INVERTEBRATES COLLECTED DURING THE SA DEPARTMENT FOR ENVIRONMENT & WATER OPERATION BOUNCEBACK AND SCIENTIFIC EXPEDITION GROUP BIOLOGICAL SURVEY 115; IKARA – FLINDERS RANGES NATIONAL PARK 16–26 SEPTEMBER 2018

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INTRODUCTION

The Ikara-Flinders Ranges National Park established in 1945, includes Wilpena Pound and the former sheep stations Oraparinna and Wilpena.

Quolls have been reintroduced into this area but they were competing with the wild cats. In 2016 the western half of this park was aerial baited for cats. The north-south highway being the dividing line and the eastern side of the highway was left unbaited. Six different vegetation sites were selected in the baited area and a corresponding vegetation site selected in the unbaited area.

History

In 1992 the *Bounceback* program was launched in the Flinders, Olary and Gawler Ranges of South Australia. The aim was to protect and restore the fragile semi-arid environments of these areas. Since the 1800's with European occupation, the resilience of the native animals has been sorely tested. Their capacity for recovery after drought has been diminished. Of the 54 original species of mammals in the Flinders Ranges, 20 species are now extinct (Lynch & Brandle, 2016).

Under *Bounceback* native vegetation has seen a marked improvement. Threatened species are rebuilding populations in response to fox control and improved habitat. The recovery of these semi-arid vegetation communities will take many decades and is dependent on good rainfall and grazing managements.

When livestock (sheep and cattle) were removed from former pastoral leases, (now managed for conservation), the new managers expected the country to bounce back. But with the removal of the top predator, (dingo baiting), the rabbits, goats and kangaroos have more than compensated for the reduction in grazing pressure with stock removal and native vegetation continues to decline.

Bounceback implemented an intensive rabbit control program in the mid-1990's targeting the low hills and plains east of Oraparinna. They have continued rabbit management, especially the rabbit warren ripping, for long-term vegetation recovery across the pastoral area.

Feral goats were a major environmental problem, with high densities in arid and semi-arid areas. They were one of the first animals to be removed physically in the *Bounceback* program, and then by aerial control with the help of the Sporting Shooters Association,

Rangers and contractors. This was very effective in the difficult terrain and has steadily reduced the numbers of goats.

Broad-scale fox baiting commenced in 1994 and has greatly reduced the numbers of this predator where dingoes have been excluded or controlled, resulting in the recovery of the Yellow-footed Rock-wallaby. Kangaroos are significantly higher today than before European settlement and kangaroo culling was introduced in the Flinders Ranges in 1999, targeting Euros, which had reached densities of more than 100/km^2 in some parts of the park.

Western Quolls were last recorded in the 1930's in the far North West of South Australia. Quolls were widespread in South Australia but the decline is considered to be due to the predation by cats and foxes as well as habitat loss and/or degradation. Years of overgrazing by sheep, goats, kangaroos and rabbits, has reduced the ground cover and maybe this is why quolls are more susceptible to cat predation (Moseby, 2018).

Location

Ikara-Flinders National Park is 400 km north of Adelaide, South Australia, situated in the Flinders Ranges. The survey base camp was at Oraparinna (30° 22' 47.8" S, 138° 44' 42.3" E), the headquarters of the National Park.

Climate

The annual average rainfall at Hawker (31.90° S, 138.44° E) in 2018 was 120.7 mm. Records have been kept since 1882.

The mean maximum temperature for September was 21.8° C, October was 26.0° C. The highest monthly maximum mean for September was 26° C and the lowest maximum monthly mean was 17.9° C. The mean minimum temperature for September was 6.6° C.

The highest monthly minimum mean for September was 9.7° C and the lowest monthly minimum mean was 3.2° C (BOM).

METHODS

Six different vegetation types were selected: Gum Coolibah (GC), Hop Bush (HB), Lemon Grass (LG), Native Pine (NP), River Red Gum (RG), and *Triodia* (TR). For each vegetation type, one site was in the baited (B) area and the other in the unbaited (U) area; a total of 12 sites, (six baited and six unbaited as detailed in **Table 1**).

Vegetation Types Selected

The six vegetation types selected were:

1. Gum Coolibah (GC), (*Eucalyptus intertexta*) open woodland over *Rhagodia* spp.
2. Lobe-leaved Hop Bush (HB), (*Dodonaea lobulata*), shrubland on rocky hills.
3. Lemon-scented Grass (LG), (*Cymbopogon* sp.) tussock grassland.
4. Native Pine (NP), (*Callitris glaucophylla*) open woodland.
5. River Red Gum, (RG), (*Eucalyptus camaldulensis*) woodland with shrub understorey along drainage lines.
6. Spinifex (TR), (*Triodia* sp.) hummock grassland.

Table 1: Vegetation type, Site Names, showing baited (B) or unbaited (U), and the site location denoted by GPS point in the middle macropit of each of the three traps at each site.

Site Vegetation	Site	Trap 1	Trap 2	Trap 3
Gum Coolibah (GC) *Eucalyptus intertexta*	**GCB**	31° 26' 09.6" S 138° 38' 59.6" E	31° 26' 12.2" S 138° 38' 57.6" E	31° 26' 11.1" S 138° 38' 55.7" E
	GCU	31° 26' 05.4" S 138° 04' 18.5" E	31° 26' 04.3" S 138° 44' 20.7" E	31° 25' 58.6" S 138° 44' 21.8" E
Hop Bush (HB) *Dodonaea lobulata*	**HBB**	31° 20' 22.7" S 138° 39' 49.6" E	31° 20' 24.2" S 138° 39' 49.1" E	31° 20' 25.4" S 138° 39' 50.8" E
	HBU	31° 20' 12.3" S 138° 42' 08.4" E	31° 20' 10.9" S 138° 42' 10.5" E	31° 20' 11.5" S 138° 42' 13.0" E
Lemon Grass (LG) *Cymbopogon* sp.	**LGB**	31° 23' 28.9" S 138° 41' 35.2" E	31° 23' 29.8" S 138° 41' 37.0" E	31° 23' 25.4" S 138° 41' 37.0" E
	LGU	31° 24' 02.2" S 138° 44' 17.6" E	31° 23' 57.1" S 138° 44' 22.4" E	31° 23' 55.2" S 138° 44' 26.4" E
Native Pine (NP) *Callitris glaucophylla* Open woodland	**NPB**	31° 20' 01.0" S 138° 41' 09.7" E	31° 19' 59.7" S 138° 41' 11.7" E	31° 20' 00.1" S 138° 41' 13.6" E
	NPU	31° 23' 08.5" S 138° 42' 40.0" E	31° 23' 09.6" S 138° 42' 37.9" E	31° 23' 09.6" S 138° 42' 36.2" E
River Red Gum (RG) *Eucalyptus camaldulensis*	**RGB**	31° 19' 50.6" S 138° 39' 07.9" E	31° 19' 49.7" S 138° 39' 12.4" E	31° 19' 47.4" S 138° 39' 19.0" E
	RGU	31° 18' 47.7" S 138° 42' 03.6" E	31° 18' 46.9" S 138° 42' 02.2" E	31° 18' 46.0" S 138° 42' 00.3" E
Spinifex (TR) *Triodia* sp.	**TRB**	31° 25' 06.2" S 138° 42' 00.2" E	31° 25' 06.9" S 138° 41' 57.5" E	31° 25' 07.0" S 138° 42' 01.9" E
	TRU	31° 25' 05.8" S 138° 42' 57.4" E	31° 25' 08.4" S 138° 42' 57.4" E	31° 25' 07.1" S 138° 43' 00.0" E

The Oraparinna shearers quarters was the Base Camp (30° 22' 47.8" S, 138° 44' 42.3" E).

At each site, three sets of traps were set out in a star formation (where possible, otherwise they were set out in a line). There were four macropits per trap, one in the centre of the star and three 10 m out on the arms of the star. Four invertebrate micropits were placed about 2 m out from the macropits in a clock-wise rotation.

Micropits were labelled and three-quarters filled with 75% ethanol. They were checked every day and topped up with 75% ethanol when needed. These micropits were left open for a maximum of seven days before being closed and brought back to Adelaide. Micropits were left open for seven nights except for site NPB that was left open for six nights. GCB, GCU, TRB and TRU were open 17–24 September 2018; HBB, HBU, RGB and RGU were open 18–25 September 2018; LGB, LGU, NPB and NPU were open 19–26 September 2018.

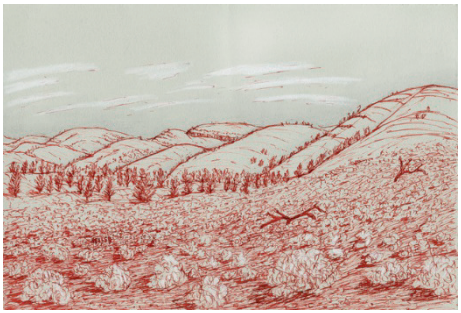
The Formicidae (ant Family members) were identified in Adelaide to genus, using Shattuck's 'Australian Ants' (1999). The Collembola (springtails) were numbered by description and the other invertebrates were sorted by their common name groupings by the author. All specimens are stored at the SA Museum Entomology Section.

Gum Coolibah Baited, GCB

Gum Coolibah Unbaited, GCU

Hop Bush Baited, HBB

Hop Bush Unbaited, HBU



Lemon Grass Baited, LGB

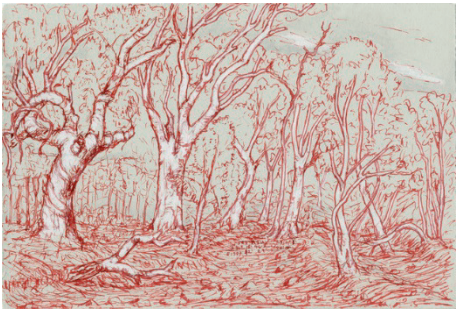
Lemon Grass Unbaited, LGU

Figure 1: 1-6 of 12 Ikara survey study sites illustrated - Flinders Ranges 2018.
The Quoll's future, Ikara, 2018, drawn by Annette Vincent. Medium: Pen and red ink drawings.
(Photograph reproduction by Black & White Photographers).

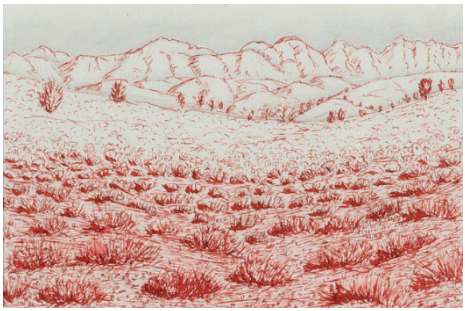
Native Pine Baited, NPB

Native Pine Unbaited, NPU

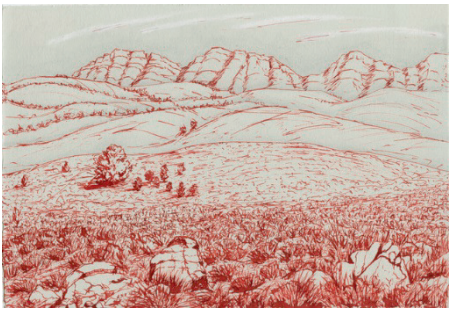
River Red Gum Baited, RGB



River Red Gum Unbaited, RGU



Triodia Baited, TRB



Triodia Unbaited, TRU

Figure 2: 7-12 of 12 Ikara survey study sites illustrated - Flinders Ranges 2018. Drawn by Annette Vincent.

RESULTS

Climate

The mean average rainfall for Hawker (weather station opened in 1868) was 283.2 mm. Hawker is 64.6 km SSW of Oraparinna. The last big rains in Hawker were in 2015, when the annual rainfall was 306.2 mm. The annual rainfall in 2018 at Hawker (31.90° S, 138.44° E) was 120.7 mm. The September 2018 rainfall totalled 6.8 mm (all on September 1st) with 25.6 mm falling in the previous three months. No rain fell during the survey period (BOM).

No daily temperatures were recorded at Hawker for the BOM database during the survey period in September 2018. Using the summary of statistics for all years, the overall mean daily maximum temperature was 21.8° C and the overall mean daily minimum temperature was 6.6° C (BOM).

Micropits Capture Summary

A total of 5,612 invertebrates were captured in the micropits over seven days from the 12 sites. The total number of specimens in the micropits from the baited sites was 3,117 (55.5%), and from the unbaited sites 2,495 (44.5%) (**Table 5**).

The Formicidae (ants) totalled 3,970 (70.74%) from 19 genera, a total of 2,237 (56.35%) from the baited sites and 1,733 (43.65%) from the unbaited sites (**Table 2**).

Collembola totalled 330 (5.88%) with 95 (28.8%) from the baited sites and 235 (71.2%) from the unbaited sites (**Table 3**). The "Other Invertebrates" totalled 1,312 (23.38%) with 785 (59.8%) from baited sites and 527 (40.2%) from unbaited sites (**Table 4**).

A total of 56 reptiles were collected in the baited areas and 27 in the unbaited areas; 28 different species of reptile were represented (Lynch & Brandle pers. comm.).

This year was the driest year for a long time, with a very dry 14 months prior to the survey. It was four years since the last big wet (BOM).

Formicidae Numbers (*Abundance*) and Genera (*Richness*)

The overall *abundance* of Formicidae was 3,970 (70.74% of all invertebrates captured in the micropits) with a *richness* of 19 genera. The baited sites had a total of 2,237 (56.35%) specimens and 1,733 (43.65%) from the unbaited sites. Five genera, *Iridomyrmex, Monomorium, Pheidole, Melophorus* and *Rhytidoponera* formed 95% (3,790) of the total 3,970 of Formicidae captured (**Table 2**).

There was some differences between baited and unbaited sites and vegetation types. The abundance in the unbaited sites GCU 287 (53%), LGU 418 (65.6%) and NPU 198 (61.3%) was larger than their corresponding baited sites. While in the HBB 927 (69.5%), RGB 510 (65.1%) and TRB 198 (58.1%) the abundance was higher in the baited sites than in the unbaited sites (**Table 2**).

The highest *abundance* was in the Hop Bush sites 1,334 or 33.6% of the total number of Formicidae collected. These Hop Bush sites were in flower and they had the highest numbers of *Monomorium* (618) and *Melophorus* (209) and the second highest number (416) of *Iridomyrmex* specimens from the survey. They were steep rocky sites, facing north or northwest, probably collecting the maximum sun and warmth for these Formicidae.

Table 2: Number of Formicidae (ants) collected in the micropits at each site.
B+U = Baited plus Unbaited sites, Veg. = Vegetation type.

Formicidae Genera	GCB	GCU	HBB	HBU	LGB	LGU	NPB	NPU	RGB	RGU	TRB	TRU	Total	Sites
Camponotus	16	4				1	1	8	3	1			**34**	**7**
Colobstruma								2					**2**	**1**
Crematogaster					1						22	45	**68**	**3**
Doleromyrma		1											**1**	**2**
Iridomyrmex	218	180	229	187	90	122	20	78	329	240	58	32	**1,783**	**12**
Melophorus	9	17	158	51	13	24	16	65	3	7	18	9	**390**	**12**
Meranoplus						3							**3**	**1**
Monomorium	2	2	517	101	74	99	20	26	8	18		2	**869**	**11**
Myrmecia										1			**1**	**1**
Notoncus					1								**1**	**1**
Nylanderia	3				9	7							**19**	**3**
Pheidole	3	77	20	56	21	151	47	7	163	11	31	30	**617**	**12**
Ponera	5	1											**6**	**2**
Rhytidoponera	1	2		10	1	4	18	6	2	1	69	24	**138**	**11**
Solenopsis		1						1					**2**	**2**
Stigmacros	1	1	1	1				1	2	1			**8**	**7**
Strumigenys							1	1					**2**	**2**
Tapinoma				1	9	1	1	3					**15**	**5**
Tetramorium		1	2			6	1					1	**11**	**5**
Total	**258**	**287**	**927**	**407**	**219**	**418**	**125**	**198**	**510**	**280**	**198**	**143**	**3,970**	**12**
Genera	9	11	6	7	9	10	9	11	7	8	5	7	**19**	
Total of B+U/Veg.	**545**		**1,334**		**637**		**323**		**790**		**341**			
% of B+U/Site	**47**	**53**	**69**	**31**	**34**	**66**	**39**	**61**	**65**	**35**	**58**	**42**		

Iridomyrmex (an aggressive ant) abundance was greatest in the four baited sites, GCB (218), HBB (229), RGB (329) and TRB (58) but not the unbaited sites of the LGU (122) and NPU (78) where it was greater in the unbaited sites. *Monomorium* had the greatest *abundance* in the baited site HBB (517) site but was more abundant in the LGU (99), NPU (26) and RGU (18) unbaited sites than baited sites (**Table 2**).

The total Formicidae *richness* was 19 (range 6–11 per site); it being greater in the unbaited sites than in the baited sites. The unbaited sites of the GCU and the NPU had the greatest *richness* (11 taxa) while the LGU site had 10 (**Table 2**).

Table 3: Numbers of Collembola (Spring tails) at each site.
B+U = Baited plus Unbaited sites, Veg. = Vegetation type.

Collembola	GCB	GCU	HBB	HBU	LGB	LGU	NPB	NPU	RGB	RGU	TRB	TRU	Total
Total	2	5	25	129	10	28	31	39	18	29	9	5	**330**
Types/Taxa	2	2	2	4	2	2	2	3	5	3	3	3	**6**
Total of B+U/Veg.	7		154		38		70		47		14		
% of B+U/Site	**29**	**71**	**16**	**84**	**26**	**74**	**44**	**56**	**38**	**62**	**63**	**36**	

Collembola

The *abundance* of Collembola (330) was greater in five unbaited sites, except for the Triodia site. The Hop Bush in flower (154) had the largest number of Collembola with Native Pine second (70). The total *richness* of the survey of Collembola was six with a range of 2–5 per site, (based on the number of different taxa I could recognize).

Other Invertebrates

The *Other Invertebrates* totalled 1,312 (23.38% of the total specimens in the micropits), with 785 (59.8%) from baited sites and 527 (40.2%) from the unbaited sites (**Table 4**).

Table 4: The number of *Other Invertebrates* collected in micropits (common name used for identity) at each site. B+U = Baited plus Unbaited sites, Veg. = Vegetation type.

Other Invertebrates	GCB	GCU	HBB	HBU	LGB	LGU	NPB	NPU	RGB	RGU	TRB	TRU	Total	Sites
Ant-lion									1				**1**	**1**
Beetle	304	4	3	13		1	5	2	13	19	1		**365**	**10**
Bug	1	2	20	8	35	22	10	5	3	4	28	17	**155**	**12**
Caterpillar						1			2		1		**4**	**3**
Cockroach										2			**2**	**1**
Earwig								1					**1**	**1**
Fly	16	8	8	8	7	8	4	7	18	24	5	8	**121**	**12**
Robber fly	24	25	5	3	7	6	2	18	51		12	1	**154**	**11**
Grasshopper		1							1				**2**	**2**
Insect?	6	4	2		1	2	6	2		2	5	1	**31**	**10**
Mite	6	12	18	35	11	43	27	21	11	35	14	19	**252**	**12**
Moth	3	1		4	1	1		1	1				**12**	**7**
Pseudoscorpion										2	1	1	**4**	**3**
Silverfish	1	1								8			**10**	**3**
Spider	2	6	16	7	10	10	4	6	2	3	13	30	**109**	**12**
Termite			1	4	1		2	2		11	20	10	**51**	**8**
Thrip				1	2	2			1	3	2		**11**	**6**
Wasp		3	3	4	3	3			2	8		1	**27**	**8**
Total	**363**	**67**	**76**	**87**	**78**	**99**	**60**	**65**	**106**	**121**	**102**	**88**	**1,312**	**12**
Genera	**9**	**11**	**9**	**10**	**10**	**11**	**8**	**10**	**12**	**12**	**11**	**9**	**18**	
Total of B+U/Veg.	**430**		**163**		**177**		**125**		**227**		**190**			
% of B+U/Site	**84**	**16**	**47**	**53**	**44**	**56**	**48**	**52**	**47**	**53**	**54**	**46**		

The *abundance* of *Other Invertebrates* was greater in the baited sites of the Gum Coolibah Baited, 363 (84%) and Triodia Baited 102 (53.7%) but not in the other sites, where the abundance was slightly greater in the unbaited sites, HBU 87 (53%), LGU 99 (56%), NPU 65 (52%) and RGU 121 (53%). The GCB site had an invasion of beetles 304 (range 7–96 per micropit over the three trap sites), while the GCU site had only four beetles over the three traps (12 micropits) (**Table 4**).

The total abundance of the baited sites was 785 (60%) and unbaited sites were 527 (40%) of the *Other Invertebrates*. Bugs had a greater abundance at four of the sites, the other two sites had only one specimen difference. The mites had greater abundance at five unbaited sites; only the NP site had a greater abundance in the baited site (**Table 4**).

The total *richness* of the Other Invertebrates (no. of taxa by common name) was 18 (range 8–12), the bugs, flies, mites and spiders occurred at all 12 sites. The robber flies and beetles occurred at 11 and 10 sites respectively (**Table 4**).

Table 5: Summary of all invertebrates captured in the micropits at each vegetation type.

	All Invertebrates		Formicidae		Collembola		Other Invertebrates	
Vegetation Type	Total	% B+U	Total	% B+U	Total	% B+U	Total	% B+U
GCB	623	63	258	47	2	29	363	84
GCU	359	37	287	53	5	71	67	16
HBB	1028	62	927	69	25	16	76	47
HBU	623	38	407	31	129	84	87	53
LGB	307	36	219	34	10	26	78	44
LGU	545	64	418	66	28	74	99	56
NPB	216	42	125	39	31	44	60	48
NPU	302	58	198	61	39	56	65	52
RGB	634	60	510	65	18	38	106	47
RGU	430	40	280	35	29	62	121	53
TRB	309	57	198	58	9	64	102	54
TRU	236	43	143	42	5	36	88	46
Total B sites	**3,117**	**56**	**2,237**	**56**	**95**	**29**	**785**	**60**
Total U sites	**2,495**	**45**	**1,733**	**44**	**235**	**71**	**527**	**40**
Total B+U	**5,612**		**3,970**		**330**		**1,312**	
% of Total		**100**		**71**		**6**		**23**

CONCLUSION

It is interesting to note that the Hop Bush, 1,651 (29.4%), RG 1,064 (18.9%), GC 982 (17.5%) and Lemon Grass, 852 (15.2%) vegetation types had the largest numbers of invertebrates captured in micropits, followed by Triodia, 545 (9.7%) and Native Pine, 518 (9.2%). This was strongly swayed by the number of beetles, 304, in the Gum Coolibah Baited site and the robber flies 51 and flies 24 at the Red Gum Baited and Red Gum Unbaited respectively. Native Pine Baited was a very dry site (**Table 5**). This year was a very dry year, with a very dry 14 months prior to the survey. It was four years since the last big wet (BOM 2018).

"During the survey 91 animals (77 reptiles and 14 mammals) were captured across the 12 sites during the seven days. It is interesting to note the distinct difference in the reptile numbers between the baited areas 49 (63.6%) and the unbaited 28 (36.4%) areas. This suggests the baiting program may be having a positive impact on other species." (Lynch & Brandle pers. comm.).

The overall abundance of invertebrates 3,117 (55.5%) at the baited sites compared to the unbaited sites 2,495 (44.5%) shows an improvement in abundance after cat baiting. This follows the trends shown in the reptiles and mammals. The population abundance of reptiles at the different vegetation sites may shine some light on why three vegetation types had more ants in the baited area, yet the other three vegetation sites had more ants in the unbaited area.

In the vegetation types the abundance at LGU (545) and NPU (302) is larger than their corresponding baited sites. However, in the HBB (1028), RGB (634) and TRB (309, the abundance is higher in the baited sites than in the unbaited sites (**Table 5**).

The biggest differences between baited and unbaited sites, change was with the Collembola. They are near the bottom of the food chain. The baited area was very low in abundance 95 (28.8%) whereas unbaited area had 235 (71.2%). It raises the question whether the cat-baiting is killing the Collembola as well? Or perhaps Collembola are the first to feel the effect of fewer cats, and more lizards to eat them. This has not shown up in the Formicidae population however. The overall numbers of Formicidae in the baited sites were 2,237 (56.4%), whereas the unbaited sites were similar with 1,733 (43.6%) (Table 5). This survey occurred only two years since the cat baiting occurred. It will be interesting to see what changes happen over another two years.

The vegetation type and flowering state can make a big difference to the abundance of invertebrates especially for beetles and Formicidae. Baiting for cats seems to be worthwhile. The increased numbers of invertebrates at four of the baited sites should mean there is more food for the lizards and reptiles. However this increase could be due to recent rains or the loss of lizards and reptiles eaten by cats. The reasons for the larger abundance at the unbaited sites of LGU 545 (64%) and NPU 302 (58%) (Table 5) are unknown. It is possible these sites received more local rain than the baited sites.

Overall the numbers of lizards and reptiles are likely to increase (since there are fewer cats to eat them), and provide more food for the quolls. Is it possible that there will be a drop in Formicidae numbers as the lizard numbers increase, and the quoll numbers increase? Can the invertebrates keep up their numbers at the base of this food chain? Future surveys that include the micropits will determine how this will pan out.

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