

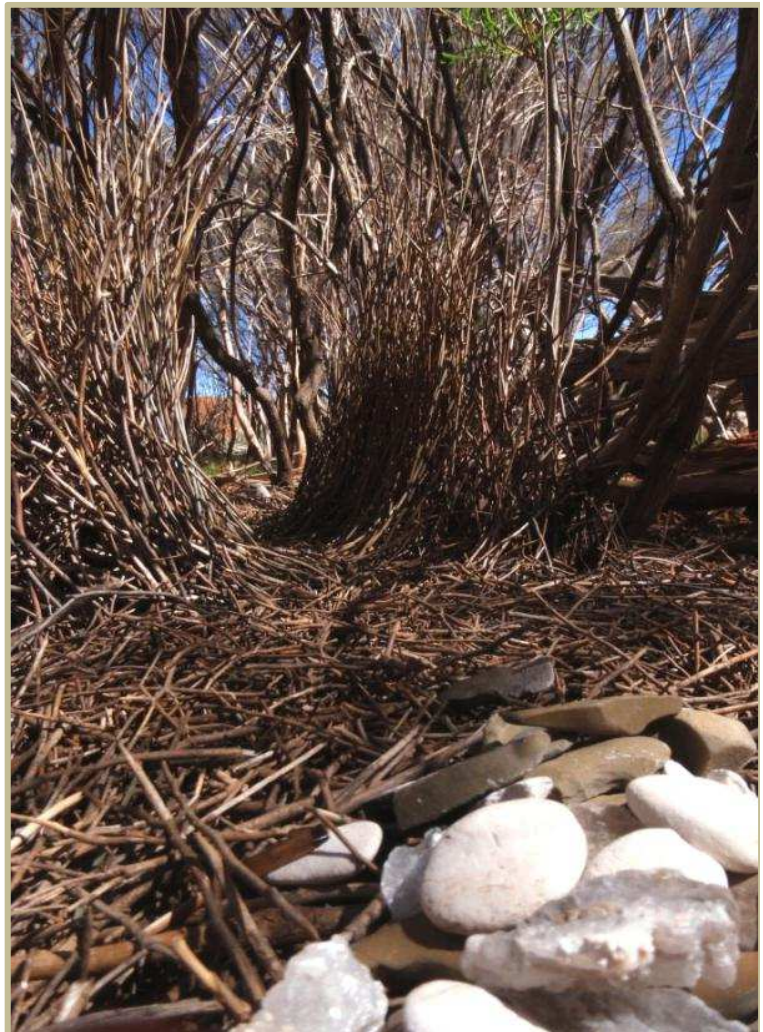


Roy Hill Iron Ore Pty Ltd
Monitoring Short Range
Endemic Invertebrates at
the Roy Hill I Mine

Final Report

Prepared for the Roy Hill Iron Ore
Pty Ltd
by Bennelongia Pty Ltd

June 2011
Report 2011/I15



Monitoring Short Range Endemic Invertebrates at the Roy Hill 1 Mine

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Front cover: Photo of bowerbird nest in site TR02

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EXECUTIVE SUMMARY

Environmental approval for the Roy Hill Iron Ore Mining Project Stage 1 on the southern slopes of the Chichester Range, 110 km north of Newman in the Pilbara this Project was given on 22 December 2009, subject to a series of Ministerial Conditions (Ministerial Statement 824).

Condition 9 of Ministerial Statement 824 is intended to ensure the protection of five species of potential short range endemic (SRE) invertebrate species found on the Roy Hill 1 mine site. Exclusion zones of 50 m radius are maintained around the places these species were recorded. A program of annual monitoring is required to ensure that the populations of SREs in the exclusion zones are being maintained during mine operation

This report provides the results of the first year of SRE monitoring at the Roy Hill 1 minesite, with particular reference to Condition 9-3. The Department of Environment and Conservation and the Western Australian Museum were consulted about the design of the monitoring program, which was approved by the Environmental Protection Authority in December 2010.

Eighteen sites were surveyed for SREs in February 2011. Seven of the sites were exclusion zones within the Roy Hill 1 mine site; the other 11 sites sampled were outside the mine site. The surveys were intended to document the occurrence of the mygalomorph spiders *Aganippe* 'MYG126', *Idiommata* sp. 'MYG128', *Missulena* sp. and *Synothele* 'MYG127' and the pseudoscorpion *Beierolpium* sp.

A total of 503 active mygalomorph spider burrows were found and 117 individuals belonging to six species were dug up from the burrows and identified. Three of the four species targeted for monitoring were collected: *Aganippe* 'MYG126' was widespread with much smaller numbers of *Missulena* sp. and *Synothele* 'MYG127'. All three species were recorded outside the mine site, as well as within it. *Idiommata* sp. 'MYG128' was not recorded.

In addition to the targeted species, three other species of mygalomorph spider were recorded: *Aname* sp., *Conothele* sp. and *Missulena* sp. B3 (a second species of this genus).

Only 24 individual pseudoscorpions, belonging to five species, were collected. The targeted pseudoscorpion, *Beierolpium* sp., was not found although it had been collected widely from the outside periphery of the mine site in 2010. In addition to the targeted species, five other species of pseudoscorpion were recorded: *Indolpium* sp. B1, *Indolpium* sp. B4, *Austrochthonius* sp., Olpiidae (unknown genus) sp. B2 and Olpiidae (nr *Austrohorus*) sp. B3.

For species known to occur outside the Roy Hill 1 mine site, it is recommended that:

1. Habitat condition of selected sites should be monitored every three years to ensure the persistence of suitable habitat for these species. Management targets for these sites are proposed.
2. Monitoring should measure a combination of total plant cover, plant species richness and litter index to ensure compliance with the management targets for each site.
3. Additional sampling should be undertaken to identify more sites where the spiders *Missulena* sp. and *Synothele* sp. 'MYG127' occur to provide appropriate sites for habitat monitoring.

For the one species (*Idiommata* sp. 'MYG128') known only from the Roy Hill 1 mine site, it is recommended that:

4. Additional sampling should be undertaken to identify occurrences of *Idiommata* sp. 'MYG128'.

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1. INTRODUCTION

Roy Hill Iron Ore Pty Ltd operates, and is the proponent for, the Roy Hill Iron Ore Mining Project Stage 1 on the southern slopes of the Chichester Range, 110 km north of Newman in the Pilbara. Environmental approval for this Project was given on 22 December 2009, subject to a series of Ministerial Conditions (Ministerial Statement 824).

A survey of short range endemic (SRE) invertebrates undertaken between May and July 2009 by Ecologia, using in wet-pit trapping, had shown that several potential SRE species occurred within the Roy Hill 1 mine site (Framenau and Harvey 2009). Earlier surveys using only foraging and seven days of dry-pit trapping did not collect any potential SRE species (Ecologia 2006, 2008). The potential SRE species at the Roy Hill 1 mine site were the mygalomorph spiders *Missulena* sp., *Synothele* 'MYG127', *Idiommata* 'MYG128', *Aganippe* 'MTG126' and the pseudoscorpion *Beierolpium* sp. Only female *Missulena* sp. were collected and males are needed to assess the conservation status of this species. The conservation status and, in some cases, taxonomy of the other species is also uncertain.

Mygalomorph spiders live in burrows nearly all the time, emerging only to catch prey or, in the case mostly of males, to disperse small distances. The locations of the burrows of the pit-trapped SRE spiders were unknown but they were assumed, when constructing Ministerial Conditions, to be near the site of capture.

1.1. Ministerial Condition 9

Condition 9 of Ministerial Statement 824 adopted a precautionary approach to the conservation of the potential SRE species and required that exclusion zones of 50 m radius be maintained around the points where potential SRE species were captured. A program of annual monitoring was also required to ensure that the populations of SREs in the exclusion zones were being maintained during mine operation. Condition 9 stated:

Condition 9-1. The proponent shall implement the proposal to avoid disturbance to areas where *Missulena* sp., *Synothele* 'MYG127', *Aganippe* 'MYG126', *Idiommata* 'MYG128' and *Beierolpium* sp. have been recorded as shown in Figure 4 attached and delineated by MGA coordinates specified in Schedule 3.

Condition 9-2. The proponent shall install and maintain fencing and signage around areas specified in Schedule 3 and delineated in Figure 4 to prevent access by humans or machinery.

Condition 9-3. The proponent shall monitor the population sizes of the species *Missulena* sp., *Synothele* 'MYG127', *Aganippe* 'MYG126', *Idiommata* 'MYG128' and *Beierolpium* sp. within the areas specified in Schedule 3 and delineated in Figure 4 to verify that the requirements of Condition 9-1 are met. This monitoring is to be carried out to the satisfaction of the CEO and in liaison with the Western Australian Museum and is to be carried out in such a way that, if a significant decline in the population of any of the above taxa is detected, it will be possible to determine whether the decline is attributable to the implementation of the proposal [Roy Hill 1 Mine] or to other factors.

Condition 9-4. The proponent shall submit annually the results of monitoring required by Condition 9-3 to the CEO.

Condition 9-5. In the event that monitoring required by Condition 9-3 indicates a decline in the population of any or all of the taxa:

- the proponent shall report the findings to the CEO within 21 days of the decline being identified;
- the proponent shall provide evidence which allows determination of the cause of the decline;
- if determined by the CEO to be the result of activities undertaken in implementing the proposal, the proponent shall submit actions to be taken to remediate the decline to the CEO; and
- the proponent shall implement actions to remediate the decline upon approval of the CEO and shall continue such actions until such time as the CEO determines that the remedial actions may cease.

Condition 9-6. The proponent shall make the monitoring reports required by Condition 9-3 publically available in a manner approved by the CEO.

1.2. Monitoring framework

The report provides the results of the first year of SRE monitoring at the Roy Hill 1 minesite, with particular reference to Condition 9-3. The Department of Environment and Conservation (DEC) and the Western Australian Museum (WAM) were consulted about the design of the monitoring program. The subsequent *Proposed Monitoring Plan for Short Range Endemic Invertebrate Species at the Roy Hill 1 Mine*, which was approved by the Environmental Protection Authority (EPA) in December 2010, is based on a staged approach to monitoring, with an initial baseline survey to confirm the occurrence of SREs in the exclusion zones and to examine the wider distribution of these species. Subsequently, analysis of sampling results will identify which species require further monitoring and which do not, and then annual monitoring of any restricted species will be undertaken. The main features of the monitoring design are provided below.

Phase 1 – baseline survey. An intensive survey will be conducted during the summer and autumn of 2011 of the exclusion zones at areas specified in Schedule 3 and delineated in Figure 4 of Condition 9 (sites 4, 7, 9, 10a, 11, 13, 15 and 16). The purpose of the survey will be:

For spiders

1. To determine the number of active burrows present within each exclusion zone and the species of spider (*Missulena* sp., *Synochele* 'MYG127', *Idiommatata* 'MYG128', *Aganippe* 'MYG126') occupying these burrows.
 - Representative burrows at each site will be dug up to retrieve spiders and these spiders will be identified using morphological and genetic techniques to determine which (if any) of the four spider species to be monitored occurs in the exclusion zone.
 - The characteristics of the burrows of each spider species will be documented to enable species determinations to be made in the exclusion zones based on burrow characteristics.
 - A fiberscope will be used to determine whether spiders are present in remaining burrows.
 - All spider burrows will be mapped.
2. To determine whether species are restricted to the exclusion zones on Roy Hill 1 Mine or whether they occur more widely.
 - Drainage lines around the Mine will be intensively surveyed for the four spider species.

For pseudoscorpions

3. To determine whether the pseudoscorpion *Beierolpium* sp. is present in the exclusion zones of sites 10a and 13 (and any other sites).
 - The habitat characteristics of each site will be measured and related to the presence or absence of the pseudoscorpion.

4. To determine whether the pseudoscorpion is restricted to the exclusion zones on Roy Hill 1 Mine or whether it occurs more widely.
 - Drainage lines around the Mine will be intensively surveyed for *Beierolpium* sp.

Phase 2 – determine species to be monitored. Results of the baseline survey will be compiled and the distribution of the five potential SRE species will be re-evaluated in relation to whether they occur in the exclusion zones listed in Condition 9 or they have a wider distribution. A report will be prepared in accordance with Conditions 9-4 and 9-6. This report will contain recommendations about:

5. Species that require future monitoring, the sites where these species should be monitored, and the monitoring targets to be used.
 - Monitoring targets for spiders will be related to the number of active burrows of each spider species at a site.
 - Monitoring targets for the pseudoscorpion will be related to habitat condition at a site.
6. The species that appear to be under no threat from development of the Roy Hill 1 Mine and which do not require monitoring.
 - Management targets will be proposed to protect the habitat of these species but there will be no species monitoring.

Phase 3 – annual monitoring. Annual monitoring will be undertaken for species known only from Roy Hill 1 Mine or for which most of the known population is located within the mine site.

For species being monitored

7. Monitoring will be undertaken at all exclusion zones within the Roy Hill 1 Mine where the species occurs.
8. Monitoring will be undertaken in such a way as to enable reporting against the monitoring targets determined in Phase 2 of the program.

For species not being monitored

9. Habitat condition of the sites outside the mine site where the species occurs will be reported, using the management targets as the basis for monitoring.

1.3. Report content

This report deals principally with Phases 1 and 2 of the monitoring program. In Phase 1 a baseline survey was conducted in the exclusion zones to confirm which potential SRE species were present and in surrounding areas to show wider distribution of the SRE species. In Phase 2 the species requiring further monitoring were identified and monitoring targets were derived for these species. Management targets were derived for other species. Phase 3 will be addressed in 2012.

2. METHODS

2.1. Sites surveyed

Eighteen sites were surveyed for SREs (Figure 1). Ministerial Statement 824 identified eight exclusion zones for monitoring. However, sites 9 and 11 have the same coordinates and represent a single exclusion zone, so that only seven exclusion zones were sampled (Table 1). In addition, 11 sites outside the mine site were surveyed for wider occurrence of species found on the mine site.

Two of the sites, exclusion zone 10a and site TR02 outside the mine, were located on the footslopes of the Chichester Range, where water is funnelled into drainage lines that flow across rocky substrate. These drainage lines supported *Grevillea wickhamii*, acacias and grasses. The surrounding country was covered in sparse spinifex and woody perennials.

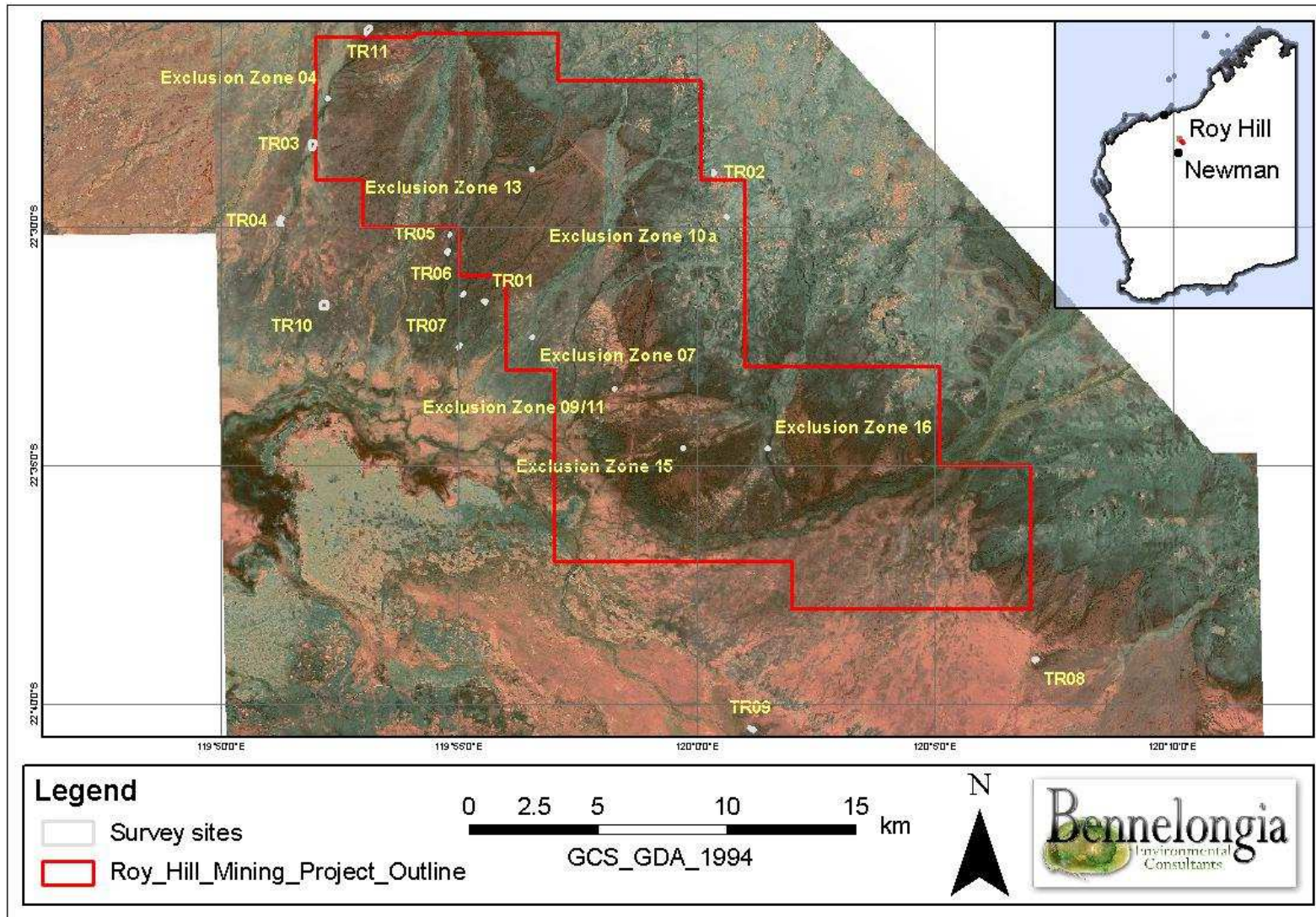


Figure 1. Map of sites surveyed for SREs in February 2011.

Table 1. Details of sites sampled in SRE monitoring program (coordinate centroids provided).

Site Name	Site classification	Site coordinate	Area (m ²)	Dominant vegetation
Site 04	Exclusion zone	-22.45477 S, 119.87086 E	7825	Closed mulga woodland
Site 07	Exclusion zone	-22.53833 S, 119.94235 E	7826	Open mulga woodland
Site 09/11	Exclusion zone	-22.55656 S, 119.97030 E	7826	Open mulga woodland
Site 10a	Exclusion zone	-22.49618 S, 120.01038 E	7826	Open triodia-senna grassland
Site 13	Exclusion zone	-22.47936 S, 119.94214 E	7826	Closed mulga woodland
Site 15	Exclusion zone	-22.57691 S, 119.99519 E	7826	Closed mulga woodland
Site 16	Exclusion zone	-22.57717 S, 120.02470 E	7827	Closed mulga woodland
TR01	Off mine-site	-22.52588 S, 119.92579 E	16011	Open mulga woodland
TR02	Off mine-site	-22.48081 S, 120.00587 E	10915	Open mulga woodland
TR03	Off mine-site	-22.47117 S, 119.86553 E	57416	Closed mulga woodland
TR04	Off mine-site	-22.49795 S, 119.85420 E	37159	Open mulga woodland
TR05	Off mine-site	-22.50245 S, 119.91354 E; -22.50850 S, 119.91271 E	13855	Closed mulga-A. <i>atkinsiana</i> woodland
TR06	Off mine-site	-22.52313 S, 119.91825 E	8969	Closed mulga-A. <i>atkinsiana</i> woodland
TR07	Off mine-site	-22.54148 S, 119.91679 E	10888	Open mulga woodland
TR08	Off mine-site	-22.65112 S, 120.11833 E	18807	Open mulga woodland
TR09	Off mine-site	-22.67540 S, 120.01915 E	17664	Open mulga woodland
TR10	Off mine-site	-22.52702 S, 119.86944 E	60659	Open mulga woodland
TR11	Off mine-site	-22.43075 S, 119.88497 E	46037	Closed mulga-A. <i>atkinsiana</i> woodland

The other sites were located on the floor of the Fortescue Valley, where the alluvial soil consists of clay-loam pinndan. Numerous drainage lines meander across the plain towards the Fortescue Marsh. Thickets of *Acacia aneura* and other acacias occurred along these drainage lines. The surrounding plain supported *Triodia* grasslands and scattered trees. Descriptions of the sites are provided in Appendix 1.

2.2. Antecedent rainfall

Conditions were relatively wet during the period of survey, with 158 mm of rain recorded at Bonney Downs (60 km north of Roy Hill) during the five weeks prior to survey. Average annual rainfall for January and February combined is 135 mm.

2.3. Field sampling

Field sampling occurred between 7 and 10 February 2011.

2.3.1. Mygalomorph Spiders

Each site was sampled for spiders by intensive searching to find the burrows of the four targeted species of trapdoor spider, using shape of the burrow and lids (or the absence of lids) to identify the species present. Representative burrows at each site were dug up to retrieve spiders in them and confirm identification of species. Collected spiders were preserved in 100% ethanol.

At most burrows, a fiberscope was inserted down the burrow to determine whether it was occupied but when burrows were numerous at a site occupancy of some burrows was determined by the condition of the lid and the silk lining at the top of the burrow.

The locations of all burrows were recorded using a GPS. Where no burrows were located within the designated exclusion zone, adjacent areas were also searched.

2.3.2. Pseudoscorpions

Pseudoscorpions were surveyed by searching in areas where litter had accumulated or begun to decompose (e.g. around trees, in depressions, next to rocks and logs and in dry river beds). Field staff sifted through litter and associated soil to a depth of around 5 cm, searched under bark of young and old trees, and searched under logs and rocks for pseudoscorpions. Litter and soil was also collected in calico bags and freighted to Perth for sorting in the laboratory. All pseudoscorpions caught in the field were preserved in 100% ethanol.

2.3.3. Spider burrow characterisation

The characteristics of the active burrows of each spider species were documented to improve the ability to determine the spiders present at a site by examination of burrows alone.

2.3.4. Habitat characterisation

Habitat at each site was characterised by inspecting the site and assigning representative values to five sets of attributes. These related to landform, type of vegetation (visual estimate of cover and height of all species, dominant vegetation), litter (cover according to three categories), complexity of ground habitat (occurrence of logs, woody debris, rocks) and disturbance (extent of fire, grazing).

2.4. Laboratory processing

Soil and litter samples were passed through a 2 mm sieve. Large pieces of litter retained in the sieve were discarded, after checking for presence of any animals, and material that passed through the sieve was searched using a 2.25 x magnifying lamp.

Mygalomorph spiders and pseudoscorpions were identified to species or morphospecies level, to the extent possible. Reliable species level identifications of mygalomorph spiders are possible only for adult male specimens, although females can be assigned to genus and it is usually possible to determine whether one or more species occur in a group of female specimens. DNA analysis was used to establish species level relationships amongst selected female spiders.

Legs from 20 mygalomorph specimens were analysed by the South Australian Museum for a 455 base pair sequence of the CO1 gene (Appendix 2). This included eight specimens collected during previous field work at the Roy Hill 1 mine site by Ecologia.

2.5. Personnel

Fieldwork was undertaken by Michael Curran, Grant Pearson, Jim Cocking and Dean Main. Sample sorting was carried out by Jane McRae and Heather McLetchie. Identifications were made by Jane McRae and Michael Curran. Assistance with identifications was provided by Mark Harvey and Julianne Waldock (WAM) for pseudoscorpions and mygalomorph spiders, respectively. DNA analysis was undertaken by Remko Leijds (South Australian Museum).

3. RESULTS

3.1. Survey results

3.1.1. Mygalomorph spiders

A total of 503 active mygalomorph spider burrows were found. In total, 117 individuals belonging to six species were dug up from the burrows and identified. Three of the four species targeted for monitoring

were collected (43 specimens from 472 active burrows, Table 2). These spiders were predominantly *Aganippe* 'MYG126', with much smaller numbers of *Missulena* sp. and *Synothele* 'MYG127' (Table 2, Figure 2).

Active burrows of *Aganippe* sp. 'MYG126' were widespread amongst exclusion zones (312 burrows) and off-mine sampling sites. Allowing for occurrence slightly outside the exclusion zone, *Aganippe* sp. 'MYG126' burrows were found in all the exclusion zones where *Aganippe* sp. 'MYG126' was recorded during environmental assessment surveys (exclusion zones 04, 07, 09/11, 15), as well as in 82% of sites sampled outside the mine (Table 2, Appendix 3).

Ten active burrows of *Missulena* sp. were found in exclusion zone 16, where previously recorded, as well as a further 11 burrows in or near exclusion zones 09/11 and 15. Three burrows were found at one site outside the mine (Appendix 3).

Ministerial Statement 824 did not list locations of *Synothele* sp. 'MYG127' but it was trapped in exclusion zones 09/11 and 10a during environmental assessment (Ecologia unpublished data). In this survey, three active burrows were recorded in exclusion zones 13 and 16 and three burrows were recorded at three sites outside the mine (Table 2).

The fourth species targeted for monitoring, *Idiommata* sp. 'MYG128', was not located during this survey, although five disused burrows that were seen in exclusion zone 13 may belong to this species (Appendix 4).

In addition to the targeted species, small numbers of three other mygalomorphs were collected: *Aname* sp. (exclusion zones 10a, 15, 16 and 36% of sites sampled outside the mine), *Conothele* sp. (exclusion zone 16 and 45% of outside sites) and *Missulena* sp. B3 (a single outside site) (Appendix 3).

3.1.2. Pseudoscorpions

Twenty-four individual pseudoscorpions, belonging to five species, were found by foraging or in litter samples in February 2011. The targeted pseudoscorpion, *Beierolpium* sp. not was not found in exclusion zones 10a and 13, where previously collected (Table 2). However, a species of *Indolpium* collected at both sites is likely to match previous records (Framenau and Harvey 2009). In the previous sampling, *Beierolpium* sp. occurred in lower abundance at these sites than *Indolpium*.

The pseudoscorpions collected in February 2011 were *Indolpium* sp. B1 (exclusion zones 10a and 13), *Indolpium* sp. B4 (outside the mine), *Austrochthonius* sp. (exclusion zone 02), Olpiidae (unknown genus) sp. B2 (exclusion zones 10a and 13 and outside the mine) and Olpiidae (nr *Austrohorus*) sp. B3 (outside the mine) (Table 2).

3.2. DNA results

Specimens identified as *Missulena* sp. and *Synothele* sp. 'MYG127' in February 2011 had similar DNA sequences to specimens collected during previous environmental assessment and lodged in WAM, confirming that the species collected in 2011 are those referred to in Ministerial Statement 824. It should be noted, however, as a point of general scientific interest that both species exhibited significant within-population genetic variation in February 2011 (about 5%, Appendix 2). The WAM specimen of *Aganippe* sp. 'MYG126' did not yield DNA; however, morphological analysis of males suggested that specimens identified as *Aganippe* sp. 'MYG126' in 2011 matched the targeted species.

Table 2. Numbers of active burrows seen of mygalomorph spider species, and specimens collected of pseudoscorpion species, during baseline survey in February 2011.

Grey-highlighted cells represent sites where species were collected during environmental assessment.

Species	Exclusion zone							Outside mine site											Total
	04	07	09/11	10a	13	15	16	TR01	TR02	TR03	TR04	TR05	TR06	TR07	TR08	TR09	TR10	TR11	
Mygalomorphae																			
<i>Aganippe</i> sp. 'MYG126'	26	132	98				56	43		26	8	16	19	4	4		5	5	442
<i>Aname</i> sp.				1			1	2					1		1	1		2	9
<i>Conothele</i> sp.								1		3				5	9		2	1	21
<i>Idiommata</i> sp. 'MYG128'																			
<i>Missulena</i> sp.			5				6	10					3						24
<i>Missulena</i> sp. B3															1				1
<i>Synothele</i> sp. 'MYG127'					1			2						1	1			1	6
Pseudoscorpionida																			
<i>Austrochthonius</i> sp.							2												2
<i>Beierolpium</i> sp.																			
<i>Indolpium</i> sp. B1				6	3														9
<i>Indolpium</i> sp. B4															2				2
Olpidae (unknown genus) sp. B2				1	1							2	1		1				6
Olpidae(nr <i>Austrohorus</i>) sp. B3									2						3				5

Table 3. Summary of site characteristics and numbers of mygalomorph spiders and pseudoscorpions recorded.

The most desirable condition of each attribute (other than habitat type and dominant species) has darkest shading. Maximum mygalomorph and pseudoscorpion numbers should align with darkly shaded environmental variables. Crk, creekline; Aa, *Acacia aneura*; Aat, *Acacia aneura/atkinsiana*; Vf, *Vachellia farnesiana*.

Attribute	Exclusion zone							Outside mine site											
	04	07	09/11	10a	13	15	16	TR01	TR02	TR03	TR04	TR05	TR06	TR07	TR08	TR09	TR10	TR11	
Habitat type	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk	Crk
Total vegetation cover (%)	94	57	58	118	85	97	100	54	59	94	68	119	79	68	62	64	91	132	
Predominant height ¹ . (m)	7	7	7	1	7	7	7	7	7	7	7	4	7	7	7	7	4	7	
Dominant species	Aa	Aa	Aa	Se	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aat	Aat	Aa	Aa	Aa	Vf	Aat	
No. of plant species	13	10	11	14	12	8	10	11	8	12	11	11	7	7	7	7	6	12	
Litter index	38	3.2	0.2	0.2	135	130	26	3.2	6.2	15	3.2	123	15	15	15	3.2	1.8	95	
Soil (1 rocky, 2 pindan)	2	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2	
Fire (0 none, 3 severe)	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	
Grazing (0 none, 3 severe)	1	2	1	0	1	1	1	2	1	1	2	1	2	2	2	3	3	0	
No. of mygalomorph burrows	26	132	103	1	1	63	15	43	0	29	8	16	23	10	16	1	7	9	
No. of mygalomorph species	1	1	2	1	1	3	4	1	0	2	1	1	3	3	5	1	2	4	
No. of pseudoscorpions	-	-	-	7	6	-	-	-	2	-	-	2	1	-	6	-	-	-	

¹ height of vegetation contributing most cover



Figure 2. Invertebrates collected during monitoring of Roy Hill in February 2011. A, *Missulena* sp.; B, Olpiidae (nr *Austrohorus*) sp. B3; C, *Synothele* 'MYG127'; D, *Aganippe* sp. 'MYG126'.

3.3. Spider burrows

Many mygalomorph species can be identified by the structure of their burrows and burrow lids. However, some species have similar burrow designs and the reliability of burrow-based identifications is uncertain, particularly when the incompleteness of mygalomorph taxonomy is taken into account, with many unrecognised species. The characteristics of the burrows of the spider species encountered during the survey are illustrated in Appendix 4. The burrows of some other invertebrate groups occurring in the vicinity (e.g. wolf spiders, crickets) are also illustrated to make correct identification of spider burrows easier. The targeted species had the following types of burrows:

- *Aganippe* sp. 'MYG126'. Female. Trapdoor consisting of thick clay plug with silk on inside. Burrow vertical with thick silk lining. Male has a thin trapdoor with leaves and twigs attached, similar to the trapdoors made by some *Conothele* mygalomorphs.
- *Idiommata* sp. 'MYG128'. Burrow characteristics are unknown. A possible burrow type is illustrated in Appendix 3 (unknown mygalomorph burrow). It appeared to have a silk lid. Burrow is vertical, possibly silk-lined.
- *Missulena* sp. Burrows look old and decrepit when active. Trapdoor has dual-lid. Burrow is vertical, oval shaped, with sparse silk lining.
- *Synothele* sp. 'MYG127'. Burrow is cryptic, under leaves or dirt. Trapdoor is unlikely to be seen. Burrow is silk-lined.

3.4. Habitat characterisation

The biophysical characteristics of each site sampled in February were documented (Table 3, Appendix 5). There was no statistical relationship between the measured biophysical attributes of a site summarised in Table 3 and the numbers of mygalomorph spider burrows seen for either total vegetation cover, number of plant species or litter index ($r < -0.15$, 0.05, 0.10, 16 df, respectively, $P > 0.5$ in all cases). Formal analyses were not conducted for other biophysical attributes or for the number of pseudoscorpions collected but visual inspection of the data (Table 3) suggested these relationships were even weaker. However, an examination of the mapped distribution of mygalomorph burrows suggests they are restricted to areas of denser woodland along creeklines (Appendix 3). It is likely that no relationships were detected in the analyses undertaken because sampling most restricted to prospective habitat. Data on habitat characteristics (accompanied by searches for burrows) should be collected from a range of habitats across the landscape to determine the factors controlling the occurrence of mygalomorph spiders and other SRE taxa. This was outside the scope of the current survey program, which focused on sampling the habitats considered most likely to yield the targeted species.

Sites TR08 and TR11 outside the mine and exclusion zone 16 supported the largest numbers of species of mygalomorph spiders (although not most burrows). Examination of the biophysical data and photographs of the sites provided no explanation for the higher numbers of mygalomorph species (Appendices 1, 5).

4. DISCUSSION

4.1. Baseline survey

Baseline survey of the exclusion zones at Roy Hill 1 mine site and adjacent creeklines showed that three of the four mygalomorph species targeted for monitoring occur outside the mine site (*Aganippe* sp. 'MYG126', *Missulena* sp., *Synothele* sp. 'MYG127'). Given that only a very small area of outside habitat

was surveyed (Figure 1), it is likely that most of the populations of all three species occur outside the Roy Hill 1 mine site.

During the survey of mine-site exclusion zones, *Aganippe* sp. 'MYG126', which had abundant burrows, was found only at sites where animals had previously been trapped (Framenau and Harvey 2009). *Missulena* sp., which had substantially lower abundance of burrows, was recorded within the mine site in the exclusion zone where it was previously trapped and at two other exclusion zones. In contrast *Synothele* sp. 'MYG127', which had even less abundant burrows, was not located in the two exclusion zones where it was previously recorded. Three burrows were found, however, in another two exclusion zones. It is likely that all mygalomorph species are more widespread within the mine site, as well as outside, than previously recognized. For example, *Synothele* sp. 'MYG127', was found about 15 and 60 km west of the Roy Hill 1 mine site during one survey (Bennelongia 2010) and immediately east of the mine site in another (Ecologia 2010).

The other two species targeted for survey, the mygalomorph *Idiommata* sp. 'MYG128' and the pseudoscorpion *Beierolpium* sp., were not collected in February 2011. *Idiommata* sp. 'MYG128' was represented by a single animal in the sampling for environmental assessment. Five unused burrows found at exclusion zone 16 may represent the burrows of this species. If so, it is possible the population in exclusion zone 16 has become extinct since 2009. Alternatively, the record of a trapped male in 2009 may represent a dispersing animal, with its source burrow being located elsewhere on the Roy Hill 1 mine site.

Beierolpium sp. was represented by two animals from exclusion zone 10a and one from exclusion zone 13 during environmental assessment. The reasons for failure to collect the species again in February 2011 are unclear but it may represent seasonal changes in the size of the population, vertical movement between soil and litter as a result of changes in moisture content or other factors (Gabbut 1970; Levings 1984). However, 22 specimens of *Beierolpium* sp. were collected at eight sites encircling the mine in March/April 2010 (Ecologia 2010).

4.1.1. Distributions of targeted SRE species

The mygalomorph spiders *Aganippe* sp. 'MYG126', *Missulena* sp. and *Synothele* sp. 'MYG127' and the pseudoscorpion *Beierolpium* sp. are not restricted to the Roy Hill 1 mine site. The available sampling evidence suggests that most of the population of each mygalomorph species occurs outside the mine site. In the case of *Aganippe* sp. 'MYG126', the species was present at 82% of the sites sampled outside the mine and further sampling would have revealed more populations. *Synothele* sp. 'MYG127' has been collected immediately east of the mine site (Ecologia 2010) and about 15 and 60 km west (Bennelongia 2010). The species probably extends along most of the northern side of Fortescue Marsh. Males of *Missulena* sp. have not yet been collected to provide a reliable species identification but the genus *Missulena* is widespread on the northern side Fortescue Marsh (Bennelongia 2010; Ecologia 2010) and it is likely that the species found at the Roy Hill1 mine is at least locally widespread.

Beierolpium sp. is also at least locally widespread, having been found both east and west of the minesite (Ecologia 2010). The genus *Beierolpium* occurs in Africa, Asia, Australia and South America, with most species widespread (http://wamuseum.com.au/arachnids/pseudoscorpions/index_files/Page2511.htm).

While the above comments can be made about local distribution of the targeted SRE species, their actual SRE status remains uncertain in the absence of intensive regional surveys. This is perhaps clearest for *Synothele* sp. 'MYG127'. Soon after release of Ministerial Statement 824, a specimen from 212 km

north-west of the Roy Hill 1 mine was determined morphologically to be conspecific with the Roy Hill *Synothele* sp. 'MYG127' and it appeared that *Synothele* sp. 'MYG127' was not an SRE. However, genetic analysis undertaken to identify the animals collected during the current survey showed there was more than 15% difference in CO1 between the Roy Hill *Synothele* sp. 'MYG127' and the north-western specimen (Appendix 4), suggesting that the latter animal belongs to a different species (see Hebert et al. 2003).

4.2. Species requiring monitoring

4.2.1. Habitat monitoring

In accordance with the *Proposed Monitoring Plan for Short Range Endemic Invertebrate Species at the Roy Hill 1 Mine* approved by the EPA in December 2010, it is proposed that no further population monitoring is required for the mygalomorph spiders *Aganippe* sp. 'MYG126', *Missulena* sp. and *Synothele* sp. 'MYG127' or the pseudoscorpion *Beierolpium* sp. However, it is proposed that habitat condition of selected sites where the four species are known to occur outside the Roy Hill 1 mine should be monitored to provide assurance that the species are unlikely to be at risk.

The sites proposed for monitoring are listed in Table 4, together with a management target for each site. For both *Missulena* sp. and *Synothele* sp. 'MYG127' additional survey should be undertaken to demonstrate the species occur at more sites outside the minesite than within it (*Missulena* sp.) and to locate additional sites suitable for monitoring (both species).

Table 4. Monitoring sites and management targets for widespread species.

Species	Sites	Management target
<i>Aganippe</i> sp. 'MYG126'	TR01, 03, 05, 06	Total plant cover and plant species richness to remain at or above 2011 levels ¹
<i>Missulena</i> sp.	TR06 plus two additional sites to be identified	Total plant cover and plant species richness to remain at or above 2011 levels ¹
<i>Synothele</i> sp. 'MYG127'	TR07, 08, 11, Site 4 of Bennelongia 2010, plus one other site	Total plant cover and plant species richness to remain at or above 2011 levels ¹
<i>Beierolpium</i> sp.	Ecologia sites 2, 6, 18	Plant species richness and litter index to remain at or above 2010 levels ¹

¹2010/11 levels \pm 30% or more litter. Quantified criteria to be developed over time as annual variation is understood

4.2.2. Species monitoring

The only targeted species not known to occur outside the mine site is *Idiommatata* sp. 'MYG128'. Until it is determined that the species occurs outside the minesite, there should be a commitment to annual monitoring of the species at exclusion zone 16, in accordance with the *Proposed Monitoring Plan for Short Range Endemic Invertebrate Species at the Roy Hill 1 Mine*.

Idiommatata sp. 'MYG128' was not recorded at exclusion zone 16 during the February 2011 survey, although five disused burrows belonging to an unknown mygalomorph are likely to be *Idiommatata* sp. 'MYG128' burrows. Accordingly, additional survey outside (and if necessary inside) the mine site should be undertaken to clarify the distribution of this species and determine whether the commitment to monitoring needs to be implemented and how this might be done.

5. RECOMMENDATIONS

Four of the five species targeted for monitoring under Condition 9 of Ministerial Statement 824 are known to occur outside the Roy Hill 1 mine site. These are the mygalomorph spiders *Aganippe* sp. 'MYG126', *Missulena* sp., *Synothele* sp. 'MYG127' and the pseudoscorpion *Beierolpium* sp.

It is recommended that:

1. Habitat condition at selected sites where the four targeted species occur, outside the Roy Hill 1 mine site, should be monitored every three years to ensure the persistence of suitable habitat for these species. Sites to be monitored and their management objectives are listed in Table 4.
2. Monitoring should measure combinations of total plant cover, plant species richness and litter index, as specified in Table 4, to ensure compliance with the management objectives for each site.
3. Additional sampling should be undertaken to identify more sites where the spiders *Missulena* sp. and *Synothele* sp. 'MYG127' occur for condition monitoring, as indicated in Table 4.

The mygalomorph spider *Idiommata* sp. 'MYG128' was not re-collected during the February 2011 survey. To date it is known only from exclusion zone 16, despite intensive searches. Five disused burrows that may belong to *Idiommata* sp. 'MYG128' were found there in February 2011 but it is also possible that the species was dispersing across exclusion zone 16 at the time of environmental assessment and that exclusion zone 16 does not contain suitable habitat for the species.





It is recommended that:





4. Additional sampling should be undertaken to identify occurrences of *Idiommata* sp. 'MYG128'.





6. REFERENCES





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Appendix 1. Habitat characteristics of sites.





Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
Exclusion Zone 4	Tributary within floodplain	Clay-loam pindan	1-5cm	10%	Low	>25 y	Low
<p>Closed mulga woodland Dominant upper story is <i>Acacia aneura</i> (mulga) 8-10 m in height, cover 70%. Area was very wet from rain ~36 h prior to sampling. A low order stream runs through the exclusion zone and contained standing water. Adjacent to the stream the area was sodden. Numerous fallen limbs/logs occurred. The stream contained multiple channels ~1 m below ground height. Area surrounding site is open, flat alluvial plain.</p>							
Exclusion Zone 7	Tributary within floodplain	Clay-loam pindan	1-5cm	1%	Low	>25 y	Moderate
<p>Open mulga woodland Dominant upper story is mulga 6-8 m, cover 40%. Area was very wet from recent rain ~36 h prior to sampling. A stream ran through exclusion zone with pools of standing water in many areas. Burrows of <i>Aganippe</i> sp. 'MYG126' occurred alongside stream. The area within and around exclusion zone is very flat. Numerous fallen branches/logs.</p>							





Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
Exclusion Zone 9/11	Tributary within floodplain	Clay-loam pindan	<1cm	<1%	Low	>25 y	Low
<p>Open mulga woodland Dominant upper story is mulga 8 m, cover 40%. Numerous dead standing mulgas. Evidence of recent, extensive, light flooding of the site. Stream running through site had standing water just outside the exclusion zone. Some coarse sand in main channel.</p>							
Exclusion Zone 10a	Tributary within floodplain	Sand-loam	1-5cm	1%	Moderate	2-5 y	None
<p>Open <i>Triodia-Senna</i> grassland Dominant upperstorey is <i>Senna artemisioides</i> subsp. <i>oligophylla</i> 2 m, cover 40%. All mulga burnt 100 m up- and downstream of exclusion zone, except for a small patch to one side. Very little shade in exclusion zone. The tributary was ~6 m wide and very flat. It lies NE of a small 10-20 m hill. Site lies west of six 100 m tall mesas, which drain farther downstream. Site very wet as a result of recent rain.</p>							





Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
Exclusion Zone 13	Tributary within floodplain	Clay-loam pindan	1-10cm	20%	Low	>25 y	Low
<p>Closed mulga woodland Dominant upper storey mulga 5-7 m, cover 70%. Well shaded area not impacted by fire. Outside the stream running through the site landscape is a flat alluvial plain. Approximately 20 mm of rain in the previous 24 h. Stream contained numerous shallow pools.</p>							
Exclusion Zone 15	Tributary within floodplain	Clay-loam pindan	1-10cm	25%	Low	>25 y	Low
<p>Closed mulga woodland Dominant upper story was mulga 7-9 m, cover 90%. Stream running through site contains pools of water and 'floodplain' area was wet from recent rain, with ~50% of the site inundated. Quite a few dead limbs and logs are scattered around. The area within and surrounding the site is very flat 'crab-hole' plain.</p>							





Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
Exclusion Zone 16	Tributary within floodplain	Clay-loam pindan	1-10cm	5%	Low	>25 y	Low
<p>Closed mulga woodland Dominant upper storey is mulga 8-10 m, cover 90%. Outside the exclusion zone the landscape is a flat alluvial, sparsely vegetated floodplain.</p>							
TR01	Tributary within floodplain	Clay-loam pindan	1-5cm	1%	Low	>25 y	Moderate
<p>Open mulga woodland Dominant upper story is mulga 6-8 m, cover 40%. A small drainage line runs through the site with evidence of recent standing water (none at time of sampling). The surrounding area is a flat alluvial floodplain intersected by small drainage lines.</p>							

Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
TR02	Tributary between mesas	Gravelly clay-loam	1-5cm	2%	Low	2-5 yrs	Low
<p>Open mulga woodland Site is a small patch of mulga 100 m north of a mesa on a lower order tributary. Dominant upper story is mulga 5-7 m, cover 30%. The tributary has a high gradient with no pooling/standing water.</p>							
TR03	Tributary within floodplain	Clay-loam pindan	1-5cm	5%	Low	>25 y	Low
<p>Closed mulga woodland Dominant upper story is mulga 8-10 m, cover 70%. Site is a tributary running through an open alluvial floodplain. Tributary is multi-channelled; the occurrence of recent flooding was indicated by many pools of standing water.</p>							

Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
TR04	Tributary within floodplain	Sand-loam	1-5cm	1%	Cool	>25 y	Moderate
<p>Open mulga woodland</p> <p>Site is a dry creek downstream of TR03. Creek bed is more focused and as a result there is no standing water and the bed has less silt/clay. The dominant upper storey is mulga 8-10 m, cover 50%. Flow of the recent water (48-72 h prior) has removed any small litter or silt</p>							
TR05	Tributary within floodplain	Clay-loam pindan	1-5cm	40%	Cool	>25 y	Low
<p>Closed mulga-<i>Acacia atkinsiana</i> woodland</p> <p>Site is a dry, wide creek bed with the main channel very narrow and focused resulting in a deep scour along eastern edge of the site. A thick stand of mulga and <i>A. atkinsiana</i> (6-8 m, cover 90%) extends ~200 m west of the main channel. The area has been affected by inundation 48-72 h prior. Clay-loam soil in the creek bed.</p>							

Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
TR06	Tributary within floodplain	Clay-loam pindan	1-5cm	5%	Cool	>25 y	Moderate
<p>Closed mulga-<i>A. atkinsiana</i> woodland Dominant upper storey is mulga 8-10 m, cover 60%; interspersed by <i>A. atkinsiana</i> 3-6 m, cover 15%. Site was inundated 48-72 h prior; evidence of standing pools.</p>							
TR07	Tributary within floodplain	Clay-loam pindan	1-5cm	5%	Cool	>25 y	Moderate
<p>Open mulga woodland Site is an alluvial floodplain. Mulga 8-10 m, cover 50% is the dominant upper storey. Tributary is multi-channelled; many recent standing pools from inundation 48-72 h prior. Site was dry at time of sampling. Soil type changes towards sand-loam with increasing distance from the tributary.</p>							

Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
TR08	Tributary within floodplain	Clay-loam pindan	1-5cm	5%	Cool	>25 y	Moderate
<p>Open mulga woodland Mulga 6-8 m, cover 50% is the dominant upper storey. Tributary is multi-channelled Tributary is dry with evidence of inundation 72 h prior with recently dried pools. The wooded tributary is surrounded by an open alluvial floodplain with “crab hole” like surface geology.</p>							
TR09	Depression within floodplain	Clay-loam pindan	1-5cm	1%	Cool	>25 y	High
<p>Open mulga woodland Site is on an alluvial floodplain. Dominant upper storey of mulga 6-8 m with 60% coverage. No tributary runs through site, but is characterised as crab-hole country, which allows some surface-water runoff to pool. Site is dry, but there is evidence of recent inundation 72 h prior. Cattle has removed nearly all under storey vegetation and mulga up to 2 m above ground.</p>							

Site	Landform	Soils	Leaf litter		Fire		Grazing
			Depth	Cover	Impact	Age	
TR10	Tributary within floodplain	Clay-loam pindan	1-5cm	<1%	Cool	>25 y	High
<p>Open mulga woodland Site on alluvial floodplain. Mulga is the only upper storey species 6-8 m, 30%, but <i>Vachellia farnesiana</i> 4-6 m, 40% is the dominant species. Surrounding floodplain is 'crab-hole' country. Large fissures 1 m deep and 2-4 m wide snake through site up to 50 m in length. Water has recently pooled in fissures during inundation 72 h prior to sampling; no standing water remains.</p>							
TR11	Tributary within floodplain	Clay-loam pindan	1-5cm	5%	Cool	>25 y	None
<p>Closed mulga-<i>A. atkinsiana</i> woodland Site on alluvial floodplain. Dominant upper story is mulga and <i>A. atkinsiana</i> (6-8 m, 60% cover and 4-6 m, 35% cover respectively). Tributary is low order and multi-channelled. No pooling due to relatively shallow channels and fast drainage. Soil is still very wet from recent inundation 72 h prior. It is noted that this site contained hundreds of scorpion burrows.</p>							

Appendix 2. DNA analysis of mygalomorph spiders.

Molecular analysis was undertaken to align names of mygalomorph spiders collected during environmental assessment and identified by the Western Australian Museum (Framenau and Harvey 2009) with those applied to specimens collected during the February 2011 survey.

DNA from 8 specimens of *Missulena* sp., *Aganippe* sp. MYG126, *Synothele* sp. MYG127 and *Idiommata* sp. MYG128 held at the Museum of Western Australia (all collected at the Roy Hill mine site during environmental assessment except for one specimen of *Synothele* sp. MYG127 from 212 km farther north-west) was compared with that of 12 specimens collected in February 2011.

Standard molecular techniques were employed to sequence fragments of the COI mitochondrial gene by Remko Leijs, South Australian Museum (see MacArthur and Leys 2006). Primer designs were by Folmer *et al.* (1994) or as modified in the Leijs Laboratory. Twenty specimens provided PCR products, of which 16 yielded sequence of 455 base pairs suitable for analysis. Additional phylogenetic analysis, including re-drawing of phylogenetic trees using the MEGA5 program was undertaken by Andrew Trotter (Bennelongia).

Six species were recognised based on genetic distances (Figure A).

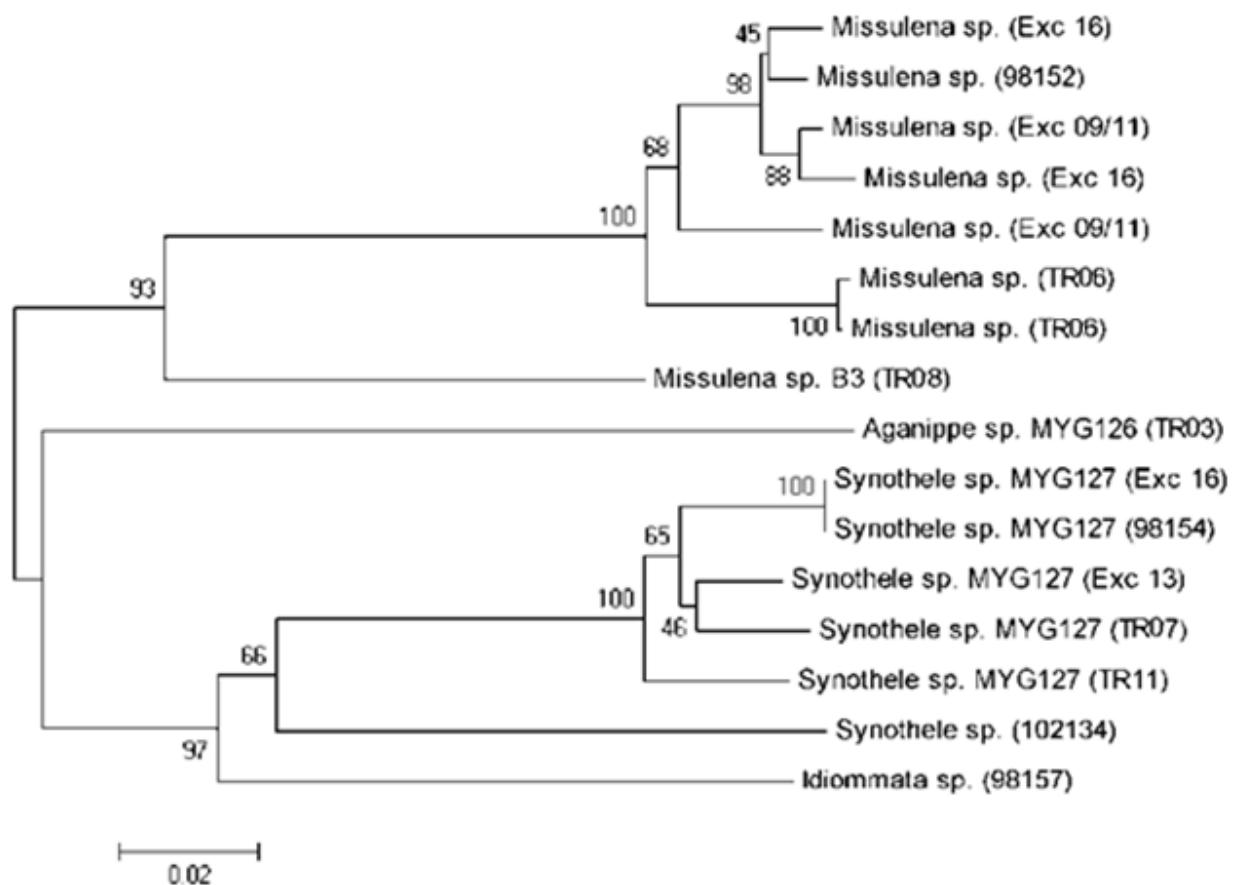


Figure A. Relationships between mygalomorph specimens based on neighbour-joining analysis (bootstrap tests based on 500 replicates). Sites or Museum codes are shown in parentheses.

Missulena sp. Specimens of *Missulena* sp. collected during February at exclusion zones 9/11 and 16 were the same species as previously collected at the Roy Hill 1 mine site (specimen WAM 98152). The species was also collected outside the mine at site TR06. Genetic variability between sites was surprisingly high (0.2 - 5.7%). However, analysis of multiple specimens at three sites (TR 06, Exc 16, Exc 09/11) showed sequence divergence was also variable within a site (0.2, 2.2 and 4.2%, respectively). A second lineage of *Missulena* (sp. B3) recorded at site TR08, approximately 24 km from the mine, is considered to be another species. It had a sequence divergence of at least 16% from specimens of *Missulena* sp. (Figure A).

Aganippe sp. 'MYG126'. The Museum specimen of *Aganippe* sp. 'MYG126' did not yield a DNA sequence. However, morphological comparison of its genitalia with those of a male specimen collected from site TR03 in February 2011 provided strong evidence that *Aganippe* sp. 'MYG126' occurs outside the mine site and suggests that all specimens of *Aganippe* collected to date around the mine site are *Aganippe* sp. 'MYG126'.

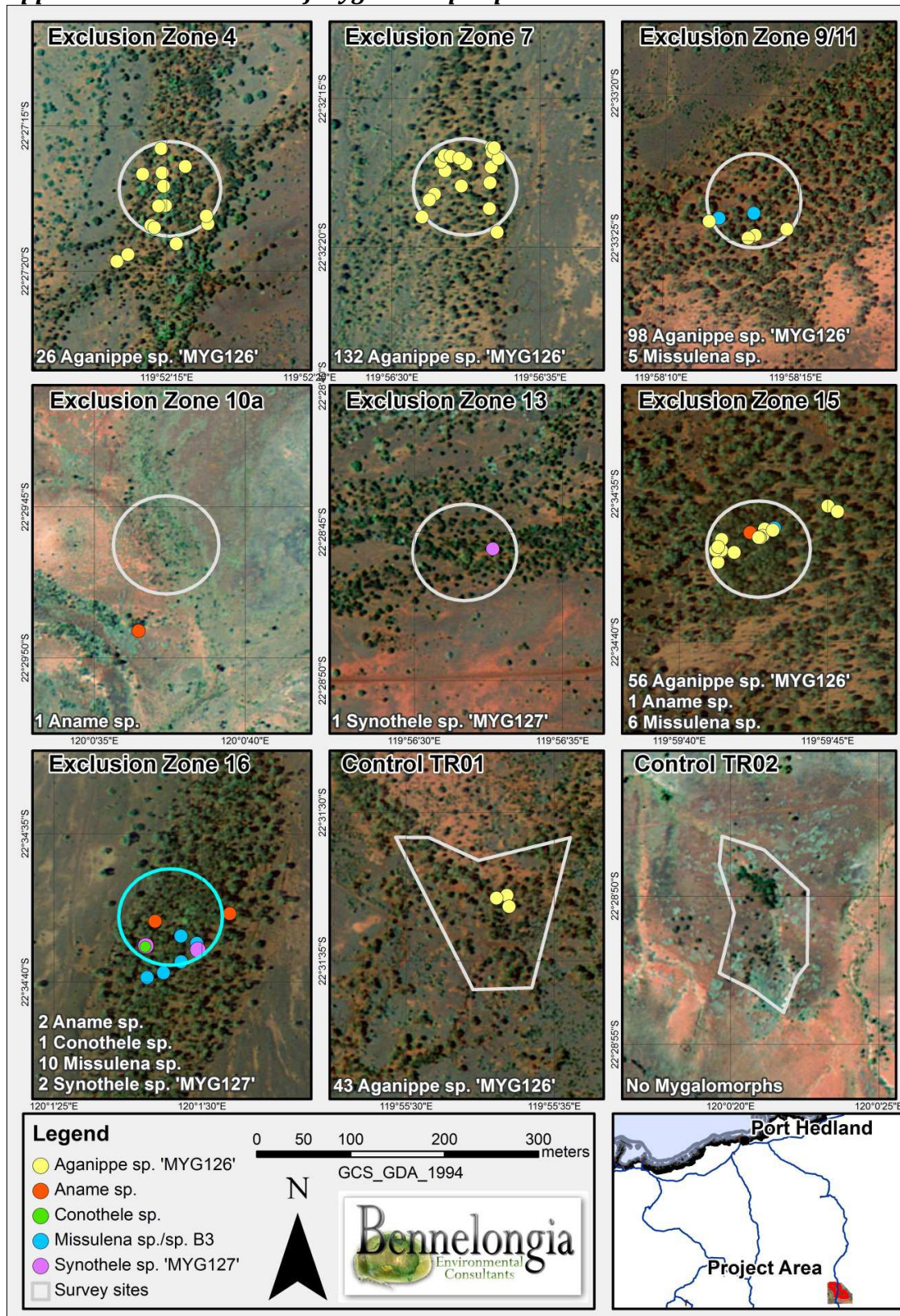
Synothele sp. 'MYG127'. The specimens of *Synothele* collected in February 2011 from sites (Exc 13, Exc 16, TR07, TR11) were shown to be conspecific with the Museum specimen of *Synothele* sp. 'MYG127' (WAM 98154) collected from Roy Hill 1 mine site during environmental assessment (Figure A). Genetic distance between specimens ranged up to 5%. Museum specimen WAM 102134 from 212 km north-west of the mine, which was determined morphologically to be *Synothele* sp. 'MYG127', was more than 15% divergent from specimens collected in the vicinity of the mine. It was considered to be a second species.

Idiommata sp. 'MYG128'. No specimens of *Idiommata* were collected in February 2011. However, DNA of a specimen of *Idiommata* sp. 'MYG128' collected during environmental assessment of the Roy Hill 1 mine site (WAM 98157) was analysed to provide a reference for any future genetic work (Figure A).

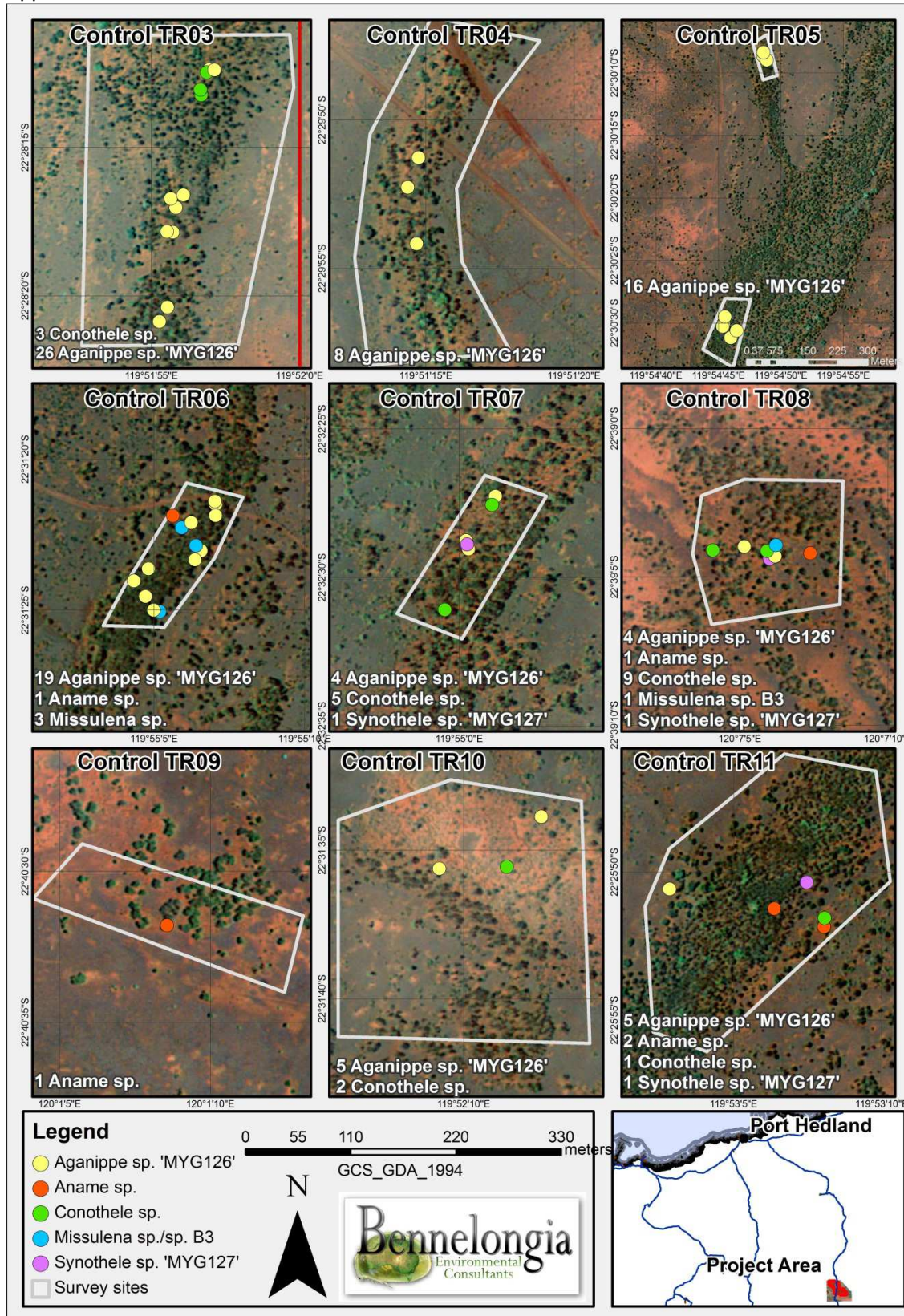
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Appendix 3. Distribution of mygalomorph spider burrows.












Appendix 3 contd.



Appendix 4. Burrows of spider species near Roy Hill 1 mine site.

Species	Image 1	Image 2
<p><i>Aname</i> sp.</p> <p>Open burrow (no lid) with a near horizontal opening above ground. After 1 – 5 cm the burrow descends vertically for 15 – 25 cm. Burrow walls are covered in a thin layer of white silk especially so at the entrance. Sometimes the entrance is also obscured by fine web.</p>		
<p><i>Aganippe</i> sp. 'MYG126'</p> <p>Near vertical burrows with a clay-plug trapdoor; entire burrow encased in thick, white silk; a fine layer of silk covers the inside of the plug. Burrows are usually 15 – 40 cm deep (substrate dependent). Clay-plug lids are usually 4 – 6 mm thick. The single male found had a <i>Conothele</i> -style lid with leaves and twigs affixed.</p>		
<p><i>Conothele</i> sp.</p> <p>A very similar burrow design to that of <i>Aganippe</i> sp. 'MYG126'; however, the trapdoor is always thinner (3-4 mm thick) and can have leaves and twigs affixed.</p>		

Species	Image 1	Image 2
<p><i>Missulena</i> sp./sp. B3</p> <p>An oval shaped burrow with a dual-lidded trapdoor, 20-40 cm deep. The interior burrow walls are sparsely silk-lined and a feature of the silk and trapdoor is an old, dirty and disused look.</p>		
<p><i>Synochele</i> sp. 'MYG127'</p> <p>Silk-lined burrows are usually under leaf litter or mounds of dirt below shrubs. As such, the entrances are cryptic (yet to see one), but the burrows can be found by intersecting litter and dirt below shrubs.</p>		
<p>Wolf & false wolf spiders (Lycosidae/Miturgidae)</p> <p>Near vertical burrow with an open entrance, usually adjacent a single, small stone. Some burrows have a few fine strands of silk around entrance.</p>		

Species	Image 1	Image 2
<p>Caterpillars and burrowing crickets</p> <p>Caterpillars (left) create a small semi-circular flap of silk on the ground. Burrowing crickets (right) use saliva to create a small pebble and stick-imbued saliva turret.</p>		
<p>Unknown mygalomorph burrow</p> <p>Five burrows found at Exc 16 may represent disused '<i>Idiommata</i>' burrows or another unknown species. All trapdoors were silk, but burrows have been empty for some time or filled in.</p>		<p>No Image</p>

Appendix 5. Habitat raw data.

Table A. Floristics – species height and cover per site.

Species	Lifeform	Height (m)	Plant cover (%)																	
			Exclusion Zone #							TR #										
			4	7	9/11	10a	13	15	16	1	2	3	4	5	6	7	8	9	10	11
<i>*Aerva javanica</i>	Woody perennial	0.5				0.5														
<i>Atriplex</i> sp.	Woody perennial	0.5													1					
<i>Commelina ensifolia</i>	Herb	0.1	0.5	0.5				2	0.5	0.5		0.5								0.5
<i>*Citrullus lanatus</i>	Herb	0.1			0.5															0.5
<i>Acacia aneura</i>	Tree	4-10	70	40	40		70	90	90	40	30	70	50	30	60	50	50	60	30	60
<i>Acacia atkinsiana</i>	Tree	2-6	0.5				0.5			0.5	5			70	15					35
<i>Acacia bivenosa</i>	Shrub	1				5					0.5									
<i>Acacia inaequilatera</i>	Shrub	1-3									0.5									
<i>Acacia pyrifolia</i> var. <i>pyrifolia</i>	Shrub	3-4		0.5	5		5	1		0.5		1	5		0.5	5	10	0.5		4
<i>*Vachellia farnesiana</i>	Shrub	2-4										0.5	2					0.5	40	
<i>Acacia synchronicia</i>	Shrub	3		5			1			5				5	0.5	10		1	10	
<i>Acacia tetragonophylla</i>	Tree	5		2	2		5	1		5		1	0.5	5						
<i>Acacia tumida</i>	Shrub	1				5														
<i>Acacia xiphophylla</i>	Tree	2-10	5	5	5	0.5			1	0.5	2	1		5						5
<i>Senna artemisioides</i> subsp. <i>helmsii</i>	Shrub	0.5-2	1		1	0.5		1	1	1			2	0.5	2					0.5
<i>Senna artemisioides</i> subsp. <i>oligophylla</i>	Shrub	0.5-2			1	40	0.5		0.5		0.5		1							
<i>Tephrosia rosea</i>	Shrub	0.5							0.5											
<i>Eremophila</i> sp.	Shrub	0.5							0.5										0.5	
<i>Cassytha filiformis</i>	Vine	2				0.5														
<i>Hybanthus aurantiacus</i>	Herb	0.1	0.5															0.5		0.5
<i>Corchorus lasiocarpus</i>	Woody perennial	0.5				0.5														
<i>Corchorus sidoides</i>	Woody perennial	0.1	0.5					0.5												

Species	Lifeform	Height (m)	Exclusion Zone #							TR #										
			4	7	9/11	10a	13	15	16	1	2	3	4	5	6	7	8	9	10	11
<i>Eucalyptus camaldulensis</i>	Tree	7-8	2		1				5										10	
<i>Eucalyptus victrix</i>	Tree	3				5						2	0.5							
* <i>Cenchrus ciliaris</i>	Grass	0.5	10	2		10			0.5	0.5	0.5	0.5	5	0.5		0.5	0.5		10	10
<i>Cymbopogon ambiguus</i>	Grass	1				15														
<i>Trioda wiseana</i>	Grass	0.5-1.5				20					20									
<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	Herb	0.1					0.5													
<i>Grevillea wickhamii</i>	Shrub	2	2			15	0.5					10								
<i>Ficus aculeata</i>	Tree	4			1		0.5	0.5						0.5			0.5			
<i>Clerodendrum tomentosum</i> var. <i>lanceolatum</i>	Tree	8										5								
<i>Atalaya hemiglauca</i>	Tree	4	1	1			0.5					0.5	0.5	1		0.5				
<i>Ipomoea muelleri</i>	Herb	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Perennial herbs (3 species)	Herb	0.5	0.5	0.5	0.5		0.5	0.5		0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	5

Table B. Litter – depth and cover per site.

Depth (cm)	Exclusion Zone #							TR #										
	4	7	9/11	10a	13	15	16	1	2	3	4	5	6	7	8	9	10	11
<1	1	0.5	0.5	0.5	0.5	10	5	0.5	0.5	0.5	0.5	5	1	0.5	0.5	0.5	0.5	0.5
1-5	10	1			5	15	5	1	2	5	1	40	5	5	5	1	0.5	5
5+	1				15	10	1											10
Index	38	3.2	0.2	0.2	135	130	26	3.2	6.2	15	3.2	123	15	15	15	3.2	1.8	95