Kowari *Dasycercus byrnei* Distribution Monitoring in Sturts Stony Desert, South Australia, Spring 2007

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For SA Arid Lands Natural Resources Management Board

Government of South Australia
South Australian Arid Lands Natural Resources Management Board
Department for Environment and Heritage

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Contents

Summary:

This paper reports on a presence/absence population status and distribution survey primarily for the Kowari (*Dasycercus byrnei*) in areas of known or likely habitat in Sturts Stony Desert, north-eastern South Australia. The survey was carried out between 27th August to 11th September 2007 on Mulka, Cowarie, Pandie Pandie, Innamincka and Cordillo Downs pastoral leases. The Kowari's major habitat areas on Clifton Hills Pastoral Lease were not sampled as access was not approved by the property manager.

Monitoring traplines followed typical Kowari survey standards with aluminium box/treadle traps (Elliott Type A) placed 100 metres apart on 10 kilometre long transects sampling ideal habitat over two trap-nights. The only variation from this standard was the pairing of traps at each station, one having bait specifically for Kowaris and other carnivorous species, the other baited for general sampling.

Trapping was carried out at 6 locations over 12 nights with an approximate intensity of 400 trap-nights per sample. Of the 6 localities trapped, 4 were revisits to areas at which one or more Kowaris had been trapped since 1990. The other two areas (Innamincka and Mulka) were areas near to recent sightings or represented potentially suitable habitat within the species historic range.

No Kowaris were trapped in the vicinity of any of the previous known locations. Other species of small mammal known to coexist with Kowaris were captured at all sites. 21 Fawn Hopping-mice were captured at Cordillo Downs (a significant new location record for this endangered South Australian species). Other species on which Kowaris are known to prey were noticeable at most locations, eg Earless Dragons (*Tympanocriptis* sp.), gibber grasshoppers, crickets, and Gibberbirds (*Ashbyia lovensis*), Sandy Inland Mice (*Pseudomys hermannsburgensis*) and Dunnarts (*Sminthopsis* spp.). Kultarrs (*Antechinomys laniger*) were the most widely distributed species in the habitats assessed.

This paper also details a rapid assessment technique developed during the survey to measure and compare critical habitat requirements for Kowaris and other threatened stony desert mammals sharing Kowari habitat. The monitoring system is based on a series of stratified observations designed to be carried out by novice observers, with the aim of providing pastoralists an opportunity to self-assess habitat condition to determine appropriate levels of cattle impact on Kowari habitat.

In addition to the rapid assessment technique, a guide for land managers to self-assess Kowari presence and habitat quality is provided in Appendices 3 and 4.

Recommendations

1. It is critical that an assessment of the Clifton Hills Kowari population be undertaken as a matter of urgency, in order to assess the current status of that population and to provide a baseline that can be used to determine the extent of the apparent decline of Kowaris in the region (now completed: see Pedler and Read 2008).
2. Additional sites on Pandie Pandie Station that were identified during the current survey should be trapped in an attempt to locate extant Kowari populations and to further assess the current distribution of Kowaris in the region (now completed: see Pedler and Read 2008).
3. During any additional survey work, the rapid mound assessment technique described here should be further tested to assess the validity of the results described here in areas where Kowaris are known to be present.
4. Follow up surveys should be undertaken on Cordillo Downs Station to investigate population dynamics and ecological parameters of the Fawn Hopping Mouse population identified during this survey.
5. The rapid assessment method for sand mounds should be finalised and distributed to community groups, along with a photographic guide to mound assessment, for comment and to scope the possibility of its broadscale implementation in the region.
6. A complete follow-up monitoring trip visiting all sites identified in this report and in Pedler and Read (and including the Clifton Hills study grids) is funded to be conducted in Autumn 2009. This will allow for another season's progeny to hopefully further boost populations to trappable levels.
7. Survey for Kowaris in suitable habitat on the western half of Clifton Hills Station with a minimum of two 10km transects.
8. Undertake a general program to increase pastoralists' awareness of stony desert wildlife using the Kowari as an iconic species to assist in achieving sensitive and sustainable use of stony desert rangelands.

Figures

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Tables

Acknowledgments

The authors gratefully acknowledge the financial support provided by the Arid Lands Natural Resources Management Board and in-kind support from the Department for Environment and Heritage. Lease-holder permission to access pastoral lease properties is also gratefully acknowledged. Without this support the long-term survival of one of Australia's most amazing marsupials would be far less assured.

Project Aims:

1. Trap known Kowari habitat for small mammals across the species' former recent distribution in SA.
2. Develop and test rapid assessment techniques to measure sand mound condition to assist in the identification of potential habitat for threatened gibber mammals.
3. Document observations and issues relevant to the conservation and management of stony desert fauna and flora

Methods:

Areas to be surveyed were selected from the Kowari habitat map and satellite imagery in combination with historic locations from Mulka to Cordillo Downs Stations. Final trap line locations were selected following on-ground assessment of pavement gibber supporting an appropriate configuration and the best condition sand mounds in the region. It was intended to trap each major discrete habitat area for a maximum of two nights, with only one night of trapping if a Kowari was captured on the first night.

Trapping:

Properties surveyed included Mulka near the northern boundary (one line two nights), Cowarie near the northern boundary (one line two nights), Pandie Pandie near the south-west (one line two nights) and south-east (one line two nights) boundaries, Innamincka near the north-west boundary (one line two nights) and the north-east corner of Cordillo Downs (one line two nights). Trapping was carried out at 6 locations over 12 nights with an approximated intensity of 400 trap-nights per sample.

Each trapline covered a 10km transect of Kowari habitat with two type 2 Elliott traps positioned at each of the 100 trap stations, which were spaced at 100m intervals. Sand dunes and floodplains were not sampled. The traps at each trap station were baited with different baits – one with peanut paste and rolled oats, the other with dog biscuits mixed with tinned sardines in oil. This was to maximise the chance of capturing the Fawn Hopping-mouse *Notomys cervinus*, a granivorous rodent rated as endangered in SA as well as the carnivorous Kowari and Kultarr. These techniques have proved successful at capturing Kowaris within two nights when at low population levels, and to a lesser extent the Fawn Hopping Mouse.

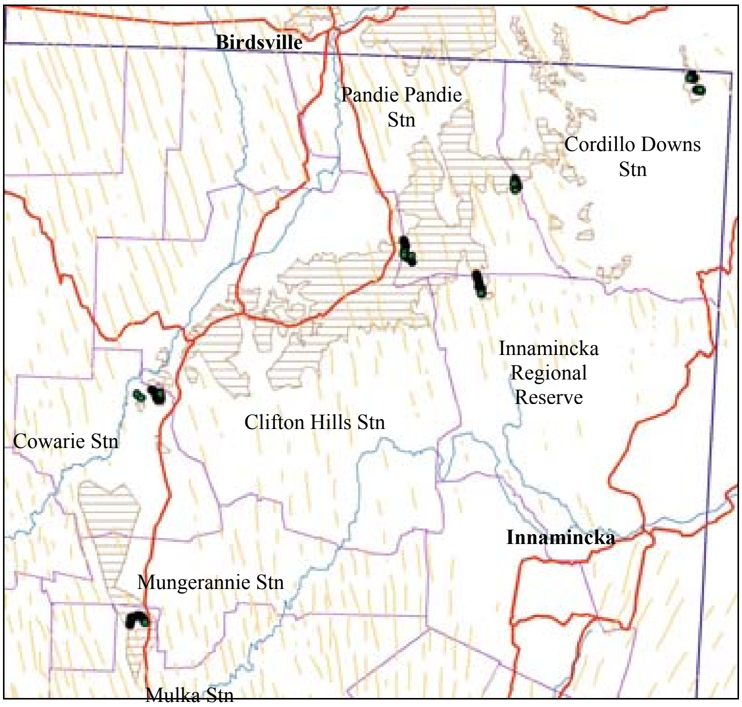

Figure 1

Map of NE South Australia showing trap-line locations (black dots, with green dots indicating where a mammal species was captured - no Kowaris were captured). Purple lines show pastoral lease boundaries; red hatched areas show Kowari habitat (red lines are major roads/tracks, blue lines are major watercourses, yellow lines are dunefields).

Sand Mound Assessment:
Samples of 10 sand mounds in a variety of conditions and distances from permanent water sources were taken in each area that trapping occurred. Initial assessment of general habitat within a 50m radius was scored prior to mound scoring to put them into a Kowari habitat suitability context.

The following parameters were scored into classes, assessed for presence/absence or counted:

- Location (name and MGA reference);
- Date;
- Gibber pavement cover (area of gibber devoid of vegetation);
- Cover of smooth gibber pavement consisting predominantly of gibbers with diameters between 5-50mm;
- Hard drainage depressions (areas of gibber pavement or hardpan that temporarily pond water following run-off events, these are usually obvious from the discoloured gibbers/soil from resulting from algal growth);
- Sand mound cover (mounds of accumulated sand/clay overlying the gibber pavement (mostly formed in hard depressions);
- Sand spread cover (areas of thin sand where gibber cover exposes soil enabling some plant growth, as well as extensive areas of deeper sand over laying gibber, similar to sand mounds and usually greater than 50m^2;
- Presence of trees or shrubs taller than 40cm (none=0, <5% of area =1 and >5%=2).

Where cover was estimated it was categorised into 5 classes (1=<5%, 2=5-25%, 3=25-50%, 4=50-75% and >75%=5) except for the cover of gibber pavement in the size range of 5-50mm diameter. Four classes were used in this case >90%=4, 75-90=3, 50-75%=2 and <50%=1. Appendix 1 contains a table of habitat classification with notes on suitability for Kowaris.

At each of 10 sand mounds (SM) in an area, the following cover estimates were recorded using the 5 percentage classes detailed above:

- % covered by tracks or trampling (species not recorded but included kangaroos and feral/domestic animals);
- % scalded by wind or water;
- % supporting a hard crust (not easily penetrated with a finger and no loose sand/soil visible on top);
- % of the perennial Five-minute Grass *Tripogon loliiformis* and/or the Common Fringe-rush *Fimbristylis dichotoma* present on a mound that is pedestalled (indicating deflation of mound has occurred);
- % cryptogam cover around the margin of a mound (indicating that the mound edge has a stable crust or that deposition is currently occurring);
- % cover with vegetation and litter (provides a measure of grazing intensity when relatively undisturbed mounds in an area are compared with those more obviously impacted by herbivores - because of the influence of rainfall it can not be used across broad areas that have had different recent climatic histories).

The following parameters had their own unique scoring codes or were counts:

- Sand mound profile:
  3 = margins mostly convex
  2 = margins concave or with predominantly more than 30% slope; margins mostly convex and with less than 30% slope
  1 = margins flat and no obvious raised centre of mound

  See diagram and photos below.

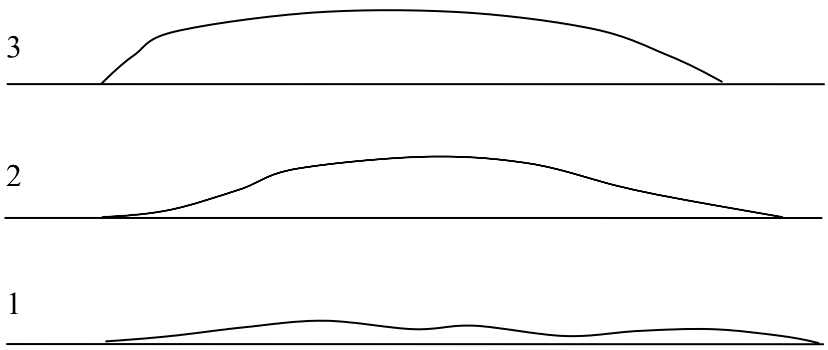

Figure 2
Sand mound profile categories

- Mound Height at tallest point (exclude vegetation):
  1 = <10cm, 2 = 10-25cm, 3 = 25-40cm, 4 = 40-60cm, 5 = > 60cm.
- The number of distinct vegetation species that exceeded 10cm in height (include dead standing material).
- The number of grass and sedge species present on the mound (include identifiably different dead grasses).
- Presence of Barley Mitchell Grass *Astrebla pectinata*: none = 0, present = 1.
- Presence of Kowari sign: none = 0, scats = 1, tracks = 2, tracks + scats = 3 (the latter together are usually found at the entrances to active burrows).
- Burrows present in mound (can be invertebrate, reptile or mammal): none = 1, < the size of a 50c coin = 2, > the size of a 50c coin = 3.
- Photo number: each mound was photographed.

An example datasheet is provided in appendix 2.

Examples of different classes of gibber cover

Photo 1
Example of ideal gibber pavement with a majority gibber size class falling in the 5-50mm diameter and an overall gibber cover of >90%. Ideal pavement often displays a ‘sheen’ in low sunlight due to the evenness of the polished gibbers.

Photo 2
Close-up photo of ideal gibber pavement with a majority gibber size class falling in the 5-50mm diameter and an overall gibber cover of >90% (class 5). Photos: P Canty

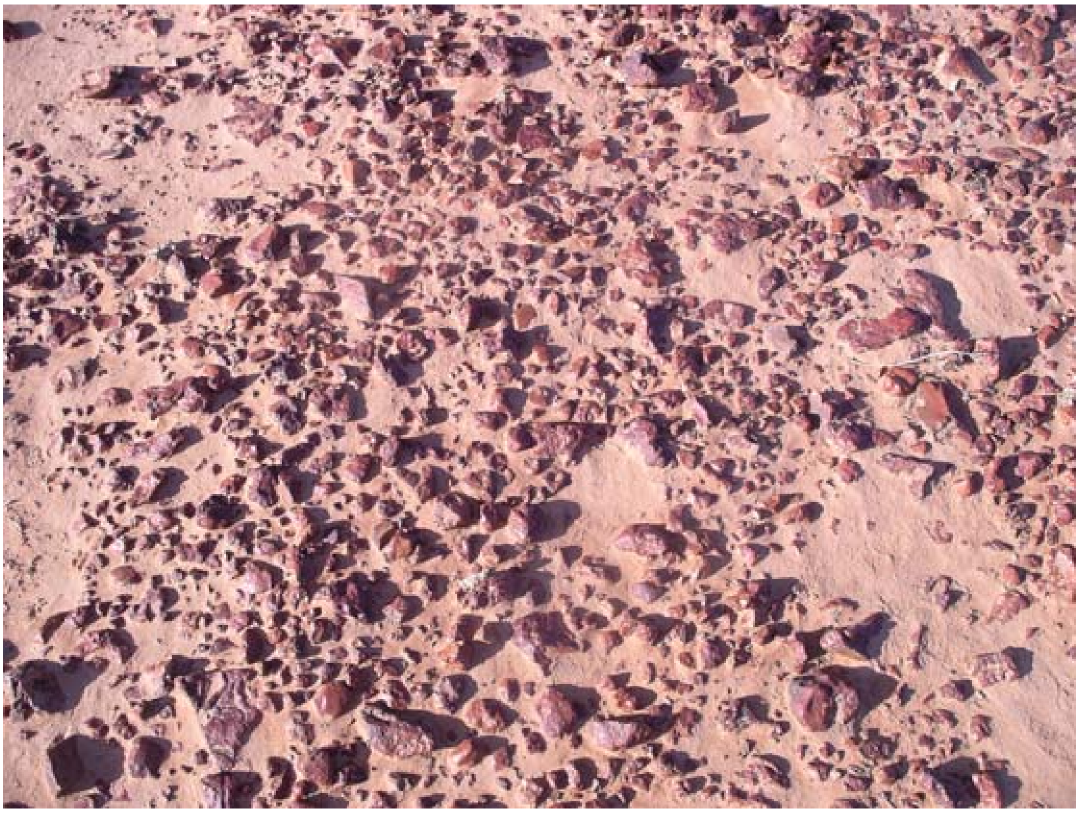

Photo 3
Close-up photo of low gibber cover (class 3: 25-50%) providing unsuitable Kowari habitat if this type covers the majority of the area. Photo: P Canty

Photos 4 & 5
Poor Kowari habitat due to the dominance of large uneven gibbers (>50mm). Kowaris have rarely been captured in areas dominated large gibbers. We presume it is too rough for them to move about on quickly and detecting and escaping stalking predators could be more difficult. Photos: P Canty

Photo 6
An example of 'Sand Spread' habitat where an often thin but consistent layer of soil covers large areas of gibber without forming distinct sand mounds. Sand Spread habitat provides a base for plant growth but insufficient depth for large burrows. This habitat appears to be more important for species such as Kultarrs, dunnarts and rodents.

Photo 7
An example of an area featuring 'Hard Depressions', which are relatively impermeable low points on the gibber pavement where water collects. The presence of a low proportion of hard depressions appears to an important feature of areas supporting Kowaris. Depending on the duration, standing water will encourage algae growth on the gibbers leaving a characteristic black stain seen clearly in this photo. Sand mounds can form in or on the edge of hard depressions, presumably due to wind-blown soil getting trapped by the water and accumulating to the point where plants can grow and act as traps for further wind-blown soil deposition. The pictured mound probably gets too deeply inundated to provide a safe haven for burrows as indicated by the dominance of Brown Beetle Grass (*Diplachne fusca*) – a summer growing grass which germinates and thrives in shallow water (Plants of Western New South Wales, Cunningham *et al*, 1992). Photos: P Canty

Photo 8. Type 3 Sand Mound

Photo 9. Type 2 Sand Mound.

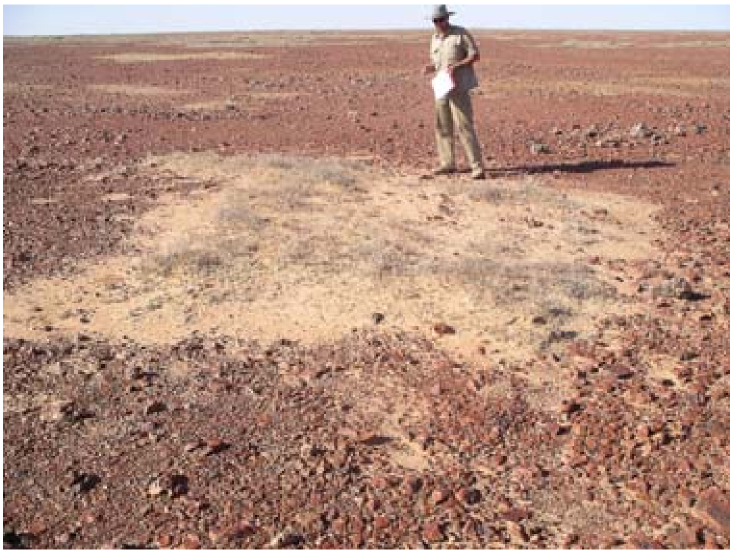

Photo 10. Type 1 Sand Mound. Photos: P Canty

Results:

Trapping
No Kowaris were trapped in the vicinity of any of the previous known locations. Other species of small mammal known to coexist with Kowaris were captured at all sites; refer to the table below for trap effort and other species captures. 21 Fawn Hopping-mice were captured at Cordillo Downs along with one Kultarr *Antechinomys laniger*. Other species on which Kowaris are known to prey were noticeable at most locations, ie Earless Dragons, gibber grasshoppers, crickets, and gibber birds, Sandy Inland Mice and Dunnarts. Kultarrs were the most widely distributed species in the habitats assessed.

Table 1. Survey locations, trapping effort, mammals and reptiles captured/detected

Location	Date	# traps	Kowari *Dasycercus byrnei*	Fawn Hopping-mouse *Notomys cervinus*	Kultarr *Antechinomys laniger*	Sandy Inland Mouse *Pseudomys hermannsburgensis*	Fat-tailed Dunnart *Sminthopsis crassicaudata*	Stripe-faced Dunnart *Sminthopsis macroura*	House Mouse *Mus musculus*	Smooth-snouted Earless Dragon *Tympanocryptis intima*	Central Netted Dragon *Ctenophorus nuchalis*	% trap success
Mulka	29/08/2007	204								2	1	1.47
	30/08/2007	204					1	1		seen	1	1.47
Cowarie	31/08/2007	200								2		1.00
	1/09/2007	200			2	1				seen		1.50
Pandie POT	2/09/2007	100	old burrow							seen		0.00
	3/09/2007	200							1			0.50
Innamincka	4/09/2007	200	old scat							seen		0.00
	5/09/2007	200	burrow		2							1.00
Pandie SE	6/09/2007	160								seen		0.00
	7/09/2007	200			1	2				1		2.00
Cordillo NE	8/09/2007	140		3								2.14
	9/09/2007	240		18	1							7.92
	Total captured		0	21	6	3	1	1	1	5	2	

Sand Mound Assessment:
170 sand mounds in 8 separate localities were assessed using the methods described above (refer to table 2). Six of the localities related to traplines whilst a further 4 were one-off locality assessments. Two on Pandie Pandie (Blue Motor Car Dam and Bank 1 Tank were assessed close to established water points, whilst Cowarie Central and Cowarie North were situated as remote from water points as could be found in those areas. The assessment points at traplines on Pandie Pandie (Pothole) and Innamincka were chosen to be at either end and in the middle of the 10km transect. In the case of Pothole this was along a gradient from a water point. For Innamincka the nearest water points are unknown and local swamps appeared to affect trampling intensity on mounds, though there appeared to be a gradient of impact toward the northern boundary fence with Pandie Pandie. Only two mound assessments were done for Pandie SE, Cordillo NE and Mulka. Distances of each location from nearest water points are detailed in table 4.

All mound assessments were done in areas with close to ideal landscape characteristics (refer to Table 2) and only mounds in the size range 2-25m^2 were assessed. The five cover classes are detailed in the methods. Ideal Kowari habitat ratings are Gibber Cover 5 (>75%), Size 5-50mm pavement cover 4 (>90% of gibber cover), hard depression cover <3 (1-25%), Sand mound cover 1 (1-5%), Sand spread cover 1 (<5%), trees/shrubs 0. These ideals are based on trapping results across various habitat types and configurations in a 32km^2 kowari population study on Clifton Hills Station.

The 10 mounds were chosen in a random progression from the nearest mound to the observer that met the 2-25m^2 criteria for assessment. There may have been some bias that excluded extremely depleted mounds with less than 5cm height as they become difficult to distinguish from sand spreads. Ideal mounds met the following class criteria (refer to Methods section): Profile 3, height > 2 and < 5, trampling/pugging cover < 3, Scald cover < 3, Hard Crust cover < 4, Pedestalling of *Tripogon*/*Fimbristylis* <4, Cryptogam cover on margins >3, Plant/litter cover consistent with the highest class on the best vegetated mound recorded (subject to climatic variation and therefore not consistent over time), number of plant species taller than 10cm > 5, number of grass species > 5, presence of Mitchell Grass *Astrebla* spp. (but not essential), presence of Kowari sign (scats of tracks and particularly in association with active burrows), presence of burrows larger than a 50c coin.

Table 3 averages the class numbers for the 10 mounds in each location. These are included in detail as appendix 1. To assist in comparing the suitability of a location for kowaris, we have calculated the percentage of mounds assessed at each site that met the ideal criteria described above (refer Table 4). The general trend from this analysis is that mounds in "preferred" condition are more likely to be found in areas remote from water points and that only at distances of 6km or more from water points do more than half the mounds meet these basic criteria. This is highlighted graphically in Figure 2. Where no mounds reach the preferred condition criteria (ie. 0%), including at distances greater than 6km there may be other factors preventing suitable mound formation. This could be related to the gibber surface and distance from nearest sandy area from which the sand that builds the mounds is sourced. Historic mound degradation could also be significant, especially where sand source areas are remote. Such areas may be considered as being marginal Kowari habitat – and may only support Kowaris during dispersal events following a run of exceptional seasons.

Table 2. Mound assessment locations and general habitat description in a 50m radius around observer.

Location	Zone	Easting	Northing	Date	Gibber Cover	Size 5-50mm Cover	Hard Drainage Depression Cover	Sand Mound Cover	Sand Spread Cover	Trees/ Shrubs >40cm
Cowarie nth	54	272000	6976600	31-Aug-07	5	4	2	1	1	0
Cowarie centre	54	244628	6933018	01-Sep-07	5	3	2	1	1	0
Cowarie sth	54	249000	6924500	01-Sep-07	5	3	3	2	1	0
Bank 1 tank	54	381900	7034977	02-Sep-07	5	4	2	2	1	0
Blue Motor Car Dam	54	381377	7051998	03-Sep-07	5	4	4	1	1	0
Pothole2	54	371313	7039372	03-Sep-07	5	3	2	1	1	0
Pothole1	54	368879	7041471	03-Sep-07	5	4	2	1	1	0
Pothole3	54	373245	7037062	03-Sep-07	5	4	2	1	1	0
Innamincka1	54	399322	7034362	04-Sep-07	5	4	2	1	1	0
Innamincka2	54	400694	7029627	04-Sep-07	5	4	2	2	1	0
Innamincka3	54	402899	7026381	04-Sep-07	5	4	1	1	1	0
Pandie SE1	54	414122	7072302	06-Sep-07	5	3	3	1	1	0
Pandie SE2	54	413094	7073901	06-Sep-07	5	3	3	2	1	0
Kachumba far	54	484000	7122000	08-Sep-07	5	4	1	1	1	0
Kachumba near	54	484043	7116995	08-Sep-07	4	2	3	1	2	1
Mulka near	54	267640	6883603	10-Sep-07	5	4	2	2	1	1
Mulka far	54	268736	6884158	10-Sep-07	5	4	2	2	1	1

Table 3. Mound assessment locations and the averages from 10 mounds assessed in each location. Please note that averages are of cover classes and should not be viewed as numeric, except for the plant and grass species counts.

Location	Profile	Height	Trampling/Pugging Cover	Scald Cover	Hard Crust Cover	Pedestalled Tripogon/Fimbristylis	Cryptogam Cover	Plant/Litter Cover	Plant sp >10cm	Grass sp	Astrebla spp.	Kowari sign	Burrows
Cowarie nth	2.3	2	3	2.7	0	2.5	1.1	2.9	2.6	2.1	0	0	0
Cowarie centre	2	2.3	1.4	2	0	3.8	1.7	3.3	1.2	1	0	0	0.2
Cowarie sth	2.2	2.5	3.7	2.2	0	3.1	2.1	4	3.6	1.8	0	0	0.5
Pandie Pothole1	2.7	2.9	1	2.1	0	2.4	4.6	3.8	8.1	5.8	0.3	0.1	1
Pandie Pothole2	2.6	2.2	1	2.2	4.3	3	4.6	3.8	6.6	4.5	0.1	0.1	0.6
Pandie Pothole3	2.3	2.5	1.2	3.3	0	4.7	3.3	2.3	3.8	3	0	0	1
Innamincka1	2.6	2.4	1	1.9	4	3.3	4.2	3.6	7.6	5.2	0.3	0	0.6
Innamincka2	2.7	2.6	1.1	1.9	4.2	3	4.3	3.4	8.4	6.1	0.2	0	0.6
Innamincka3	3	4.1	3	1.2	2.8	1.1	4.2	4.1	13.1	7.3	0	0.2	1.6
Pandie Bank 1 tank	2.1	2.2	2.4	1.7	4.8	3	4.9	3.5	4.8	6	0	0	0.7
Pandie Blue Motor Car Dam	2.3	2.1	2.1	1.6	3.6	2.6	3.5	3.4	7.1	6.6	0.9	0	0.4
Pandie SE1	2.8	3.1	1	2.2	3.4	3.2	2.8	3.2	6.9	6.6	0.3	0	1.2
Pandie SE2	3	3	1	1	4.5	2.2	4.8	4	9.7	7.1	1	0	1.4
Cordillo NE Kachumba far	2.5	2.7	2.2	2.6	4.4	4.2	2.1	2.6	3.9	4.4	0	0	0.6
Cordillo NE Kachumba near	1.7	1.8	1.1	2.5	4.6	4.5	1.6	3.3	3.3	4.8	0.1	0	0
Mulka near	2.2	2.9	1.3	1.1	1.4	2.1	1.2	2.4	2.6	1	0	0	0.2
Mulka far	2.5	2.7	1.6	1.4	1.9	3.8	2	2.5	2.7	1.1	0	0	1

Table 4. Percentage of the 10 mounds sampled that met ideal criteria for good sand mound condition in each location. The % in preferred condition column was derived from the combination of profile = 3, height > 2, and cryptogam cover > 3. Most of the other variables are more difficult to interpret reliably or subject to short term variation depending on climate and recent stock presence.

Location	Dist. From Water Point	Profile	Height	Trampling / Pugging Cover	Scald Cover	Hard Crust Cover	Pedestalled Tripogon/ Fimbristylis	Cryptogam Cover	Plant/Litter Cover	Plant sp >10cm	Grass spp.	% in preferred condition
Pandie Bank 1 tank	2km	30	30	70	90	10	50	100	60	60	50	**10**
Pandie Blue Motor Car Dam	2km	30	20	70	100	30	70	70	40	80	70	**20**
Pandie Pothole1	7.5km	70	70	100	80		90	90	20	90	70	**70**
Pandie Pothole2	4km	60	20	100	70	20	60	100	40	70	40	**20**
Pandie Pothole3	<2km	30	40	90	40	20	10	50	40	10	0	**20**
Innamincka1	?	60	30	100	90	30	60	80	60	60	20	**30**
Innamincka2	?	70	60	100	70	20	60	90	10	80	40	**60**
Innamincka3	?	100	100	10	100	80	100	100	20	100	100	**100**
Cowarie centre	3km	10	30	90	70		40	0	30	0	0	**0**
Cowarie north	5km	30	30	40	60		50	0	90	0	0	**0**
Cowarie south	7km	20	40	20	80		50	10	20	10	0	**0**
Pandie SE1	6km	80	90	100	60	40	60	50	10	80	70	**60**
Pandie SE2	6km	100	90	100	100	20	100	100	20	100	100	**90**
Cordillo NE Kachumba far	5.5km	60	70	50	40	10	10	20	60	30	0	**40**
Cordillo NE Kachumba near	1km	30	0	100	40	10	20	0	30	20	20	**0**
Mulka near	<1km	20	80	100	100	100	90	0	10	10	0	**20**
Mulka far	2.2km	50	70	90	100	100	30	0	50	0	0	**30**

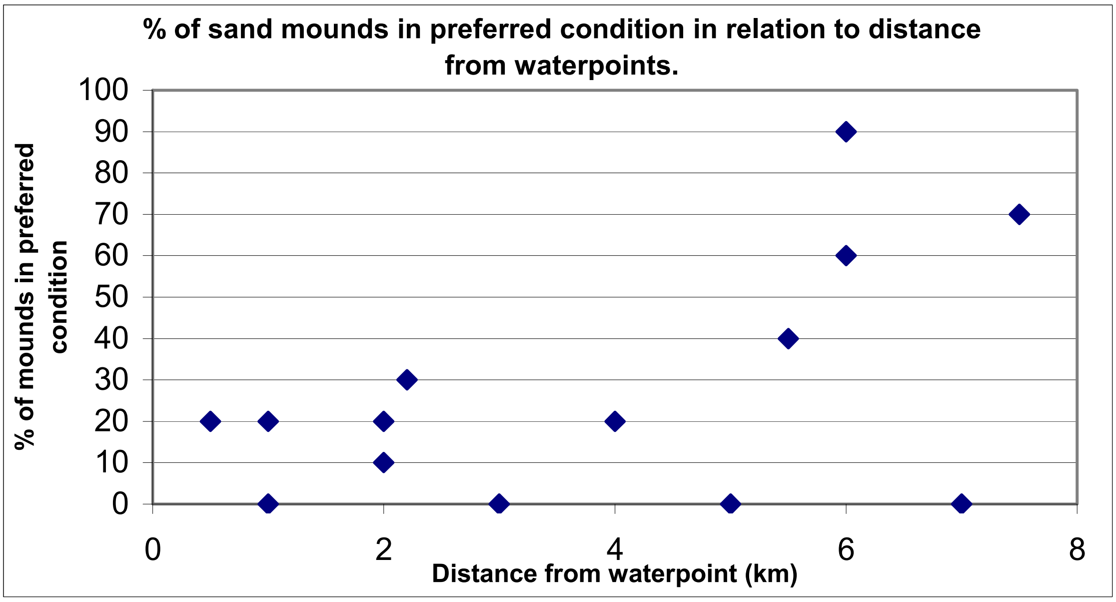

Figure 3. Plot of the % of mounds in preferred condition against distance of each cluster of 10 mounds from the nearest waterpoint (data from Innamincka was not included because distances from nearest water were not established).

Discussion

Current Kowari distribution

Of the 6 localities trapped for two nights, 5 were revisits to areas at which one or more Kowari had been trapped since 1990. No Kowari have been captured in the Mulka area since 1915, despite 6 attempts in various areas since 1990. The best potential areas were visited this trip, and the most extensive was chosen for the 10km trap line. Based on the results of this trip in combination with previous recent surveys it is unlikely that Kowari populations remain south of Cowarie Homestead at the present time. The most suitable gibber type is either in very small patches or is in extensively watered areas where sand mounds were deflated and of poor suitability for Kowaris.

A similar situation exists on north Cowarie Station, where the largest continuous and least impacted area was trapped for two nights. Maximum distance from water points was approximately 5km and at this site very few mounds met preferred condition status. It is probable that this area, being closer to larger patches contiguous with the likely core population area in SA on Clifton Hills, is occasionally re-populated following a run of above average rainfall years. The small size (<30km^2) and general condition of the sand mounds and adjacent habitats of this region probably limits the likelihood of continuous occupancy by Kowaris. This situation is also likely to reduce the probability of Kowaris re-populating vacant habitats further to the south. Unfortunately larger adjacent habitat patches on Clifton Hills were not sampled during this trip however vehicle based observations of mound condition made while travelling along the main road through Clifton Hills Station suggest that it is unlikely that this area would support a source population of Kowaris that could re-populate northern Cowarie Station in the near future.

It was hoped that the trapping results from the Pothole Dune area on the south west boundary of Pandie Pandie would provide a trapping benchmark against which to compare results from outlying patches. This area is contiguous with the two monitoring grids established 40km to the west on Clifton Hills. The lack of Kowari captures or evidence of recent occupation (based on extensive searches for burrows, scats and tracks) was of concern as the area trapped covered country greater than 7 km from water points and supported numerous mounds that met the preferred condition status. It appeared that stocking of this area had been minimal since the summer rains. Previous trapping in 1999 had produced numerous captures in this area, further enforcing the concern over the lack of captures during this trip. Similar efforts on Innamincka, at a location which was adjacent to an area producing several Kowari captures in 1995, only an old scat and some old burrows and mud embedded tracks were found in an area dominated by mounds in preferred condition status. Other species which have previously been found to have lower capture probabilities than Kowaris (based on results from the Kowari monitoring study at Clifton Hills Station) were captured at all locations indicating that the traps and baits were functioning effectively.

Patches sampled on the south-east boundary of Pandie Pandie and north-east corner of Cordillo Downs imply that despite these areas being productive for other species (particularly rodents), Kowaris were most likely locally extinct. The situation on Cordillo Downs is interesting because of repeated sampling since 1994 where a Kowari was captured at a site with 30 Elliott traps over three nights and again in 1998 using 100 traps over one night. A subsequent survey in 2002 targeting nearby areas with more sand mounds found no evidence of the species. During this trip an extensive search of all likely patches on the SA side of the Qld border located an area with a higher proportion of sand mounds in preferred condition (40%). 140 traps were placed through the main area of habitat (not meeting ideal characteristics) where previous captures had been made and left open for two nights, and a further 100 traps were placed through the area which best met preferred mound and habitat status. Seven Fawn Hopping-mice were trapped in the first 140 traps over two nights whilst 14 Fawn Hopping-mice and a Kultarr were captured in the preferred habitat from the 100 traps over one night. Neither of these species had been encountered in the area trapped on previous occasions, and supports the idea that sand mound presence and in good condition is important for the major small mammal species sharing gibber pavement habitat with Kowaris. Young Fawn Hopping-mice and pregnant females were present indicating that the population was still turning over – it would be useful to monitor the inevitable decline of this population and determine if they maintain a presence in this region over the long term following the boon provided by the previous summer's heavy rains.

The lack of Kowari captures and recent sign lead to the conclusion that Kowari populations have declined and suffered local extinctions throughout their known distribution in SA since the 1990s. This is likely a consequence of lower than average rainfall since 2002 combined with impacts of herbivores in decreasing suitability of sand mounds for shelter and numbers of Kowari prey items. The ability of Kowaris to repopulate areas will rely on an exceptional period of consecutive useful rains and appropriate management of suitable areas of habitat. This will enable gradual dispersal of individuals as populations become saturated. Unsympathetic placement of stock water points, and heavy stocking of flooded areas adjacent to good kowari habitat following heavy rains are likely to reduce the population of Kowaris to critically low levels.

Sand Mound Assessment:
The development of a rapid mound assessment method proved useful in identifying how fragile the sand mound component of the kowari habitat really is. Whilst mounds are able to rapidly form and can be naturally unstable, the conditions that form and maintain mounds suitable for medium sized burrows are readily altered by large herbivore activity and subtle changes to water flows across the gibber landscape.

Mounds appear to form in hard depressions that hold a variable level of water following rain (depending on amount and micro-topography around the depressions). The sand mounds probably form around debris blown or washed into these areas and once plants germinate more windblown and water-born sediments collect and build up. Extensive areas of depression often support a large and dense network of mounds in the preferred height class of 25-40cm. However these areas are prone to longer term inundation which has the undesirable consequence of creating islands that are susceptible to wave erosion and likely waterlogging of the base of the mound (where burrows would be prone to slumping). These areas have been shown to be less favourable for Kowaris than the more sparsely mound covered adjacent pavements, where minor depressions can only be flooded to a low level and for shorter periods.

Stable mounds tend to have a firm crust of cryptogam – usually visible as a dark layer on the surface, particularly on the margins where plant growth is often sparse. This crust protects the soil from the action of wind, rain and surface flow. Where mounds are well vegetated the loamy sand to sandy loam soils have an obvious organic component which also protect the surface from erosion and provides a suitable substrate for a diverse range of plant species to germinate. The major impact of grazing on mounds is to decrease the amount of organic matter that gets incorporated into the soil and destruction of the soil crust which exposes the soils to wind and water erosion. Trampling by stock also compacts the soils in the mound making them more difficult to burrow in when dry and potentially crushes burrows, particularly on saturated mounds.

The results of our assessment of clusters of 10 mounds at various distances from water indicate a trend of decreased impact away from permanent water. Indicators such as trampling and scalding were highly variable, the presence of swamps throughout the habitat are likely to influence these, as when they are flooded cattle move throughout the landscape and would probably concentrate on mounds for feeding. Evidence for this was the number of identifiable deep pug marks in mounds distant from permanent water. Pugging was more difficult to identify on the deflated harder mounds nearer water points, however fresh tracks were often more obvious. Scalding was only obvious where no recent deposition of sediments was occurring. Mounds close to dams on Pandie Pandie were not stocked and deposition obscured scalding and hard crust formation. It also obscured presence of cryptogams, however the base of at least half of a mound is usually an erosion zone where cryptogam cover around the margin can still be assessed and used to assess condition. Plant cover and numbers of species are useful in a comparison between groups of mounds within a region receiving the same climatic conditions. However, they are less useful for broadscale comparisons across regions because of variable climatic responses. Timing would also be an issue as grass species are most responsive to summer rain.

A rapid assessment technique which considers profile, mound height, cryptogam cover around the sloping margin and presence of Kowari sign and burrows would probably suffice for broadscale comparison of mound condition. The vegetation information will allow local comparisons of mound condition and will also allow for comparison of pre-visit climatic conditions across the areas surveyed. However, it may not be useful as part of a broadscale assessment and comparison of mound condition, simply because the types and amount of plant cover present is so dependent on preceding climatic conditions and these can be extremely variable across the current range of the Kowari.

Conclusions

Monitoring Kowaris and other native fauna

The results reported here suggest that Kowaris have suffered at least localised extinctions at a number of sites that are known to have supported Kowaris in the recent past (since 1990). These sites are spread across a large area between Mulka Station in the south and Cordillo Downs Station in the north. However during this survey, no trapping was undertaken on Clifton Hills Station (as access permission was not granted by the manager), where the largest populations of Kowaris and areas of suitable habitat are known. The fate of these core populations therefore remains unknown at this point in time.

The results of this survey have demonstrated that the two-night trapping methodology adopted here is adequate to detect the presence of native species such as Kultarr and Fawn Hopping Mouse within a study area. Although no Kowaris were trapped during this survey, the adoption of this method on previous trips has indicated that two nights trapping is also adequate to detect the presence of Kowaris, even at low densities. The results reported here, therefore provide a strong indication that Kowaris may have become locally extinct at the six sites that were trapped during this trip. This is particularly worrying given that some of these sites, notably Pothole Dune on Pandie Pandie Station have previously been the site of numerous Kowari captures. It is also of concern because this site appeared to have been lightly stocked since reasonable rainfall events in early 2007 and sand mounds appeared to be in good enough condition to support Kowaris. Further surveys of sites identified as containing suitable Kowari habitat are required to determine the extent of these localised extinctions and to obtain a better indication of the current status of Kowaris within the region.

The level of trap success recorded for other species, notably the Fawn Hopping-mouse on Cordillo Downs Station, indicates that these species are doing well in at least some parts of the region. The high number of captures at Cordillo Downs may warrant some ongoing monitoring of this population to assess important population parameters such as persistence at the site, dispersal patterns and reproductive patterns.

Sand Mound Assessment

A rapid monitoring technique for assessing sand mound condition was trialled during this survey and appears to be a useful method for comparing sand mound condition within a trapping site and between sites across the region. The suite of parameters that determine the suitability of sand mounds for use by Kowaris has been determined from the results of ongoing monitoring of Kowaris on Clifton Hills Station. Further trapping in conjunction with the use of this rapid assessment technique will provide an opportunity to evaluate the robustness of the ideas discussed within this report, most notably whether these ideal characters are truly correlated with Kowari presence outside of the Clifton Hills study area.

The sand mound assessment method described here could provide an opportunity for ongoing community participation in programs designed to identify and monitor Kowari habitat within the region. The methods are relatively simple, and with some limited training could easily be implemented by land managers and community members. Because of the passive nature of the methods, research permits and animal experimentation ethics approval are not required, further increasing the usefulness of this technique for community groups and land managers.

Recommendations

1. It is critical that an assessment of the Clifton Hills Kowari population be undertaken as a matter of urgency, in order to assess the current status of that population and to provide a baseline that can be used to determine the extent of the apparent decline of Kowaris in the region.
2. Additional sites on Pandie Pandie Station that were identified during the current survey should be trapped in an attempt to locate extant Kowari populations and to further assess the current distribution of Kowaris in the region.
3. During any additional survey work, the rapid mound assessment technique described here should be further tested to assess the validity of the results described here in areas where Kowaris are known to be present.
4. Follow up surveys should be undertaken on Cordillo Downs Station to investigate population dynamics and ecological parameters of the Fawn Hopping Mouse population identified during this survey.
5. The rapid assessment method for sand mounds should be finalised and distributed to community groups, along with a photographic guide to mound assessment, for comment and to scope the possibility of its broadscale implementation in the region.
6. A complete follow-up monitoring trip visiting all sites identified in this report and in Pedler and Read (and including the Clifton Hills study grids) is funded to be conducted in Autumn 2009. This will allow for another season's progeny to hopefully further boost populations to trappable levels.
7. Survey for Kowaris in suitable habitat on the western half of Clifton Hills Station with a minimum of two 10km transects.
8. Undertake a general program to increase pastoralists' awareness of stony desert wildlife using the Kowari as an iconic species to assist in achieving sensitive and sustainable use of stony desert rangelands.

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Satellite imagery and base topographic maps from Dept Environment and Heritage GIS Databases.

Appendices

1. The Kowari Habitat Assessment Datasheet

2. Satellite Images of Trapsites

3. Key Healthy Sand Mound Indicators

4. Other Mammal Species Likely to be Confused with Kowaris

5. Kowari Survey – Clifton Hills and Pandie Pandie Station December 2007 (R Pedler & J Read)

Appendix 1

Kowari Habitat Assessment – Data sheet

Location Coordinates: ______ Description: ______

Date: ______ Observers: ______

Site description parameters

Gibber pavement Cover: ______ five cover classes
1= <5%; 2=5-25%; 3=25-50%; 4=50-75%; 5= >75%

Cover of gibber in the preferred size range of 5-50mm: ______ four cover classes
1= <50%, 2=50-75%, 3=75-90%, 4=>90%

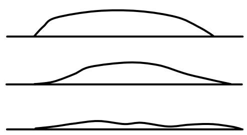
Hard depression cover: ______ five cover classes
1= <5%; 2=5-25%; 3=25-50%; 4=50-75%; 5= >75%

Sand mound cover: ______ five cover classes
1= <5%; 2=5-25%; 3=25-50%; 4=50-75%; 5= >75%

Sand spread cover: ______ five cover classes
1= <5%; 2=5-25%; 3=25-50%; 4=50-75%; 5= >75%

Cover of trees and shrubs >40cm high: ______ three cover classes
1= 0, 2= <5%, 3= >5%

Sand Mound Condition (minimum of 10 mounds)

Sand mound number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Profile: 1 >50% edges convex 2 >50% edges concave 3 edges minimal slope 										
Height at tallest point: 1 = <10cm; 2 = 10-25cm; 3 = 25-40cm; 4 = 40-60cm; 5 = >60cm										
Tracks & pugging cover: 1 = <5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = >75%										
Scald cover (bare of plants and cryptogam): 1 = <5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = >75%										
Hard crust on sloping margins: 1 = <5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = >75%										
Cryptogam cover on margins: 1 = <5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = >75%										
Vegetation plus litter cover: 1 = <5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = >75%										
Number of plants species taller than 10cm										
Number of grass species										
Mitchell Grass *Astrebla* spp. present: 0 = none 1 = Yes										
Kowari sign present: 0 = none; 1 = tracks; 2 = scats; 3 = tracks and scats; 4 = burrow with tracks or scats										
Burrows present: 0 = none; 1 = <50[c] piece in diameter; 2 = > 50[c] piece in diameter										
Photograph image number:										
Other comments:										

Appendix 2

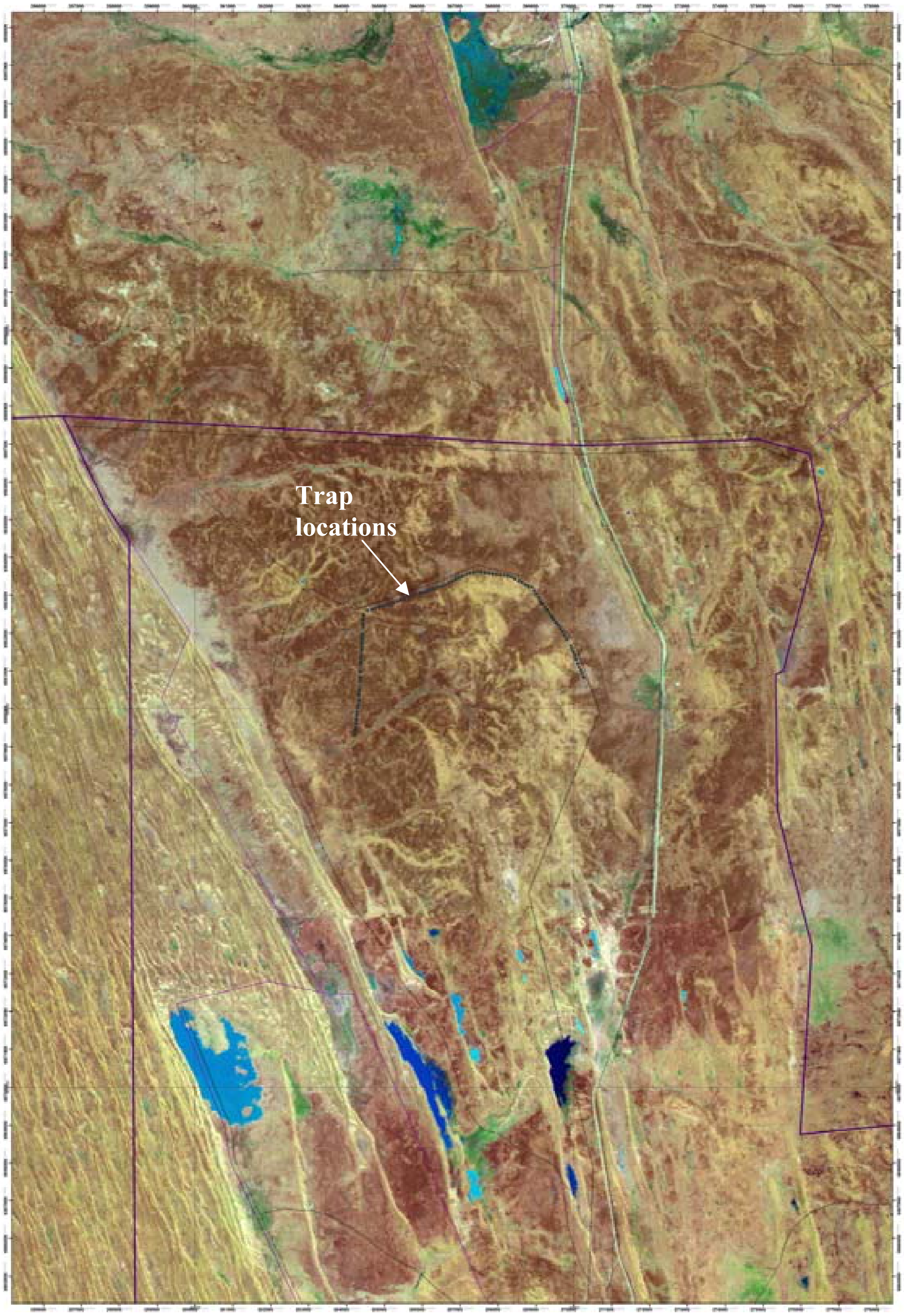


Figure 4
Satellite image of the northern section of Mulka Pastoral Lease showing the 200 trap point transect (grey dots) located in pavement gibber (dark red sections). Each grey dot (trap) is separated by about 100 metres making the total length of the traplines roughly ten kilometres. The purple line is the property boundary with Mungerannie.

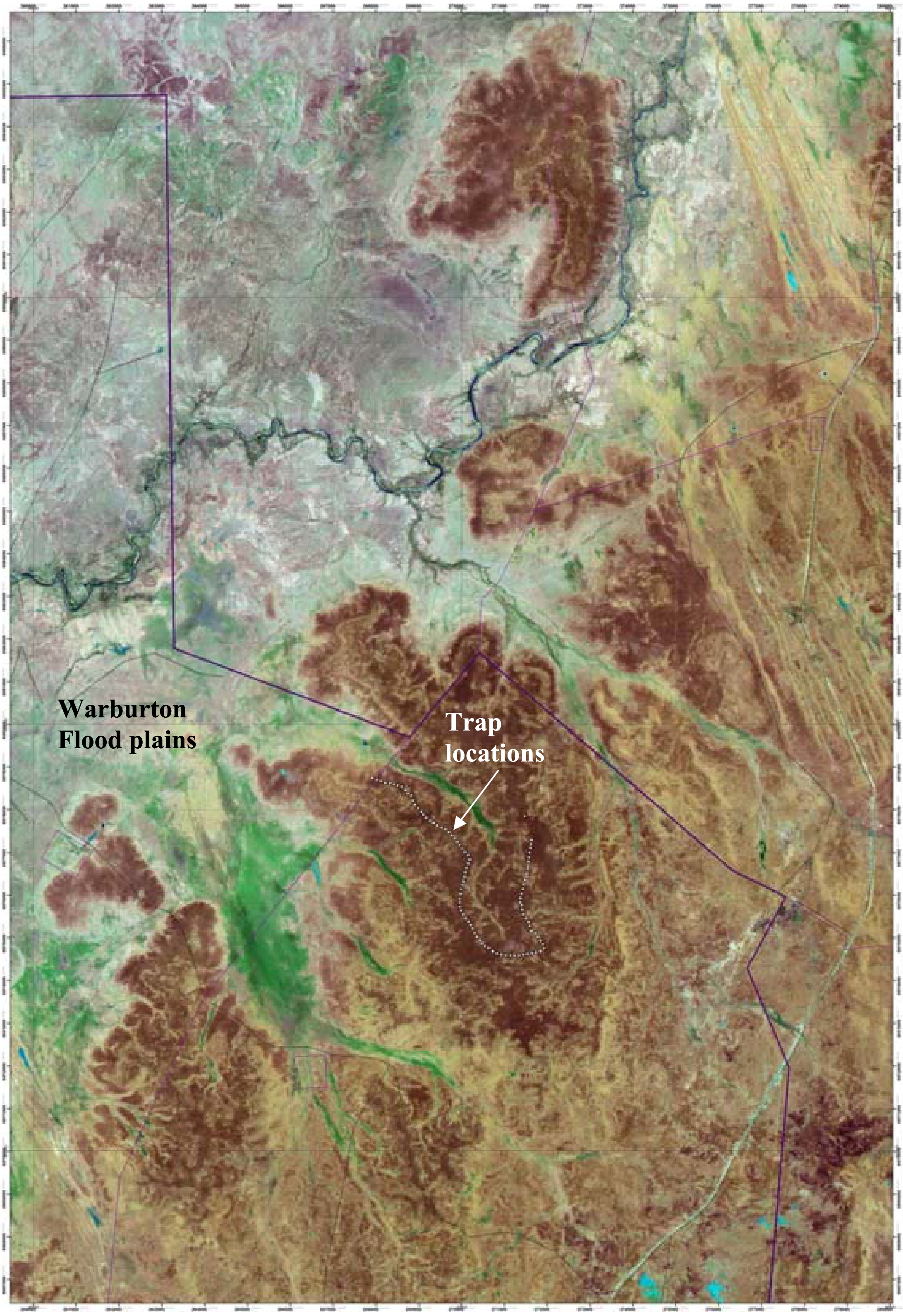


Figure 5
Satellite image of the north-western corner of Cowarie Pastoral Lease (Builders Rest area) showing the 200 trap point transect (white dots) located in pavement gibber (dark red sections). Each white dot (trap) is separated by about 100 metres making the total length of the traplines roughly ten kilometres. The purple line is the property boundary with Clifton Hills.

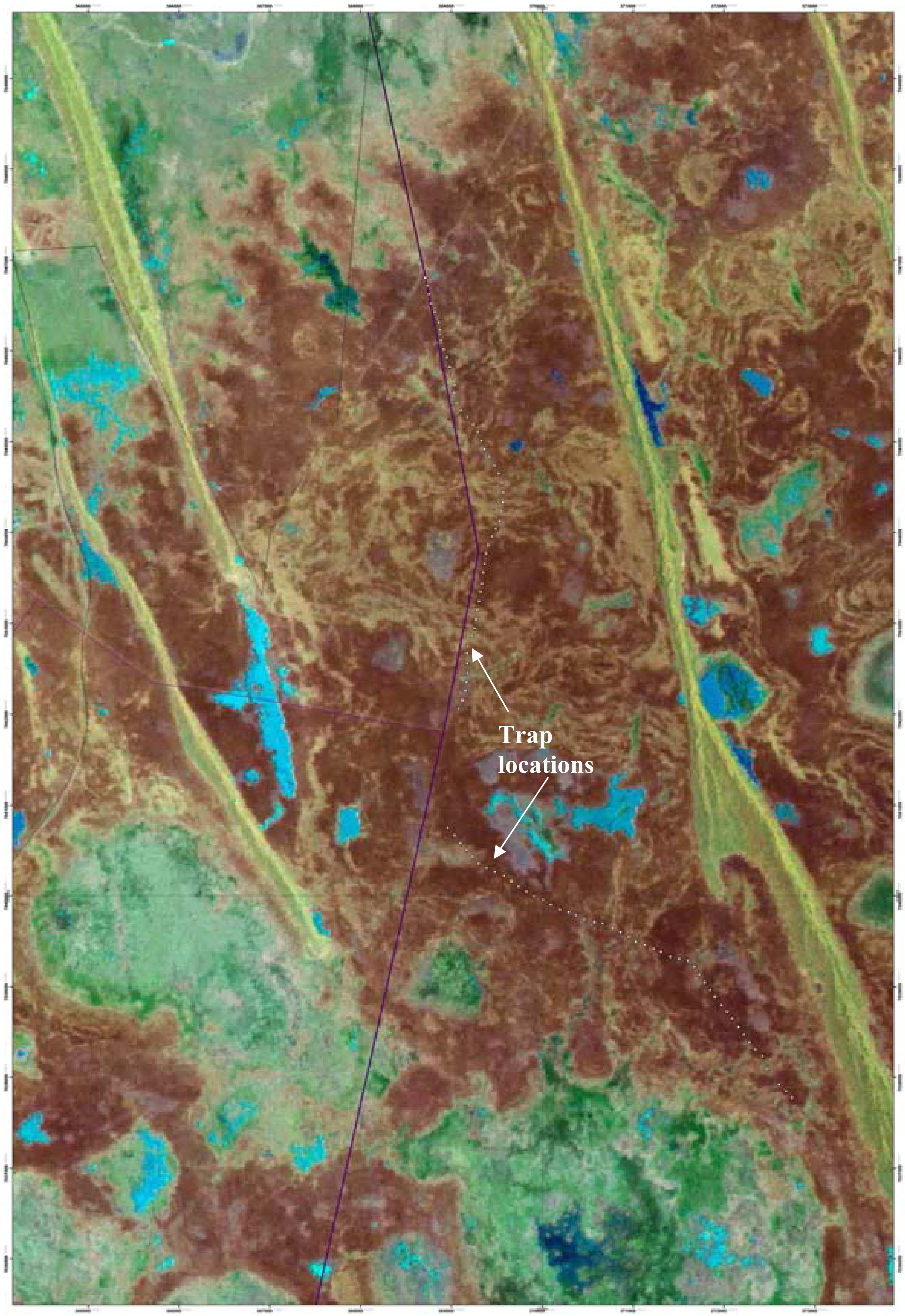


Figure 6
Satellite image of the south-western corner of Pandie Pandie Pastoral Lease (Pothole Dune area) showing the 200 trap point transects (white dots) located in pavement gibber (dark red sections). Each white dot (trap) is separated by about 100 metres making the total length of the traplines roughly ten kilometres. The purple line is the property boundary with Clifton Hills.

Figure 7
Satellite image of the north-western corner of Innamincka Regional Reserve showing the 200 trap point transect (white dots) located in pavement gibber (dark red sections). Each white dot (trap) is separated by about 100 metres making the total length of the traplines roughly ten kilometres. The purple line is the approximate property boundary with Pandie Pandie, the fence was 500m further north.

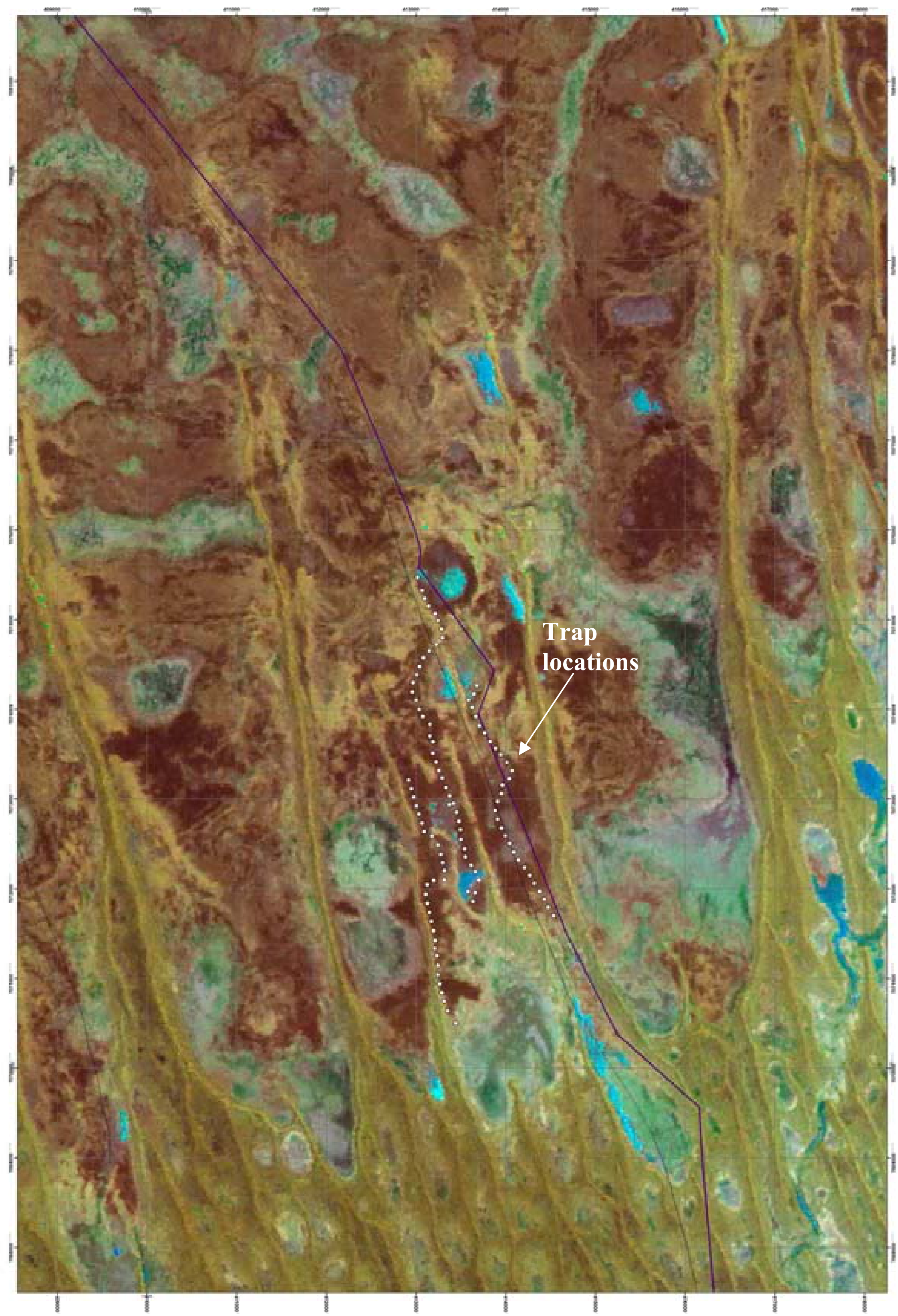


Figure 8
Satellite image of the south-eastern corner of Pandie Pandie Pastoral Lease showing the 200 trap point transect (white dots) located in pavement gibber (dark red sections). Each white dot (trap) is separated by about 100 metres making the total length of the traplines roughly ten kilometres. The purple line is the property boundary with Cordillo Downs.

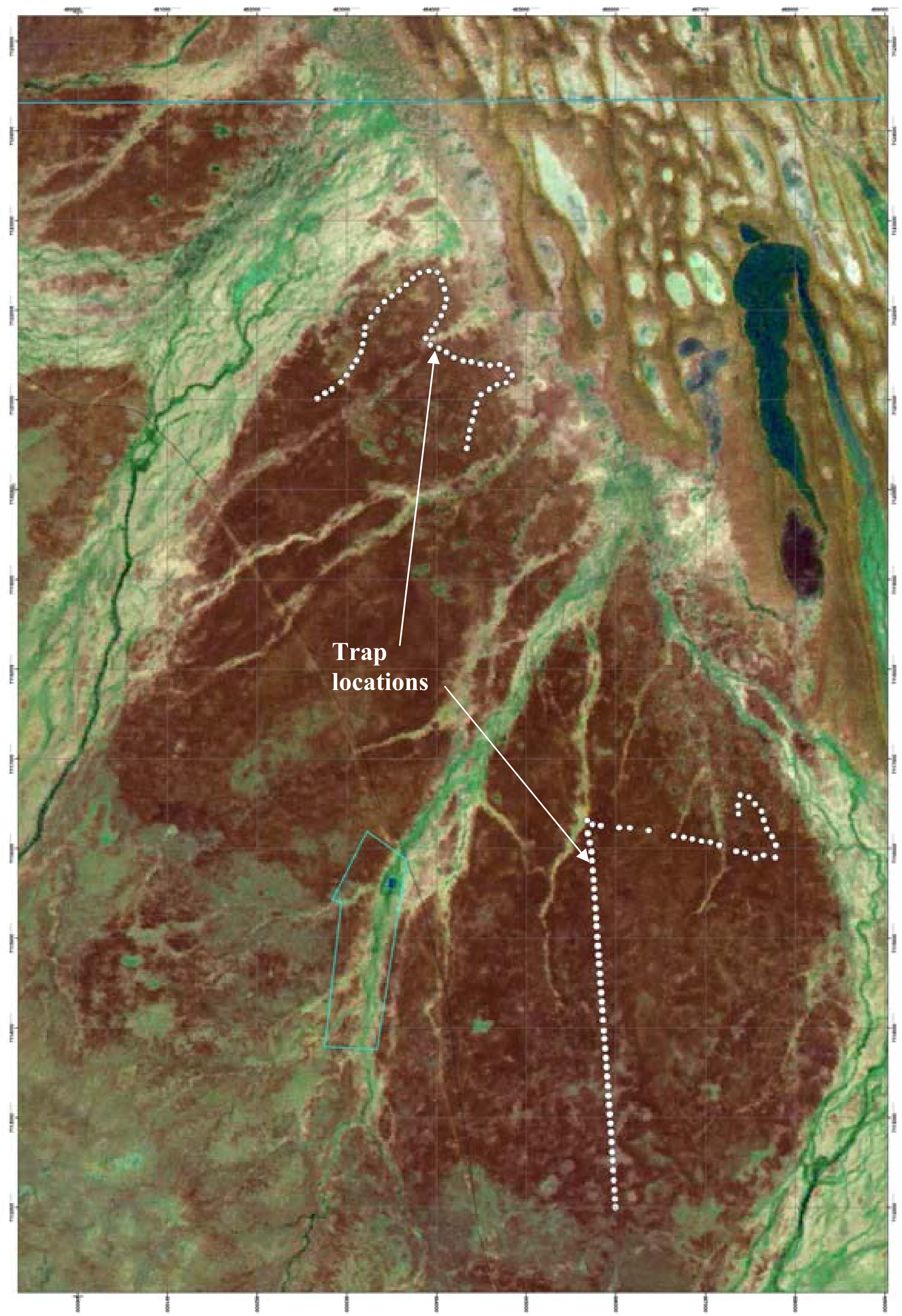


Figure 9
Satellite image of the north-eastern corner of Cordillo Downs Pastoral Lease (Kachumba Plain area) showing the 200 trap point transect (white dots) located in pavement gibber (dark red sections). Each white dot (trap) is separated by about 100 metres making the total length of the traplines roughly ten kilometres.

Appendix 3

Key Healthy Sand Mound Indicators

The following images and discussion demonstrate some of the observations and methods used to determine the relative 'health' of Kowari habitat. These have been particularly selected as they provide a ready means for land managers (who are generally familiar with stony plains country) to self assess and maintain the requirements for high quality Kowari habitat identified in this report without the need for specialised training.

Mound Features

The ideal mound profiles and areas, and the nature of the surrounding gibber plains are discussed in the main body of the report. In addition to there are some important characteristics that can be gauged by observing a number of 'key indicators' such as the presence of certain plant species and how a mound soil appears and behaves when subjected to extreme weather events such as strong winds and heavy rain.

A healthy sand mound can display different vegetation zones, depending on the depth and type of soil available. The soil around the margins of a mound can be heavily crusted both as a result of having a higher clay content and due to the presence of cryptogams – lichens, liverworts, algae that help bind the soil and provide it with some resistance to erosion. The cryptogams give the soil crust a blackened appearance when dry. The upper sections of the mound can be composed of sandier less-crusted soils with a higher organic content. Deeply rooted perennial species and a generally higher diversity of both perennial and ephemeral shrubs, herbs and grasses grow here. All sections of the mound can be damaged by grazing and trampling, with different soil types and plant communities responding in a variety of ways.

Photo 11

Cross section of a sand mound showing the build up of layers of wind-blown soil. Note the less compact and more fragile recent layers mixed with organic material on the mound crest. Photo: P Canty

The pictures below depict some of the vegetation zones on healthy mounds.

Photo 12

Photo 13
Both images clearly display a lower fringe dominated by Five-minute Grass (*Tripogon loliiformis*) leading to a cap with shrubby species.
Photos: P Canty

Photo 14
Close-up photo of different cryptogam types which help to consolidate the soil crust and make it less susceptible to erosion. Cryptogam layers usually form on the lower slopes of mounds, where the soils are less sandy and are often inundated or kept damp by water collecting in adjacent low-points or soaking into the mound.

Photo 15
An active Kowari burrow (taken on a previous trip) showing how a well-developed cryptogam crust can support a burrow entrance.
Photos: P Canty

Photo 16
Ray Grass (*Sporobolus actinocladus*). Noted in 'Plants of Western New South Wales' (Cunningham *et al*, 1992) as very palatable to stock, particularly after flowering. Although not a long-lived perennial grass, the presence and abundance of this species can indicate relatively low grazing pressure.

Photo 17
Barley Mitchell-grass (*Astrebla pectinata*). Although not necessarily present on all 'high quality' Type 3 mounds, the presence of a perennial grass species such as Barley Mitchell-grass is a good indicator of stable soils and well-managed grazing.
Photos: P Canty

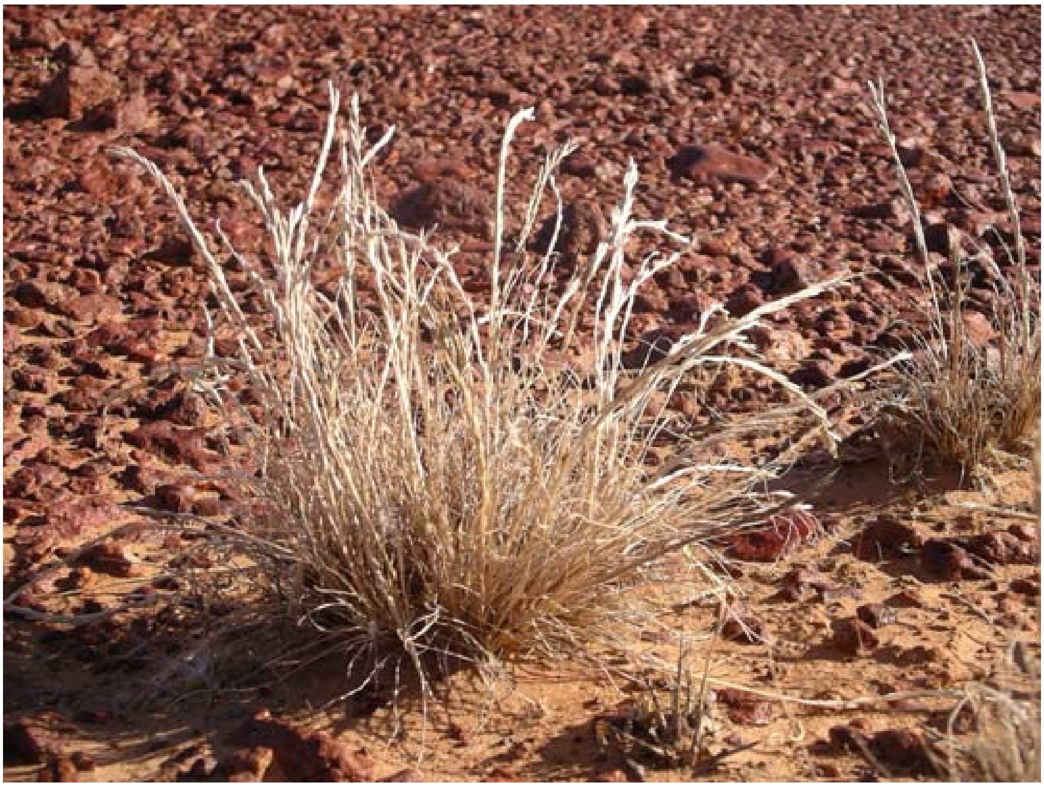


Photo 18
Five-minute Grass (*Tripogon loliiformis*). Noted for its ability to respond rapidly to rain, this perennial species can provide palatable forage (Plants of Western New South Wales, Cunningham *et al*, 1992) but its presence and condition is a good indicator of stable soils (see below for comments on 'pedestalling'). Photo: P Canty

Examples of ‘pedestalling’ of some of the key ‘mound health’ indicator plant species. Pedestalling is a result of the relatively rapid loss of topsoil causing in the exposure of perennial plant roots, which effectively leave the normal above ground parts of the plant perched up on a soil pedestal. Pedestalled perennial plants may be less likely to respond to small quantities of rain as run-off is more likely and the little soil surrounding their roots will dry more rapidly than if they were fully embedded. If the erosion continues the plants will either die from root dehydration and damage, or get completely uprooted. The examples here show a loss of soil depth of approximately 10 cm

Photo 19

Five-minute Grass *Tripogon loliiformis.*

Photo 20

Common Fringe-rush *Fimbristylis dichotoma*. Photos: P Canty

Photo 21

Photo 22
A badly eroded sand mound with highly pedestalled, barely surviving Five-minute Grass. The remaining hard soil crust provides few opportunities for seeds to lodge and grow. Without a return to better conditions, deflated mounds either continue to erode or just support short-lived plant species such as the pop saltbush (*Atriplex* sp.) seen in this photo, which can germinate and grow quickly when the soil is softened by rain.
Photos: P Canty

Photo 23

Photo 24
Mounds heavily impacted by ongoing grazing and trampling. Very few perennial plant species remain to bind the soil and help form an organic crust leaving little barrier to wind and water erosion.
Photos: P Canty

Photo 25
'Pugging' of rain-softened mound soils by cattle as a demonstration of the potential damage to animal burrows, plant roots and to soil structure.

Photo 26
'Scalding' (a scald is a bare area caused by the loss of topsoil and vegetation) affecting an entire mound.
Photos: P Canty

Soil function
A simple test to determine the 'health' of a soil layer in terms of its ability to withstand erosion and function as a growth medium for plants and other soil organisms.

Photo 27
For comparison, two pieces of soil crust, the one on the left is from a well vegetated intact mound (note the black cryptogams); the piece on the right is from a 'scalded' section of mound where the organic topsoil layer has been eroded leaving a hard, bare sterile surface (see photo above).

Photo 28
To test the stability of a soil crust, the piece needs to be gently immersed in a container with enough water to just cover the samples. Almost immediately the 'damaged' soil begins to disintegrate (note the air being forced from the soil). Photos: P Canty

Photo 29
Major slumping after approximately 30 seconds for the 'damaged' soil; virtually no change in the healthy soil.

Photo 30
After approximately 1 minute the damaged soil has completely slumped. The healthy soil has just begun to lose some structure in the layer below the immediate surface crust but has generally maintained its integrity. The slump test is a good indication of how a soil will behave when subjected to rainfall. Obviously from this test the soil on the right is going to be highly susceptible to erosion. If continually trampled and grazed, any mound featuring this soil type will quickly disappear unless plants are able to recolonise and help re-establish organic material in the soil profile.
Photos: P Canty

Kowari Prey
Finding an abundance of potential prey species in ideal habitat is a good indicator of the health and productivity of that habitat. Although all areas examined had what appeared to be a good range and density of prey as a result of recent rains, Kowaris can only breed at most twice a year from winter to summer, but mostly once, usually in Spring. Therefore a build-up in Kowari numbers may only be apparent after a prolonged good season (provided the benefits of that increased productivity are not totally removed). The images below indicate some of the potential prey species living on or using gibber plains and sand mounds. A preliminary analysis of Kowari droppings (Queale *et al* 2000) indicated that 80% of the diet consisted of invertebrates with the remaining portion made up of rodents, reptiles and birds.

Photo 31
Central Bearded Dragon (*Pogona vitticeps*) juvenile
Photo: P Canty

Photo 32
Smooth-snouted Earless Dragon (*Tympanocryptis intima*)
Photo: R Brandle

Photo 33
Nest and eggs of the Gibberbird (*Ashbyia lovensis*)
Photo: P Canty

Photo 34
Gibber Grasshopper (*Raniliella testudo*).
Photo: R Brandle

Photo 35
Fawn Hopping Mouse (*Notomys cervinus*).
Photo: P Canty

Photo 36
Kultarr (*Antechinomys laniger*).
Photo: P Canty

Determining Kowari Presence

The ultimate test of gauging the suitability and quality of Kowari habitat is to discover that Kowaris are using it! There are, however, limited means by which a land manager can legally determine their presence. All native mammals are protected throughout the State under the National Parks and Wildlife Act which basically means that Kowaris cannot be deliberately captured, restrained, killed etc without getting an appropriate permit from the State Government. To catch a threatened species such as a Kowari, the only permissible grounds for granting a permit are for legitimate scientific research. These permits are normally only granted to reputable scientists who must also get separate approval from an animal experimentation ethics committee to justify their need to do the research balanced against any suffering experienced by their subject animals, and their skills and techniques for minimising any suffering. The best option for anyone unable to meet those requirements is to use indirect methods such as looking for fresh tracks, droppings and burrows.

Kowaris, like most resident desert animals, have populations that respond to times of drought and abundance, with our studies showing trapping variations from around 2 animals per 20 km² to over 50 per 20 km² which closely correlate to cycles of rainfall and biotic productivity. Obviously, monitoring is most likely to detect Kowaris at times of sustained high productivity (given some lag between the availability of rain-induced vegetation growth and subsequent increases in the abundance of prey species and the coincidence with optimal Kowari breeding times).

Simple means of detecting Kowari presence/absence from an area can be used without the need to use physically trap animals. Kowari tracks are relatively distinctive (see photo) and although gibber pavement does not provide many opportunities for animals to leave tracks, the sand mounds can. In addition, we have developed a monitoring technique called a 'scent-pad' (initially designed to detect the presence of potential Kowari predators such as Dingoes, foxes and cats), which is generally a circular area of about 1.5 metres in diameter cleared of gibbers with a rake to expose the soil layer beneath with a scented lure in the centre (usually fish-oil (eg from tinned sardines) drizzled on a flat gibber – note that it is best to use lures that won't be readily removed by scavengers such as ants or birds). The technique works best in soils with a fine sandy or gypseous nature as the soil surface can be raked and worked into a smooth loose surface that will show small animal tracks (see photo). Alternatively if the soil is hard or crumbly, sand can be brought in from a nearby dune and either spread directly on the gibbers or over an area cleared of gibbers as described above.

Photo 37. Morning check of a 'Scent Pad' to record overnight animal tracks. The spiralling ridge is caused by dragging a trap box from the centre outwards to help smooth the surface (the back of a spade will also work). Once the tracks are noted, the pad can be resmoothed to provide a fresh surface for the next night's activities. The pad can be 'reactivated' for future monitoring at any time by breaking up and powdering the soil crust.

Photo: P Canty

Photo 38. Close-up of the same scent pad. Kowari tracks are visible on the right side of the pad and around the scented gibber in the centre.

Photo 39. A scent pad placed on a dune flank showing small mammal tracks (possibly Kultarr). Signs of a 'scuffle' in the top portion of the pad could indicate dust bathing or the capture of some invertebrate of which tracks are also abundant.

Photos: P Canty

Photo 40. Photo showing Ampurta (*Dasycercus cristicauda*) tracks – a closely related species to the Kowari (although Kowaris only have four toes on the rear foot as distinct from five on the Ampurta, individual toe patterns on the rear foot print are not usually clearly visible). In the photo the animal is travelling from right to left, with the tracks on the right being made by the forepaws hitting the ground first and the tracks on the left being the rear paws 'following through' after the forepaws have lifted off for the next bound. Photo: P Canty

Photo 41. Photo showing a sequence of tracks left by a Kowari bounding along the soft disturbed soil left in a fresh vehicle track. Note that the soft soil in vehicle tracks can be a useful means of detecting Kowari presence in areas of gibber pavement and are best viewed early in the morning when tracks are fresh and the light is low and more likely to show up subtle relief. Kowaris probably specifically check out freshly disturbed or 'different' things in their territories. Finely pulverised soil like that in the photo above and on scent pads also seems to be used by Kowaris and other animals as opportunistic dust bathing spots. Photo: N Haby

A selection of burrows used by Kowaris. Some are dug originally by other animals and enlarged by Kowaris. Deeper, more complex burrows will have a large spoil heap at the entrance and if used, will likely show fresh tracks and droppings. If you have the opportunity, the soil in front of a suspected burrow can be softened and smoothed and rechecked the following day for fresh tracks. The presence of spider webs and wind-blown plant litter in the entrance indicate the burrow is unused. Also check the size and pattern of any tracks and dropping types as abandoned Kowari burrows can also be adopted by other species, particularly reptiles (reptile and bird droppings show the characteristic white portion composed of uric acid not seen in mammal droppings)

Photo 42 **Photo 43**

Sand mound with a Kowari burrow. Note the many tracks on the spoil heap at the mouth of the burrow.

Photo 44

Kowari burrow entrance and excavated spoil. Kowaris will often enlarge and deepen holes dug by other animals. The burrow pictured appears to be an old Sand Goanna (*Varanus gouldii*) dig (the indentation at the top of the entrance looks like the remains of an old trapdoor spider tunnel – goannas dig down along these to catch the spider at the bottom leaving a characteristically shaped excavation). The Kowari has taken advantage of the goanna's efforts in breaking through the soil crust and, using the cover afforded by the dig, created a much deeper refuge. Kowaris use a number of burrows throughout their home range. Many are relatively simple tunnels used for brief periods of shelter between foraging trips at night, or for daytime refuge. Some burrow systems have multiple entrances and side chambers. Breeding burrows used by females with young can be deeper and more complex with side chambers and lined nests (eg Lim 1998). Lim found evidence of a side chamber used as a latrine by a female, possibly to avoid venturing too far from her young and to reduce predator-attracting scents around the burrow entrance.

Photos: P Canty

Photo 45
Kowari burrow close-up. Well-used burrows can display a centre ridge on the floor caused by Kowari foot movement on either side. Photo: P Canty

Photo 46.
Kowari burrow system with multiple entrances. Note soil-supporting cryptogams and Barley Mitchell Grass (see also photo below which is a closer shot of the uppermost burrow showing faeces). Photo: P Canty

Photo 47
Kowari burrow with fresh faeces on the spoil heap. Photo P Canty

Photo 48
Adult Kowari faecal pellets. Kowari faeces are typically roughly cylindrical with clearly visible coarse fragments of indigestible prey remains such as invertebrate parts, pieces of bone, teeth, claws, scales, and in several of the examples above, mammal fur. Faeces on a sand mound, particularly around burrow entrances are good indicators of recent Kowari presence. If the pellets are not fresh, they take on more of a weathered grey appearance, can be partially embedded into the ground by rain or wind, and fall apart readily. Another means of determining recent Kowari activity can be to remove all the pellets from a mound and then, by rechecking the mound a day or so later, noting any new ‘deposits’. If a burrow is present, the soft soil at the entrance can be smoothed and checked next day for fresh tracks (noting that unoccupied Kowari burrows can in turn be used by other animals such as lizards – check any tracks and tail drag marks carefully). Photo: P Canty

Appendix 4

Other mammal species likely to be confused with Kowaris

Information in this section derived from Canty *et al* (in prep), Lim 1998 and Van Dyke & Strahan 2008.

Photo 49

Photo 50

Photo 51

Photo 52

A **Kowari (*Dasycercus byrnei*)** for comparison. Key characteristics: agile carnivorous marsupial, weight range 70-175g, 4 toes on rear foot, stout tail with conspicuous black brush. Tail can be distinctively arched over the back in an 'S' shape or held out straight (particularly when running quickly). Photos: P Canty

Photo 53
Kultarr (*Antechinomys laniger*). Key characteristics: carnivorous marsupial but much smaller, more 'graceful' build (most noticeable in the slender tail with a finer brush tip), 20-30g, shares 4 toes on rear foot. Occurs in same habitat as Kowari (plus a much wider range of habitats), a potential prey species.
Photo: P Canty

Photo 54
Stripe-faced Dunnart (*Sminthopsis macroura*). Key characteristics: carnivorous marsupial but smaller (15-25g) and no brush on tail tip. Occurs in similar habitats to Kowaris (plus a wider range), a potential prey species. Photo: P Canty

Photo 55
Ampurta (*Dasycercus cristicauda*). Key characteristics: carnivorous marsupial of similar size (65-185g) but stockier build, 5 toes on rear foot, black hairs on tail with more of a pronounced crest on the upper side, not an all-over brush. Lives in sand dunes in warrens often under Sandhill Canegrass (*Zygochloa paradoxa*). Has been found to venture out into Kowari habitat, possibly crossing from one dune to another or just foraging. Sightings of 'Kowaris' on Mungerannie and Mulka Stations over the last 40 years have all been in the vicinity of dunes where Ampurtas have been found in recent times. Photo: P Canty

Photo 56
Mulgara (*Dasycercus blythi*). Key characteristics: carnivorous marsupial can be similar sized (75-110g) but generally smaller than Kowaris and Ampurtas. Five toes on rear foot as per Ampurta; appears to now prefer deserts with spinifex (*Triodia* species). Has not been recorded in South Australia for around 50 years but closest locations are in the northern Simpson Desert and around Uluru. May still occur in the northern Strzelecki Desert where thorough surveys have not yet been carried out. Photo: P Canty

Notes

Appendix 5

Kowari Survey
Clifton Hills and Pandie Pandie Station, December 2007

Reece Pedler - Community Fauna Recovery Officer SA Arid Lands NRM Board

Fieldwork conducted by Reece Pedler and John Read

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Introduction

During August 2007, surveys were conducted in search of kowaris across several properties on the upper Birdsville Track area by Peter Canty and Robert Brandle on behalf of SA ALNRM. Areas within previously known Kowari distribution were targeted, including appropriate gibber habitat on Mulka, Mungerannie, Pandie Pandie, Cordillo Downs and Innamincka Stations. Trapping was carried out at six locations over 12 nights with at an approximate intensity of 400 trap-nights per sample. Despite the widespread nature and intensity of this trapping session, not a single Kowari was captured and no fresh signs were observed despite other small mammals and prey items being recorded. Clifton Hills Station, which has been the site of a great deal of work on Kowari over many years was unfortunately not accessible at the time of the survey. Two areas on Clifton hills have permanent monitoring grids, each consisting of 200 trap sites to compare between high and low grazing intensities.

Given the concerning lack of Kowaris encountered in other parts of their known range, the need to visit Clifton Hills was deemed particularly crucial and access was organised for a limited survey at the monitoring grid sites. The aim of the survey was to detect evidence of Kowari in the area. For this purpose, the monitoring grid considered to be the best Kowari habitat with lowest grazing intensity (Walker's Crossing or WAL grid) was chosen and areas where kowari had been trapped before were targeted. An adjacent area on Pandie Pandie Station (~40 km to NE) was also visited. This was the site of an unconfirmed spotlighting sighting of a Kowari by Arian Wallach and Adam O'Neil (who were conducting dingo research in the area) in late July/early August 2007.

Methods

Trapping effort was targeted in areas deemed most likely to yield captures. Given the warm weather conditions at the time of the survey, traps were also placed in a manner that made checking them achievable in a short space of time to avoid problems with trapped animals overheating.

Trapping was conducted over 2 nights at Walker's Crossing Grid on Clifton Hills (with a total of 330 trap-nights). Traps were placed at each trap site (100 m spacings) on the four western-most lines of the grid (1 per site, unlike during previous trapping sessions comparing between WAL and PAN grids) and some areas of suitable habitat within the grid area were also targeted with additional traps. Several of the track monitoring sites at WAL grid were also prepared by powdering up the soil and placing a rock covered in tuna oil in the centre. In the Blue Motor Car Dam area on Pandie Pandie Station, 120 traps were set on the first night, with an additional 50 set the following night (total 290 trap nights). Traps were placed at 100m intervals in lines through suitable sand mound habitat. Two different types of bait were used. Around half of traps were baited with a rolled oats and peanut paste mixture, while the other half were baited with a mixture of cat biscuits soaked in tuna oil. Captured animals were marked with black texta on the base of their tail.

Spotlighting was conducted from a vehicle at both sites for several hours each night. An effort was made to catch most mammals observed in the spotlight in order to check sex, breeding condition etc. Sand mound condition assessments were conducted at several sites, following the methods developed by Brandle and Canty. Track surveys were also carried out at several locations in sand dune habitat, following the 2 ha sand spoor plot methodology developed by Southgate *et al*, 2005.

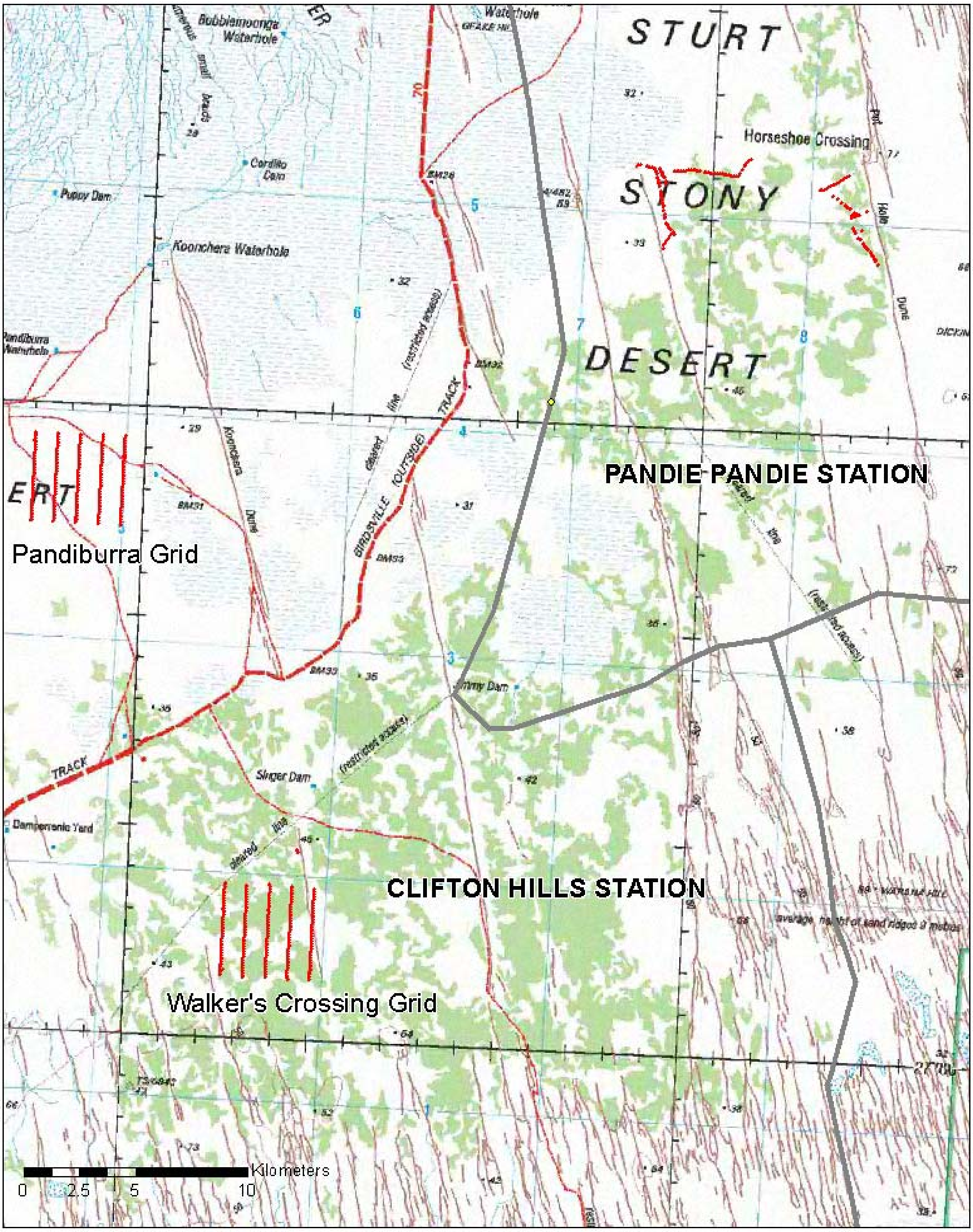

Figure 1. *Location of trapping sites (red dots), showing the Walker's Crossing (WAL) Grid on Clifton Hills Station and the and Blue Motor Car Dam area on Pandie Pandie Station (near Horseshoe Crossing).*

Results and Discussion

A total of seven Kowaris were captured, including four at the Walker's Crossing grid on Clifton Hills and a further three animals in the area around Blue Motor Car Dam on Pandie Pandie Station. All four Kowaris captured at the WAL Grid were females, while two males and a female were caught on Pandie Pandie (**Error! Reference source not found.**). All animals were relatively small (range 46 - 77g) and all females caught had barely visible pouches showing no signs of previous breeding. All animals caught appeared to be young animals, indicating that breeding had occurred recently (**Error! Reference source not found.**). The number of Kowaris trapped was encouraging, given the lack of animals detected earlier in the year in other nearby areas. Trap success was high at both trapping sites and although trapping did not follow the same methods as previous monitoring, trap success levels were comparable to those recorded during previous trapping at the WAL grid (Brandle et al, unpublished, 2004).

Differences in habitat characteristics between the Clifton Hills and Pandie Pandie sites were noted, with substantially fewer sand mounds in the area around Blue Motor Car Dam than at the WAL grid. Sand spreads or depleted sand mounds were more common at the Pandie Pandie site, however some mounds in good condition were noted in the area and most were generally much higher and larger in diameter than those at WAL grid, with substantial perennial vegetation growing on them. Habitat conditions at the time of trapping appeared to be favourable, with around 15 mm of rain in the area about three weeks prior resulting in a flush of growth of grasses and herbage on sand mounds.

From aerial images, appropriate kowari habitat appears to be continuous between the two trapping sites, and Kowari have been captured throughout this area previously (Brandle et al, unpublished, 2004). Confirmation that Kowari are still present in the area suggests that they are also likely to remain in other areas of appropriate habitat on Clifton Hills and the south-eastern areas of Pandie Pandie Station. More extensive follow-up trapping during cooler conditions is required to determine if this is the case. Repeating a full trapping session at the two monitoring grids on Clifton Hills (using the methods previously used at those sites) will also be important in determining the status of the species in the area.

A range of other species were also captured in Elliot traps and through spotlighting at both sites including Kultarr (*Antechinomys laniger*), Fawn Hopping Mouse (*Notomys cervinus*) and Plague Rat (*Rattus villisosimus*) (**Error! Reference source not found.**). Interestingly, the vast majority of Kultarr trapped were female (22 out of the 27 examined from both sites) and nearly all had either pouch young or showed signs of recent breeding (Appendix). This high ratio of females and the large number of those exhibiting signs of breeding may suggest a male senescence event. Male senescence has been recorded in a range of dasyurid marsupials but possibly not in Kultarr.

Track surveys conducted in dune habitats at both trapping areas revealed very low numbers of rabbits. Rabbit tracks were detected at only two of the five plots surveyed and in both cases only one set of tracks was observed. In addition, no evidence of cats or foxes was found at any of the track survey sites on Clifton Hills or Pandie Pandie, but tracks of dingos were reasonably abundant. Several dingos were observed at the Pandie Pandie site, where 2 or 3 animals were seen singly as well as a group of 4 individuals. Discussions with Peter Morton from Pandie Pandie Station revealed that from his observations, rabbit numbers had remained low since Rabbit Calicivirus Disease (RCD) moved through the area in the late 1990's. The reason for the lack of re-establishment and continued low numbers is of particular interest, as this trend of continued low rabbit numbers has not been the case in many other areas.

Date	Site/Area	No. Traps set	Trap success (%) (Kowari only)	Total Trap success (%) (all mammal species)	**Kowari** *(Dasycercus byrnei)*	**Kultarr** *(Antechinomys laniger)*	**Fawn Hopping Mouse** *(Notomys cervinus)*	**Stripe-faced Dunnart** *(Sminthopsis macroura)*	**Plague Rat** *(Rattus villosisimus)*
11/12/07	WAL Grid, Clifton Hills	160	0.62	5.00	1	5		2	
12/12/07	WAL Grid, Clifton Hills	170	1.17	9.41	3	13	1		
13/12/07	Blue Motor Car Dam, Pandie Pandie	120	0.83	6.66	1	5	2		
14/12/07	Blue Motor Car Dam, Pandie Pandie	170	1.17	7.06	2	4	4		2

Table 1. Summary of all Elliot captures, showing species captured and trap success.

Table 2. Details of Kowaris captured at both sites.

Date	Site	Sex	Age	Breeding Condition	Weight (g)	PES (mm)	Wpt/Grid No.	Bait	Comments
11/12/2007	WAL Grid	F	Sub-adult	Pouch not visible	77	36	WE12	Fish oil & dog biscuits	
12/12/2007	WAL Grid	F	Sub-adult	Pouch not visible	71	32	WC10	Oats/Peanut Paste	
12/12/2007	WAL Grid	F	Sub-adult	Pouch not visible	59	33.7	WD31	Oats/Peanut Paste	Ran down dragon burrow on release
12/12/2007	WAL Grid	F	Sub-adult	Pouch not visible	61		WD04	Oats/Peanut Paste	Tick attached to end of ear. Ran down dragon burrow on release.
13/12/2007	Blue Motor Car Dam	F	Sub-adult	Pouch not visible	46	34.6	198	Oats/Peanut Paste & dog biscuits	Ran into small dragon hole, ~8m from trap in small sand mound ~0.5 m diameter
14/12/2008	Blue Motor Car Dam	M	Sub-adult		55	34.4	168	Oats/Peanut Paste & dog biscuits	Ran to burrow ~200m to NW
14/12/2008	Blue Motor Car Dam	M	Sub-adult		70	38.3	218	Oats/Peanut Paste & dog biscuits	

Table 3. *Summary of species observed during spotlighting*

Site	Date	Species
WAL Grid, Clifton Hills	10 & 11 Dec 2007	*Antechinomys laniger* *Notomys cervinus* *Pseudomys hermansbergensis* *Pogona vitticeps* *Diplodactylus byrnei*
Blue Motor Car Dam area, Pandie Pandie	12 &13 Dec 2007	*Antechinomys laniger* *Notomys cervinus* *Canis lupus dingo*

a)

b) 

Figure *2.* a) and b) Sub-adult female Kowari captured on Pandie Pandie Station, south of Blue Motor Car Dam.

Figure 3. *Female Kultarr, showing five small joeys attached to nipples in the pouch.*

***Figure 4.**. An active Notomys cervinus ‘pophole’.*

***Figure 5.** Sand mound habitat at the Walker’s Crossing trapping grid, Clifton Hills. Most mounds showed good growth of grasses and other vegetation from rainfall around 3 weeks prior, including Mitchell Grass (Astrebla sp.).*

Appendix

Table 4. *Summary of all species captured*

Species	Date	Site	Sex	Age	Recap	Breeding Cond	Weight (g)	PES (mm)	Wpt/Grid No.	Comments
Antechiomys laniger	11/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WB29	
Antechiomys laniger	11/12/2007	WAL Grid	F						WD05	
Antechiomys laniger	11/12/2007	WAL Grid	F	Adult		Pouch young			WD07	
Antechiomys laniger	11/12/2007	WAL Grid	F	Adult		Nipples distended			WD09	
Antechiomys laniger	11/12/2007	WAL Grid	F	Adult		Pouch young			WD13	
Dasycercus byrnei	11/12/2007	WAL Grid	F	Sub-Adult		Pouch not visible	77	36	WE12	
Sminthopsis macroura	11/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WB02	Run-on patch
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Nipples distended			WB30	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WB21	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WB30	
Antechiomys laniger	12/12/2007	WAL Grid	M	Adult					WB39	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WC39	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WC28	Very groggy on release
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WC--	
Antechiomys laniger	12/12/2007	WAL Grid	?	Adult					WC07	escaped
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WE10	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Enlarged pouch and nipples			WE11	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Pouch young			WD15	
Antechiomys laniger	12/12/2007	WAL Grid	M	Adult					WD09	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult	Y	Enlarged pouch and nipples			WE12	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Pouch young			WD08	
Antechiomys laniger	12/12/2007	WAL Grid	F	Adult		Nipples distended			WD03	
Dasycercus byrnei	12/12/2007	WAL Grid	F	Sub-Adult		Pouch not visible	71	32	WC10	
Dasycercus byrnei	12/12/2007	WAL Grid	F	Sub-Adult		Pouch not visible	59	34	WD31	Ran down dragon burrow on release
Dasycercus byrnei	12/12/2007	WAL Grid	F	Sub-Adult		Pouch not visible	61		WD04	tick attached to end of ear. Ran down dragon burrow on release.
Notomys cervinus	12/12/2007	WAL Grid	?	Adult					WE03	escaped
Sminthopsis macroura	12/12/2007	WAL Grid	M	Sub-Adult					WB01	
Antechiomys laniger	13/12/2007	Blue Motor Car Dam	M	Adult					171	
Antechiomys laniger	13/12/2007	Blue Motor Car Dam	m	Adult					170	
Antechiomys laniger	13/12/2007	Blue Motor Car Dam	F	Adult		Enlarged pouch and nipples			267	
Antechiomys laniger	13/12/2007	Blue Motor Car Dam	F	Adult					254	
Antechiomys laniger	13/12/2007	Blue Motor Car Dam	M	Juvenile					307	
Dasycercus byrnei	13/12/2007	Blue Motor	F	Sub-		Pouch not visible	46	35	198	Ran into small dragon hole, ~8m from trap in small

Species	Date	Site	Sex	Age	Recap	Breeding Cond	Weight (g)	PES (mm)	Wpt/Grid No.	Comments
		Car Dam		Adult						sand mound ~0.5 m diameter. 54J 0.373937, 7049291
Notomys cervinus	13/12/2007	Blue Motor Car Dam	F	Adult					118	
Notomys cervinus	13/12/2007	Blue Motor Car Dam	M	Adult					115	
Antechiomys laniger	14/12/2008	Blue Motor Car Dam	?	Juvenile					171	
Antechiomys laniger	14/12/2008	Blue Motor Car Dam	F	Adult		Enlarged pouch and nipples			268	
Antechiomys laniger	14/12/2008	Blue Motor Car Dam	F	Adult		Pouch young (5)			264	
Antechiomys laniger	14/12/2008	Blue Motor Car Dam	F	Adult		Enlarged pouch and nipples			258	
Dasycercus byrnei	14/12/2008	Blue Motor Car Dam	M	Sub-Adult			55	34.4	168	Ran to burrow ~200m to NW. 54J 0376794, 7052013
Dasycercus byrnei	14/12/2008	Blue Motor Car Dam	M	Sub-Adult			70	38	218	54J 0373318, 7050970
Notomys cervinus	14/12/2008	Blue Motor Car Dam	M	Adult					189	Ran to pophole ~100m to N
Notomys cervinus	14/12/2008	Blue Motor Car Dam	F	Adult					179	
Notomys cervinus	14/12/2008	Blue Motor Car Dam	F	Adult					232	Followed to pop-hole ~100m to E in sand spread
Notomys cervinus	14/12/2008	Blue Motor Car Dam	M	Adult		Testes scrotal				throat pouch obs
Notomys cervinus	14/12/2008	Blue Motor Car Dam	M	Adult						
Notomys cervinus	14/12/2008	Blue Motor Car Dam	M	Adult	Y					
Notomys cervinus	14/12/2008	Blue Motor Car Dam	M	Adult	Y					Ran to same 3 hole warren as yesterday
Notomys cervinus	14/12/2008	Blue Motor Car Dam	F	Adult						Ran to single hole on E side of track
Rattus villosisimus	14/12/2008	Blue Motor Car Dam	M	Adult			146			
Rattus villosisimus	14/12/2008	Blue Motor Car Dam	F	Sub-Adult			82			