139	Kalabity	plot	1	
CM03	11-Apr-11	54	J	373443	6514530	-31.49715	139.66741	Curnamona	plot	1	
CM04	11-Apr-11	54	J	381874	6512992	-31.51192	139.75599	Curnamona	plot	1	
CM05	11-Apr-11	54	J	387871	6513106	-31.51149	139.81915	Curnamona	plot	1	
CM06	11-Apr-11	54	J	392666	6519532	-31.45398	139.87033	Curnamona	plot	1	
CM07	11-Apr-11	54	J	393764	6527816	-31.37935	139.88277	Curnamona	plot	1	
ER01	11-Apr-11	54	J	379039	6529752	-31.36045	139.72818	Erudina	plot	1	
GL01	11-Apr-11	54	J	344213	6516766	-31.47341	139.36008	Gas pipeline	plot	1	
GL02	11-Apr-11	54	J	344660	6528233	-31.37005	139.36658	Gas pipeline	plot	0	

WI01	11-Apr-11	54	J	306919	6549017	-31.17697	138.97394	Wirrealpa	plot	1
GL03	12-Apr-11	54	J	346069	6564529	-31.04287	139.38696	Gas pipeline	plot	1
GL04	12-Apr-11	54	J	346303	6570447	-30.98953	139.39031	Gas pipeline	plot	0
MV01	12-Apr-11	54	J	321460	6583443	-30.86882	139.13252	Mulga View	plot	1
WI02	12-Apr-11	54	J	301897	6549098	-31.1754	138.92128	Wirrealpa	plot	1
WI03	12-Apr-11	54	J	301704	6547548	-31.18935	138.91896	Wirrealpa	plot	1
WR01	12-Apr-11	54	J	357804	6571154	-30.9846	139.51082	Wertaloona	plot	0
WR02	12-Apr-11	54	J	360183	6563612	-31.05291	139.53469	Wertaloona	plot	0
WR03	12-Apr-11	54	J	353017	6574888	-30.95033	139.46125	Wertaloona	plot	1
WR04	12-Apr-11	54	J	340745	6596706	-30.75194	139.33622	Wertaloona	plot	1
MO02	14-Apr-11	54	J	380468	6636508	-30.39752	139.75571	Moolawatna	plot	1
MO03	14-Apr-11	54	J	382151	6631107	-30.44641	139.77262	Wooltana	plot	1
MO04	14-Apr-11	54	J	375687	6629129	-30.46361	139.70508	Wooltana	plot	1
MO05	14-Apr-11	54	J	365715	6629052	-30.46323	139.60122	Wooltana	plot	1
WO01	14-Apr-11	54	J	375728	6638325	-30.38065	139.7066	Wooltana	plot	1
WO06	14-Apr-11	54	J	373639	6638419	-30.37958	139.68487	Wooltana	plot+trap grid	1
WO07	14-Apr-11	54	J	378680	6689669	-29.91771	139.7432	Moolawatna	plot	0
WO10	14-Apr-11	54	J	385304	6634957	-30.41198	139.80587	Wooltana	plot	1
WO11	14-Apr-11	54	J	376668	6645047	-30.3201	139.71717	Wooltana	plot	1
WO12	14-Apr-11	54	J	375707	6654662	-30.23325	139.70831	Wooltana	plot	1
WO13	14-Apr-11	54	J	373794	6649776	-30.27714	139.68785	Wooltana	plot	1
MN01	14-Apr-11	54	J	383908	6701530	-29.8112	139.79863	Murnplorie	plot	1
WO14	15-Apr-11	54	J	385831	6667490	-30.11851	139.81489	Wooltana	plot	0
WU02	15-Apr-11	54	J	361733	6723274	-29.61273	139.57199		plot	0
ML01	15-Apr-11	54	J	300590	6673981	-30.04902	138.93167	Mt Lyndhurst	plot	0
ML02	16-Apr-11	54	J	263859	6654226	-30.22058	138.54654	Mt Lyndhurst	plot	0
MA01	17-Apr-11	53	J	783983	6757329	-29.28107	137.92292	Muloorina	plot	1
MA02	17-Apr-11	53	J	781509	6761684	-29.24237	137.89637	Muloorina	plot	1
MA03	17-Apr-11	53	J	762643	6777994	-29.09939	137.6986	Muloorina	plot	1
MA04	17-Apr-11	53	J	767131	6769514	-29.17489	137.7467	Muloorina	plot	1
MA05	17-Apr-11	54	J	231621	6739996	-29.44074	138.2333	Muloorina	plot	0
MU01	16-Apr-11	54	J	231994	6690262	-29.81074	139.79859	Mundowdna	plot	0
MU02	16-Apr-11	54	J	229063	6708477	-29.72431	138.19912	Mundowdna	plot	1
MU03	18-Apr-11	54	J	245572	6706734	-29.7435	138.36931	Mundowdna	plot+trap grid	1
MU04	17-Apr-11	54	J	247431	6703550	-29.77217	138.38902	Mundowdna	plot	1
MU05	17-Apr-11	54	J	251502	6704188	-29.76768	138.4299	Mundowdna	plot	0
MU06	17-Apr-11	54	J	252272	6703089	-29.76768	138.42938	Mundowdna	plot	0
MU07	17-Apr-11	54	J	256423	6710990	-29.70734	138.48229	Mundowdna	plot	1
MU08	17-Apr-11	54	J	255577	6713498	-29.68456	138.47412	Mundowdna	plot	0
MU09	17-Apr-11	54	J	251262	6715241	-29.66799	138.42996	Mundowdna	plot	0
MU10	17-Apr-11	54	J	248166	6714602	-29.67312	138.39785	Mundowdna	plot	1
MU20	17-Apr-11	54	J	228194	6708277	-29.72593	138.19009	Mundowdna	plot	1
FA01	18-Apr-11	54	J	245027	6648496	-30.26843	138.34966	Farina	plot	0
FA02	18-Apr-11	54	J	238099	6667104	-30.09922	138.28233	Farina	plot	0
DHM01	9-Apr-11	54	J	468761	6502448	-31.61267	140.67065		specimen	1
DHM02	10-Apr-11	54	J	354567	6474316	-31.85762	139.46276		specimen	1
S01	8-Apr-11	54	J	489097	6485771	-31.76351	140.88487		spotlight obs	1
S02	8-Apr-11	54	J	484956	6495151	-31.67883	140.84128		spotlight obs	1
S03	9-Apr-11	54	J	429547	6470324	-31.90075	140.25493		spotlight obs	1
S04	9-Apr-11	54	J	427510	6471177	-31.89292	140.23344		spotlight obs	1
S05	9-Apr-11	54	J	427393	6471912	-31.88628	140.23227		spotlight obs	1
S06	9-Apr-11	54	J	427441	6471432	-31.89061	140.23274		spotlight obs	1
S07	9-Apr-11	54	J	427913	6470742	-31.89687	140.23767		spotlight obs	1
S08	9-Apr-11	54	J	430124	6470210	-31.90181	140.26102		spotlight obs	1
S09	10-Apr-11	54	J	354514	6472446	-31.87448	139.46191		spotlight obs	1
S10	10-Apr-11	54	J	358699	6473311	-31.86721	139.50627		spotlight obs	1
S11	10-Apr-11	54	J	355732	6473564	-31.86455	139.47495		spotlight obs	1
T01	12-Apr-11	54	J	304115	6550667	-31.16163	138.94485		tracks	1
T02	12-Apr-11	54	J	302109	6549538	-31.17147	138.92359		tracks	1
T03	12-Apr-11	54	J	301450	6548298	-31.18254	138.91643		tracks	1
T05	13-Apr-11	54	J	351574	6600778	-30.71661	139.44991		tracks	1
O15	15-Apr-11	54	J	385543	6696389	-29.85774	139.815		tracks	1