Terrestrial Vertebrate Fauna Monitoring Results for the Mount Gibson Iron Ore Mine and Infrastructure Project

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Prepared for:

Mount Gibson Mining Limited
PO Box 55
WEST PERTH WA 6872

By:

Terrestrial Ecosystems
10 Houston Place
Mt Claremont WA 6010

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DISCLAIMER

Front cover: Spiny-tailed Skink (*Egernia stokesii badia*)

TABLE OF CONTENTS

Diagram

1. Trap layout at each site on the sand plain and eucalypt woodland

Plates

1. A drift fence on the hill slope showing a series of paired funnel traps located either side of a fly-wire drift fence
2a. Sand plain 1
2b. Sand plain 2
2c. Sand plain 3
2d. Sand plain 4
2e. Sand plain 5
2f. Sand plain 6
2g. Sand plain 7
2h. Sand plain 8
2i. Sand plain 9
2j. Sand plain 10
2k. Eucalypt woodland 1
2l. Eucalypt woodland 2
2m. Eucalypt woodland 3
2n. Eucalypt woodland 4
2o. Eucalypt woodland 5
2p. Eucalypt woodland 6
2q. Eucalypt woodland 7
2r. Eucalypt woodland 8
2s. Eucalypt woodland 9
2t. Eucalypt woodland 10
2u. Iron Stone Ridge control
2v. Iron Stone Ridge control new
2w. Iron Stone Ridge impact
3. Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)
4. Western Spiny-tailed Skink (*Egernia stokesii badia*)
5. Western Spiny-tailed Skink scats

Tables

1. Attributes of various Rehabilitation and Degradation Index scores
2. Daily weather data for survey periods in 2008, 2011 and 2013
3. Number of individuals caught by species by habitat type in 2008 and 2011
4. Number of individuals caught by species by trap type in 2008, 2011 and 2013
5. Asymptotes for species accumulation curves and estimates of species richness for the combined data for control and impact sites for each of the habitat types
6. Morisita-Horn similarity scores for the combined control and impact sites for each of the three habitat types
7. Fisher's alpha, recorded species richness and evenness scores for each of the sites on the sand plain and eucalypt woodland
8. Comparison of the original and new ridge control sites using the RHI score
9. Summary of RDI scores for the three habitat types for 2008, 2011 and 2013
10. The location of Major Mitchell's Cockatoo sightings
11. Western Spiny-tailed Skink records

Figures

1. Regional location
2. Site plan showing survey sites

Appendices

A. Coordinates of survey sites

EXECUTIVE SUMMARY

An approval condition for the development of the Mount Gibson Iron Ore Mine and Infrastructure project was the preparation of a Mine Fauna Management Plan that addressed the management and monitoring of fauna. An objective of the fauna monitoring program is to demonstrate that the effects of vegetation clearing, noise, vibration, light overspill and vehicle movement on the fauna, in particular on fauna of conservation significance [*Egernia stokesii badia* (Western Spiny-tailed Skink), *Falco peregrinus* (Peregrine Falcon), *Lophochroa leadbeateri* (Major Mitchell's Cockatoo), *Merops ornatus* (Rainbow Bee-eater) and the Malleefowl (*Leipoa ocellata*)] are minimised. To partially satisfy this monitoring requirement, Terrestrial Ecosystems was commissioned by Mount Gibson Mining Limited (MGM) to undertake a vertebrate fauna survey. This survey is the third in the bi-annual monitoring program.

A 14 night terrestrial vertebrate trapping program was undertaken in October-November 2013 in each of the three major fauna habitat types (i.e. sand plain, eucalypt woodland and banded iron ridges) around the mining operations. Prior to the commencement of the 2013 survey, 20 new control survey sites were installed on the Iron Hill North. These sites will take the place of the original control sites on Iron Hill South due to current iron ore exploration programs. The new and old control sites are used in the comparison with the impact sites on the banded ironstone ridge in this report.

There were marked differences in the trapped fauna assemblage when compared with surveys undertaken in 2008 and 2011. Six species were trapped during the 2013 survey that had not been trapped during previous surveys (*Oryctolagus cuniculus, Tachyglossus aculeatus, Strophurus assimilis*, *Ctenotus mimetes Ramphotyphlops hamatus* and *Ramphotyphlops bicolor*).

Rehabilitation and Degradation Index (RDI) scores for the eucalypt woodland and ironstone ridge were similar to those calculated in 2008 and 2011; however, the score for the sand plain had increased to a very high level. The RDI score for the ironstone ridge has a lower reliability than those calculated for the other two habitats due to the low number of individuals caught.

Conservation significant fauna recorded during the survey included Major Mitchell's Cockatoo (*Lophochroa leadbeateri*), Western Spiny-tailed Skink (*Egernia stokesii badia*), Malleefowl (*Leipoa ocellata*), Rainbow Bee-eater (*Merops ornatus*), White-browed Babbler (*Pomatostomus superciliosus*), Peregrine Falcon (*Falco peregrinus*) and Crested Bellbird (*Oreoica gutturalis*).

1 INTRODUCTION

1.1 Background

The Mount Gibson Iron Ore Mine and Infrastructure project was approved by the Minister for the Environment on 24 October 2007 (Ministerial Statement 753). Condition 12 of the Ministerial Statement required a Mine Site Fauna Management Plan be prepared prior to the commencement of ground disturbing activities that addressed the management and monitoring of fauna. An objective of the fauna monitoring program is to demonstrate that the effects of vegetation clearing, noise, vibration, light overspill and vehicle movement on the fauna, in particular on fauna of conservation significance [*Egernia stokesii badia* (Western Spiny-tailed Skink), *Falco peregrinus* (Peregrine Falcon), *Lophochroa leadbeateri* (Major Mitchell's Cockatoo), *Merops ornatus* (Rainbow Bee-eater) and the Malleefowl (*Leipoa ocellata*)] are minimised.

Terrestrial Ecosystems was commissioned by Mount Gibson Mining Limited (MGM) to undertake a vertebrate fauna survey in 2013. This survey is the third in the bi-annual monitoring program series. Terrestrial Ecosystems staff, who were working for Coffey Environments at the time, were responsible for the design, set up and implementation of the first survey (Coffey Environments 2008) and Terrestrial Ecosystems undertook the second monitoring survey in 2011 (Terrestrial Ecosystems 2012).

There are three broad fauna habitats within and adjacent to the MGM project; sand plain, eucalypt woodland and banded ironstone formation (BIF). In 2008, five vertebrate fauna survey 'control' and 'impact' sites were installed in each of the sand plain and eucalypt woodland habitat types. Due to access restrictions on the BIF, 20 flywire drift fences supporting six pair of funnel traps were installed on Extension Hill South (impact site) and Iron Hill South (control site).

Since the planning and implementation of the first survey in 2008, MGM has commenced mining. This required the construction of supporting infrastructure and re-routing the Great Northern Highway around the infrastructure. This activity impacted on previously installed sand plain fauna survey sites and five new sand plain sites were installed prior to the 2011 fauna monitoring survey.

MGM is currently investigating the possibility of expanding its mining operations and this could include Iron Hill South, which is the BIF control site. Prior to this vertebrate fauna monitoring survey, an additional 20 sites were established on Iron Hill North and laid out in a similar fashion to that on Iron Hill South (original control site). This report considers the similarity between the fauna assemblage on the original control site and the new control site.

1.2 Site description

The MGM project is located within the Mt Gibson Ranges, approximately 350km north-east of Perth (Figure 1). Bennett Environmental Consulting (2000) recorded a diverse vegetation community comprising of six woodlands, four mallee communities, 12 thicket communities and two heath communities in the project area prior to mining activity commencing. The peaks of the Mount Gibson Range have different vegetation communities, with *Acacia* species, *Melaleuca* species and *Allocasuarina acutivalvis* being the dominant taxa. The woodland plain typically consists of *Eucalyptus loxophleba* or mallees of *E. brachycorys* and *E. hypochlamydea*, which are often associated with *Callitris glaucophylla* and *Eucalyptus loxophleba*. On the edge of the Great Northern Highway there is an extensive area of sand plain which exhibits a varied flora (Bennett Environmental Consulting 2000).

From a fauna perspective, the mining operations area can be divided into three broad fauna habitat types;

- flat sand plains,
- flat eucalypt woodlands, and
- banded ironstone ridges.

1.3 Potential impacts

Potential environmental impacts on fauna at or in the vicinity of the mine include a loss of habitat due to vegetation clearing, habitat fragmentation, altered fire regimes, dust, noise, vibration, feral species, uncapped drill holes, mining voids, road deaths and edge effects. Each of these was discussed in the initial baseline survey report (Coffey Environments 2008) and is not repeated here.

1.4 Fauna monitoring strategy

It was resolved in an earlier report to use the Rehabilitation and Degradation Index (RDI; Thompson et al. 2007b) to measure differences in the fauna assemblage between impact and control sites, as this index examines guilds of species (e.g. nocturnal, widely-foraging predators, fossorial) susceptible to these impacts. The RDI measures the extent to which the reptile assemblage in a disturbed site resembles that in a control site. It utilises a combination of diversity, assemblage composition and ecological parameters. Each of these parameters is further sub-divided and an overall weighted score out of 100 can be calculated to determine the similarity between the control site and impacted site. The unachievable RDI score of 100 indicates no difference between impact and control sites, while a RDI score of less than 10 indicates that only a few of the early colonising species are present in the impact site. The attributes of various RDI scores are provided in Table 1.

Table 1. Attributes of various Rehabilitation and Degradation Index scores

Attribute	RDI Score
Comparable to the best situation without human impact, regionally expected species for habitat type, species present with a full array of age(size) classes, balanced ecological structure, self sustaining functional ecosystem	86-100
Species richness approaching expected levels, not all late succession species present, some species present with less than optimal abundances or size distribution, ecological structure incomplete	61-85
Species richness below that in the undisturbed area, some groups not well represented, some specialists not present	41-60
Lack of specialists, fewer species than in undisturbed area, skewed ecological structure and relative abundances	21-40
Few vertebrates present, only early colonisers present, lack of community structure	11-20
Only opportunistic early colonisers present, no community structure	0-10
No reptiles present	0

The trappable terrestrial vertebrate fauna assemblage is likely to vary both spatially and temporally (Thompson et al. 2003a, Cowan and How 2004, Thompson and Thompson 2005, Thompson and Thompson 2008), so any monitoring survey protocol must accommodate these changes. It is therefore necessary that control and impact sites are surveyed simultaneously to minimise temporal variations, and multiple sites are surveyed within each habitat type to accommodate spatial variability in fauna assemblages.

Published data (Thompson and Thompson 2005, Thompson and Thompson 2008) suggest that spring and summer are the optimum times for vertebrate fauna surveys in the Goldfields of Western Australia. As there is no published information about the best time to survey in the Mid-west or Murchison, it is assumed that given similar climatic conditions, the vertebrate fauna assemblages would act similarly and spring and summer would be the optimum survey periods.

2 METHODS

A 14 night terrestrial vertebrate trapping program was undertaken in control and impact sites in each of the major habitats (i.e. sand plain; eucalypt woodland; and banded ironstone ridges).

2.1 Site selection

Survey sites representing 'impact areas' were previously selected adjacent to the intended mining and infrastructure areas (Figure 2; Appendix A). Every effort was made to select control sites that approximated the habitat in the impact sites, however, due to differences in the habitat it was anticipated that there would be some differences in the fauna assemblages between control and impact sites.

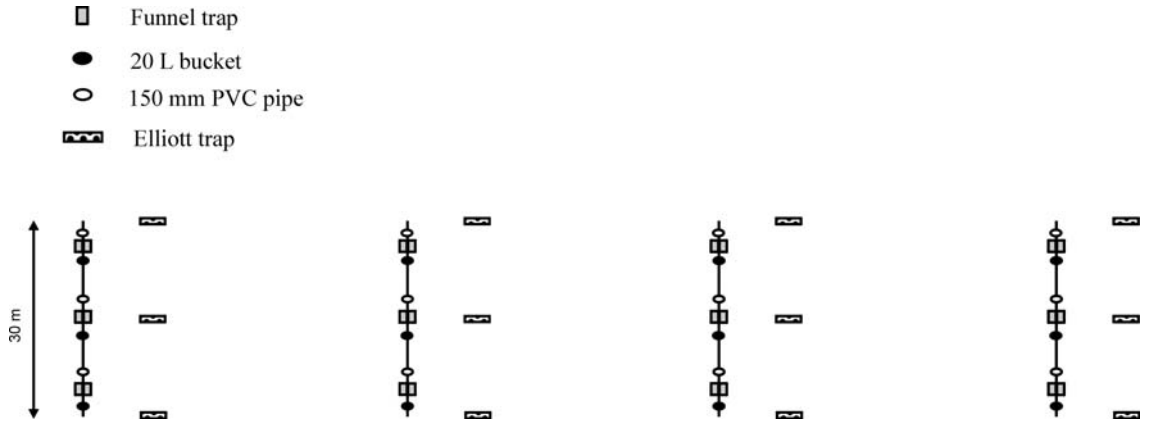
In the sand plain and eucalypt woodland habitats, five impact and five control sites were selected. Sites were far enough apart to minimise the potential for most individuals moving among sites. Data from these five sites have been combined in calculating RDI scores.

Traps in the impact and control sites on the banded ironstone ridges were laid out differently to those in the sand plain and eucalypt woodland due to the presence of declared rare flora (DRF; *Darwinia masonii* and *Lepidosperma gibsonii*). Fauna habitat varied depending on the location on the slope or ridge tops. It was previously decided that these trap lines would run perpendicular to an existing track that ran along the ridge immediately adjacent to the mining area (Figure 2) and in a similar manner on an adjacent ridge (i.e. Iron Hill South and Iron Hill North). The Iron Hill South control ridge habitat varied appreciably (e.g. different density and composition of plant species, more recent fire) from the impact habitat, but it was the best available when the sites were setup. Trap lines were approximately 30-50m apart in areas selected to minimise impacting on the vegetation and in particular, *D. masonii* and *L. gibsonii*.

2.2 Trap design and layout

Each site on the eucalypt woodland and sand plain contained four trap lines. Each trap line contained three 20L PVC buckets, three 150mm by 500mm deep PVC pipes as pit-traps and three pair of funnel traps evenly spaced along a 30m fly-wire drift fence (300mm high; Diagram 1). In addition, three aluminium box traps were set adjacent to each drift fence. Aluminium box traps were baited with a mixture of sardines, rolled oats and peanut butter (i.e. universal bait).

Diagram 1. Trap layout at each site on the sand plain and eucalypt woodland



On the banded ironstone ridges six pairs of funnel traps (Plate 1) were evenly spaced along each trap line. Three baited aluminium box traps were placed adjacent to each trap line.

Plate 1. A drift fence on the hill slope showing a series of paired funnel traps located either side of a fly-wire drift fence

Most animals were marked with a permanent dark coloured marking pen. For lizards, this was normally on the abdomen, and for mammals it was along the base of the tail. Marked recaptured animals were recorded, however, as large snakes were not handled, they were not marked. The mark comes off or rapidly fades on the abdomen of shiny skinned skinks and possibly on the fur of small mammals during grooming. The number of recaptures during the 2008 survey was very low with the consequence a decision was made before the analysis in 2008 to include recaptures within the dataset for all analyses. Recaptures were included in the 2011 analysis and have again been included in the data analysis.

2.3 Animal ethics

Environmental consultants in WA are currently not required to obtain approval from an established animal ethics committee to undertake terrestrial vertebrate fauna surveys. Nevertheless, the fauna surveying procedures and protocols utilised during this terrestrial vertebrate trapping survey have been approved by the Edith Cowan University Animal Ethics Committee (see http://www.ecu.edu.au/GPPS/ethics/assets/General_ Terrestrial_Fauna_Surveys_Protocol.pdf).

To minimise deaths due to heat stress all funnel traps had a shade cover (Plate 1), and all buckets contained one or two pieces of polystyrene. Aluminium box traps were placed underneath vegetation. All traps were cleared daily commencing at about 5:30am.

To minimise deaths due to bites and stings, ant powder was placed around and in pit, funnel and aluminium box traps where ants were an obvious problem.

2.4 Survey timing

All BIF, eucalypt sites and the sand plain sites were dug in during January 2008. The impact sand plain sites were moved and dug in prior to the 2011 survey. The new Iron Hill North control site was set up in October 2013, prior to this survey. This survey was undertaken between 23 October and 7 November 2013, providing 14 trapping nights of data for all sites.

2.5 Survey and reporting staff

The field survey was coordinated by Drs Scott Thompson and Graham Thompson, and Ray Turnbull, with assistance from Edward Swinhoe, Lawson Brandis, Callum Smithyman, Dr Margot Oorebeek and Aleksander Vuksic. The survey was undertaken under a *Wildlife Conservation Act (1950)* Regulation 17 licence number SF009487.

2.6 Data analysis

2.6.1 Species richness and relative abundance

The actual number of species caught at each site is one measure of species richness but it rarely includes all species present and is directly related to the trapping effort and number of individuals caught.

2.6.2 Species accumulation curves

Species accumulation curves, or collectors' curves, plot the cumulative number of species discovered in a defined sampling area with increasing levels of survey effort (Thompson et al. 2007a). Species accumulation curves provide a measure of species inventory efficacy and completeness, and can be used to compare species richness among sites based upon standardized sampling protocols (Moreno and Halffter 2000). Soberón and Llorente (1993) suggested that species accumulation curves lend rigour to fauna inventories, particularly in poorly collected areas. They are most frequently used in these types of reports to indicate the adequacy of the survey effort and to compare species richness among habitat types and to estimate species richness.

To demonstrate the adequacy of the survey effort, species accumulation curves were prepared using a custom written randomising program (Thompson and Thompson 2007), so that the catch was randomised across the number of trapping days (i.e. 14). Ten thousand iterations were used to average the curves. A non-linear regression curve was then calculated using the Beta-P model (Thompson et al. 2003b) in NLREG software (Sherrod 2001) for each habitat type and the overall trapping survey results. Species accumulation curves were plotted with the ordinate axis as species richness and on the abscissa the number of individuals caught. Species accumulation curves were calculated for the combined sites for control and impact areas for the three habitat types. Species accumulation curves were also used to estimate species richness based on 500 and 1000 captures for each habitat type.

2.6.3 Evenness

The evenness method described by Smith and Wilson (1996), and supported by Magurran (2004), was calculated (E_{var}) for each of the trapped assemblages using Species, Diversity and Richness software (Pisces Conservation Ltd 2010).

2.6.4 Diversity

Log series diversity (Fisher's alpha) was used to measure diversity because of its good discriminating ability and low sensitivity to sample size (Kempton 1979, Magurran 1988, Hayek and Buzas 1997). Log series diversity was calculated using Species, Diversity and Richness software (Pisces Conservation Ltd 2010).

2.6.5 Similarity

The Morisita-Horn index was used to compare similarity between combinations of sites across the project area. The quantitative Morisita-Horn similarity index was selected because it is not strongly influenced by either species richness or sample size (Wolda 1981) and it was recommended by Magurran (2004); however, it is heavily influenced by the abundance of the most abundant species.

2.6.6 Rehabilitation and Degradation Index

The RDI (Thompson et al. 2007b) was used to assess the difference in the fauna assemblage between the control and impact sites, utilising the reptile assemblage as an indicator of the total faunal assemblage. The method of calculating for RDI scores is as outlined in Thompson *et al*. (2007b).

3 RESULTS

As the results from the 2008 and 2011 surveys will be used for comparative purposes in the discussion, they are also included in the tables in the results section, as this avoids repeating these tables in the discussion.

3.1 Fauna habitats

Images of the various fauna habitats at each of the survey sites are shown in Plates 2a-w.

Plate 2a. Sand plain 1

Plate 2b. Sand plain 2

Plate 2c. Sand plain 3

Plate 2d. Sand plain 4

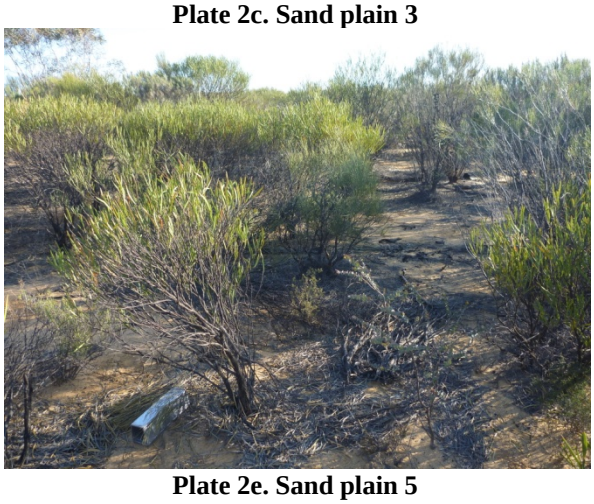


Plate 2e. Sand plain 5

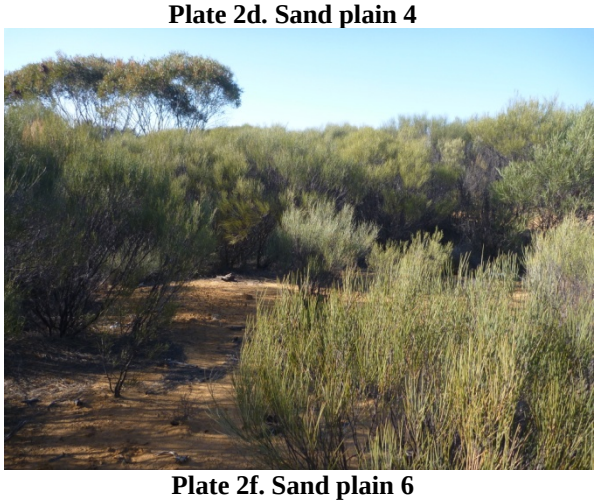


Plate 2f. Sand plain 6

Plate 2g. Sand plain 7

Plate 2h. Sand plain 8

Plate 2i. Sand plain 9

Plate 2j. Sand plain 10

Plate 2k. Eucalypt woodland 1

Plate 2l. Eucalypt woodland 2

Plate 2m. Eucalypt woodland 3

Plate 2n. Eucalypt woodland 4

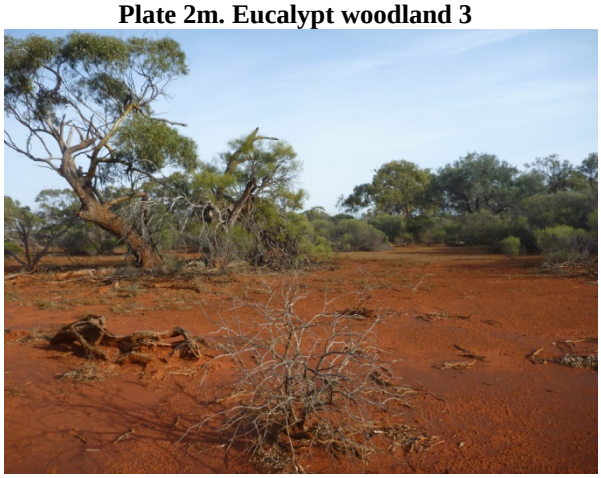


Plate 2o. Eucalypt woodland 5

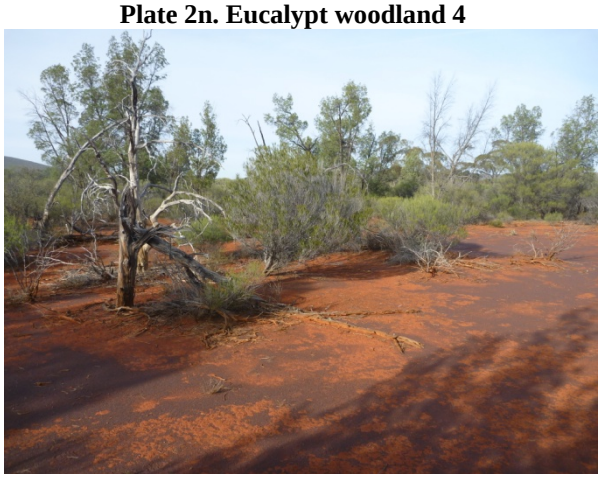


Plate 2p. Eucalypt woodland 6

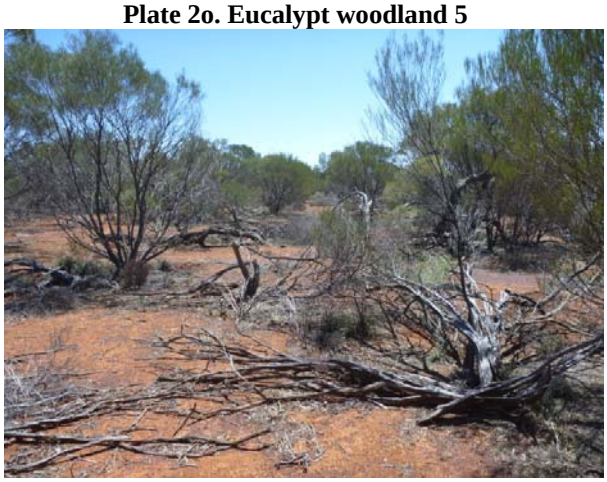


Plate 2q. Eucalypt woodland 7

Plate 2r. Eucalypt woodland 8

Plate 2s. Eucalypt woodland 9

Plate 2t. Eucalypt woodland 10

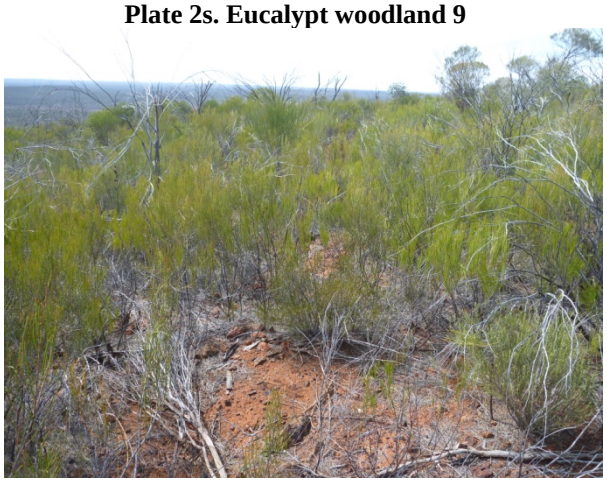


Plate 2u. ironstone Ridge control

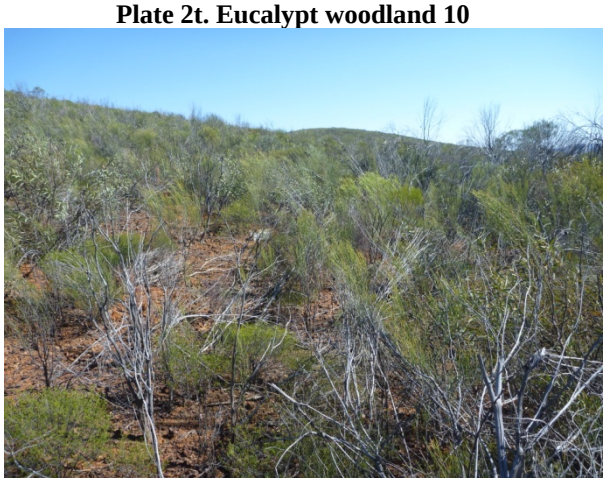


Plate 2v. ironstone Ridge control new

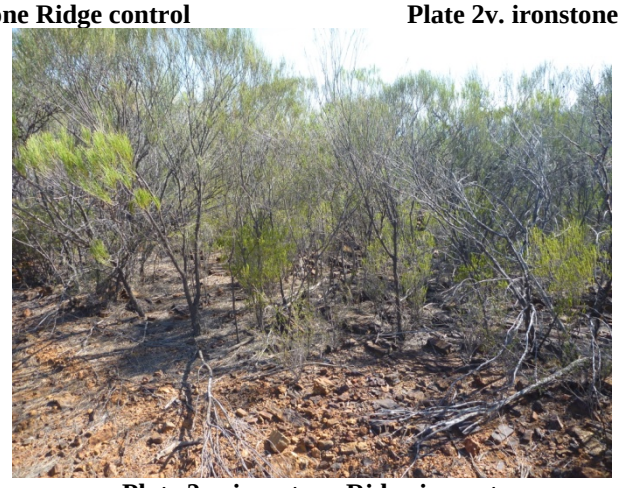


Plate 2w. ironstone Ridge impact

3.2 Local environmental conditions during survey periods

Data from the MGM weather station has been used to describe daily weather during the October-November 2013 survey. The Paynes Find weather station data were used to describe the daily weather during the 2008 survey period and MGM weather station for the 2011 survey. Dates shaded in grey in Table 2 show the days when traps were open.

Table 2. Daily weather data for survey periods in 2008, 2011 and 2013

2008				2011				2013			
Date	**Min. Ta (ºC)**	**Max Ta. (ºC)**	**Rainfall (mm)**	**Date**	**Min. Ta (ºC)**	**Max Ta. (ºC)**	**Rainfall (mm)**	**Date**	**Min. Ta (ºC)**	**Max Ta. (ºC)**	**Rainfall (mm)**
20/1/2008	23.3	36.8		3/12/2011	20.1	34.3		21/10/2013	14.4	22.4	
21/1/2008	22.4	36.5		4/12/2011	24.0	35.3	1.2	22/10/2013	10.9	26.2	
22/1/2008	22.6	36.6		5/12/2011	19.7	34.9		23/10/2013	13.4	29.7	
23/1/2008	19.2	38.5		6/12/2011	18.1	32.7	9.4	24/10/2013	16.2	33.6	
24/1/2008	22.1	41.0		7/12/2011	15.5	29.9		25/10/2013	13.4	30.6	
25/1/2008	23.2	39.5		8/12/2011	15.8	29.1		26/10/2013	11.1	31.5	
26/1/2008	22.8	41.3		9/12/2011	17.1	28.9		27/10/2013	13.2	34.6	
27/1/2008	24.7	42.0		10/12/2011	18.6	30.3		28/10/2013	16.0	35.6	
28/1/2008	23.7	40.7		11/12/2011	19.0	29.4	4.8	29/10/2013	18.8	37.7	
29/1/2008	22.1	38.6		12/12/2011	18.0	34.3	0.6	30/10/2013	22.2	39.4	
30/1/2008	21.6	36.9		13/12/2011	19.0	30.0		31/10/2013	16.2	38.5	
31/1/2008	21.4	37.8		14/12/2011	15.5	30.0		1/11/2013	18.5	36.2	
1/2/2008	23.5	40.8		15/12/2011	19.8	29.2		2/11/2013	17.0	31.7	
2/2/2008	27.4	40.0	5.8	16/12/2011	17.6	30.6		3/11/2013	18.3	37.4	
3/2/2008	20.7	38.1	0.2	17/12/2011	18.8	35.8		4/11/2013	19.1	37.7	
4/2/2008	25.7	37.7	2.8	18/12/2011	15.9	34.0		5/11/2013	16.1	33.9	
5/2/2008	21.0	31.7	3.2	19/12/2011	13.6	32.8		6/11/2013	12.1	31.2	
6/2/2008	21.4	32.0		20/12/2011	14.8	36.3		7/11/2013	14.4	30.3	
Averages	22.7	38.1			17.8	32.1			16.2	34.7	

Ambient temperatures in October and November 2013 (Table 2) were lower than those during the survey period in 2008 but generally higher than during the survey in 2011. Local flooding was evident from two rain episodes in 2008, with the consequence that many of the bucket pit-traps in the eucalypt woodland had to be bailed out on at least two occasions. Rain during the 2011 survey only contributed small quantities of water to the bottoms of some pit-traps in the eucalypt woodland. This rain would have reduced the number of animals captured. It did not rain during the 2013 survey. The impact of these weather variations is addressed in the discussion.

3.3 Fauna assemblage structure

Reptiles and mammals caught in traps during the survey are shown in Table 3. Most terrestrial vertebrates were caught in the eucalypt woodland sites, followed by the sites in the sand plain. As would have been expected, no reptile hatchlings were caught. It was noted in the 2008 survey report that there was an abundance of reptile hatchlings in that dataset and there were a small number of hatchlings recorded in the 2011 survey. The composition of the captured fauna assemblage in 2013 differs remarkably from previous years (Table 3) although there is no significant difference in Fisher's diversity index scores ($F_{2,27}$ = 2.61, P = 0.09 for the 10 eucalypt woodland sites, and $F_{2,17}$ = 0.11, P = 0.89 for the sand plain sites).

The addition of the new banded ironstone ridge control site has added an additional 104 individuals to the overall tally. However, even when these additional animals are taken into account, the overall total number of mammals caught in 2013 (92) was less than in 2008 (112) and a lot less than 2011 (219), although the total number of species was similar (i.e. 8, 7 and 8 respectively). Other major differences include a change in the number of agamids caught from 78 in 2008, to 28 in 2011 to 52 in 2013; for snakes from 36 in 2008 to 24 in 2011 to 74 in 2013. However, no Yellow-faced Whip Snakes were caught in 2011 and 2013 and no mulga snakes were caught in 2013 but 3 were caught in 2008 and 2 in 2011. In contrast, 28 Shovel-nosed snakes were caught in 2013, whereas, 6 were caught in 2008 and 7 in 2011. Almost twice the number of geckos were caught in 2013 (640) compare with 2008 (375) and 2011 (310). Pygopod numbers were similar among surveys (37, 38 and 34), whereas, skink numbers varied appreciably with 510 in 2008, 656 in 2011 and 285 in 2013.

3.4 Fauna assemblage by trap type

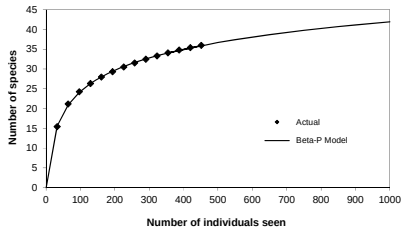
Table 4 shows the number of individuals caught in each trap type. Aluminium box traps caught the most mammals, followed by pipe and bucket pit-traps. Box trap capture numbers were heavily influenced by the total number of *Notomys alexis* and *N. mitchellii* caught. Bucket pit-traps caught more lizards in 2008 and 2013, whereas, funnel traps caught more lizards in 2011. For snakes, funnel traps caught the most, followed by bucket and pipe-pit traps in 2008, 2011 and 2013.

3.5 Species accumulation curves

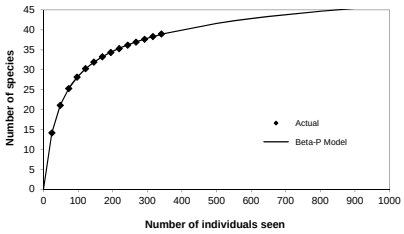
Species accumulation curves for control and impact sites for each habitat type are presented in Graph 1. These graphs extrapolate the existing data to indicate the likely number of species that would have been caught had additional survey effort been undertaken. An asymptote in the species accumulation curve provides a clear indication of the species richness in an area. The asymptote was clearly only reached for the new control site on the ironstone ridge, indicating that this ridge was likely to support 26 species. Species accumulation curves have commenced to flatten for the eucalypt woodland and sand plain control and impact sites so species richness can be compared for these habitats based on nominated additional individuals being caught (i.e. 500 and 1000 individuals), but additional trapping is required for the species accumulation curves to provide an accurate estimate of species richness (i.e. curves form an obvious asymptote) for these habitats. Species accumulation curves for the original control and ironstone impact ridge sites have not commenced to plateau, so species richness cannot be estimated for these two areas.

Table 5 shows the estimated number of species likely to have been caught in control and impact sites if 500 and 1,000 individuals were caught. Large differences between the estimated species richness for when 500 and 1000 individuals are caught generally indicates the estimate is unreliable.

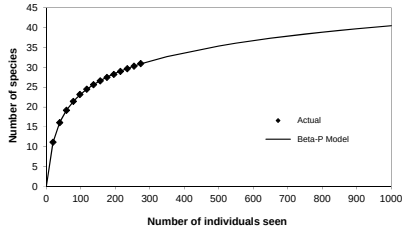
Graph 1. Species accumulation curves for control and impact sites for each of the habitat sites surveyed



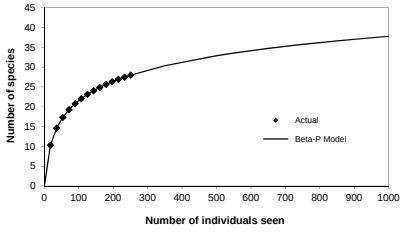
A: Eucalypt woodland control



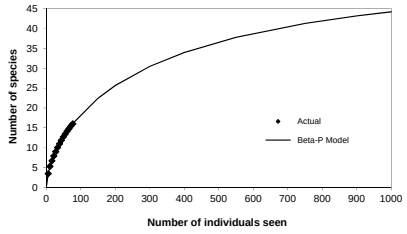
B: Eucalypt woodland impact



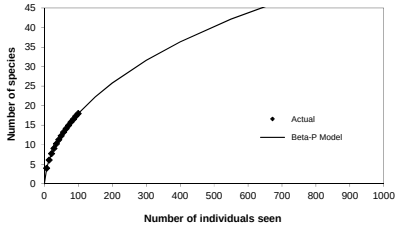
C: Sand plain control



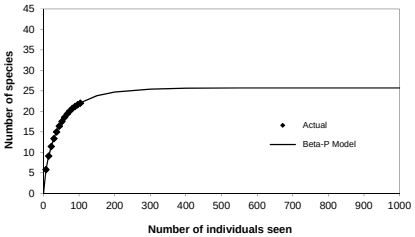
D: Sand plain impact



E: Ridge control



F: Ridge impact



G: Ridge control new

Table 3. Number of individuals caught by species by habitat type in 2008, 2011 and 2013

	Years	2008							2011							2013							
Family	Species	Euc Control	Euc Impact	Ridge Control	Ridge Impact	Sand Control	Sand Impact	Total	Euc Control	Euc Impact	Ridge Control	Ridge Impact	Sand Control	Sand Impact	Total	Euc Control	Euc Impact	Ridge Control (orig)	Ridge Control (new)	Ridge Impact	Sand Control	Sand Impact	Total
Mammals																							
Dasuridae	*Antechinomys laniger*		1					1															
	Pseudantechinus woolleyae						1	1			13				13			1					1
	Sminthopsis crassicaudata	2	2				1	5		2					2		4				1	2	7
	Sminthopsis dolichura	8	10			25	27	70	19	18			34	16	87	1				1	7	9	18
	Sminthopsis gilberti		1				2	3															
Leporidae	*Oryctolagus cuniculus*																		2				2
Muridae	*Mus musculus*						3	3	11	16	1		13	15	56	12	9		2		5	8	36
	Notomys alexis													1	1						17	1	18
	Notomys mitchellii					1	11	12	2				8	11	21						5	2	7
	Pseudomys hermannsburgensis	11	5				1	17	11	24			3	1	39	1	1		1				3
Tachyglossidae	*Tachyglossus aculeatus*																				1		1
	Number of individuals	21	19	0	0	26	46	112	43	60	14	0	58	44	219	14	14	1	5	1	36	22	93
	Number of species	3	5	0	0	2	7	8	4	4	2	0	4	5	7	3	3	1	3	1	6	5	9
Reptiles																							
Agamidae	*Diporiphora amphiboluroides*						1	1															
	Ctenophorus cristatus				1			1								1							1
	Ctenophorus reticulatus	2	6					8															
	Ctenophorus scutulatus	9	9	3	2	12	18	53	7				7	4	18	12			5	3	7	6	33
	Moloch horridus			1		2	3	6					1	4	5						4	2	6
	Pogona minor			1		5	3	9	1		1		3		5	3	1		1	1	1	5	12
Boidae	*Antaresia stimsoni*			1				1				1			1					1			1
Elapidae	*Brachyurophis fasciolata*												1		1								
	Brachyurophis semifasciata	2	3				1	6	2	3	1			1	7	9	11		1		1	6	28
	Demansia psammophis				1		1	2															
	Furina ornate				1			1									1	1					2
	Neelaps bimaculatus																		3				3
	Parasuta monachus	1	2	1	1	2	1	8	1				1		2		1			1	5	1	8
	Pseudechis australis	2				1		3	1					1	2								
	Pseudonaja mengdeni					2		2					5		5	1					1		2
	Pseudonaja modesta	1		2	1			4			1				1		1	1			2		4
	Simoselaps bertholdi	5	2					7	1	2					3	16	6	1	1	2			26
	Suta fasciata	1	1					2	1	1					2								
Gekkonidae	*Diplodactylus granariensis*	16	4		3	12	3	38	20	5	1	1	12	8	47	27	13	2	4		30	28	104

	Years	2008							2011							2013								
Family	Species	Euc Control	Euc Impact	Ridge Control	Ridge Impact	Sand Control	Sand Impact	Total	Euc Control	Euc Impact	Ridge Control	Ridge Impact	Sand Control	Sand Impact	Total	Euc Control	Euc Impact	Ridge Control (orig)	Ridge Control (new)	Ridge Impact	Sand Control	Sand Impact	Total
	Diplodactylus pulcher	13	11	8	6	6	9	53	14	5	2		15	17	53	20	20	2	11	2	14	23	92
	Gehyra variegate	60	40	12	8	10	4	134	30	20	21	22	8		101	76	40	21	15	46	22	5	225
	Heteronotia binoei	4	9	42	23			78	6	9	32	7			54	12	12	29	19	15			87
	Lucasium maini	10				1		11	8	5			1		14	16	14					1	31
	Lucasium squarrosum	5	11			1		17	5	5			2		12	7	18				3	2	30
	Underwoodisaurus milii				1			1			1	2			3		3	2	2	9			16
	Oedura reticulata	11	1					12		1					1	9	3						12
	Rhynchoedura ornata	19	9			1	2	31	8	7			4	4	23	7	7				4	18	36
	Strophurus assimilis															2	2						4
	Strophurus strophurus												2		2						3		3
Pygopodidae	*Delma australis*	1	1		2			4	6					5	11	3	3			1		4	11
	Delma butleri	1						1		1					1							3	3
	Lialis burtonis	1	1					2								1	1			1	1	1	5
	Pygopus nigriceps	13	6	2		5	4	30	12	11			1	2	26	6	6		2		1		15
Scincidae	*Cryptoblepharus buchananii*	15	5					20	6	4					10	9	9						18
	Ctenotus mimetes																		1			1	2
	Ctenotus pantherinus			1				1				1		8	9			1		2	1	12	16
	Ctenotus schomburgkii	43	93			74	17	227	51	104		5	132	40	332	43	54		2		41	39	179
	Ctenotus severus		12	2		1	8	23		5	2			1	8			1	16				17
	Ctenotus uber										1				1								
	Egernia depressa	3	13	12	15			43	1	3	2	4			10		6	8	2	8			24
	Eremiascincus richardsonii	6	6					12	13	7			2	2	24	17	12						29
	Lerista gerrardii	2						2	13	10	1	1	2	3	30	5	5				1		11
	Lerista kingi	21	4	2	4	6	12	49	14	5		2	5	13	39	33	9	1	4	1	23	14	85
	Liopholis inornata					28	28	56		2		2	22	43	69	1	3				40	36	80
	Menetia greyii	27	19		12	4	4	66	47	26		3	2	10	88	71	30	2	4	4	6	16	133
	Morethia butleri	4	3				1	8	7	19					26	15	12						27
	Tiliqua occipitalis					2	1	3					5	5	10						8	1	9
Typhlopidae	*Ramphotyphlops australis*	1	2			1	1	5									2						2
	Ramphotyphlops bicolor															2	2						4
	Ramphotyphlops bituberculatus									1					1	2	4						6
	Ramphotyphlops hamatus															1	1	1	3				6
	Ramphotyphlops waitii	1	2		1			4		3					3	4	9				2		15
Varanidae	*Varanus caudolineatus*	9	5					14	8	3					11	3	4			1			8
	Varanus gouldii	1				14	6	21					6	3	9		1				10	3	14
	Varanus panoptes	1					1	2		1			1		2	1	1				7	2	11

	Years	2008							2011							2013							
Family	Species	Euc Control	Euc Impact	Ridge Control	Ridge Impact	Sand Control	Sand Impact	Total	Euc Control	Euc Impact	Ridge Control	Ridge Impact	Sand Control	Sand Impact	Total	Euc Control	Euc Impact	Ridge Control (orig)	Ridge Control (new)	Ridge Impact	Sand Control	Sand Impact	Total
	Varanus tristis	3		1	2			6	6	3	2	1			12	3		3	3	1			10
	Number of individuals	314	280	91	84	190	129	1088	289	271	68	52	240	174	1094	438	327	76	99	99	238	229	1506
	Number of species	34	27	15	17	21	22	47	26	28	13	13	23	19	44	33	36	15	19	17	25	23	49
Total		**335**	**299**	**91**	**84**	**216**	**175**	**1200**	**332**	**331**	**82**	**52**	**298**	**218**	**1313**	**452**	**341**	**77**	**104**	**100**	**274**	**251**	**1599**

Table 4. Number of individuals caught by species by trap type in 2008, 2011 and 2013

	Years	2008					2011					2013				
Family	Species	Bucket	Pipe	Funnel	Box trap	Total	Bucket	Pipe	Funnel	Box trap	Total	Bucket	Pipe	Funnel	Box trap	Total
Mammals																
Dasyuridae	*Antechinomys laniger*		1			1										
	Sminthopsis crassicaudata	2	3			5	2				2	2	5			7
	Sminthopsis dolichura	21	49			70	9	76	2		87	8	9		1	18
	Sminthopsis gilberti	1	2			3										
	Pseudantechinus woolleyae		1			1				13	13				1	1
Leporidae	*Oryctolagus cuniculus*														2	2
Muridae	*Mus musculus*		3			3	22	27	1	6	56	9	12	3	12	36
	Notomys alexis							1			1	4	1		13	18
	Notomys mitchellii			1	11	12	2	19			21		2		5	7
	Pseudomys hermannsburgensis	5	8		4	17	18	20	1		39	1	1		1	3
Tachyglossidae	*Tachyglossus aculeatus*											1				1
	Subtotal	29	67	1	15	112	53	143	4	19	219	25	30	3	35	93
Amphibians																
Myobatrachidae	*Neobatrachus wilsmorei*	1				1										
	Neobatrachus sp.	12	25	3		40										
	Subtotal	13	25	3	0	41										
Lizards																
Agamidae	*Diporiphora amphiboluroides*			1		1										
	Ctenophorus cristatus			1		1								1		1
	Ctenophorus reticulatus	4	3	1		8										
	Ctenophorus scutulatus	26	15	12		53	5	3	10		18	13	6	14		33
	Moloch horridus	2	2	2		6	4	1			5	4	1		1	6
	Pogona minor	6	1	2		9	2	1	2		5	4	5	3		12
Gekkonidae	*Diplodactylus granariensis*	19	7	12		38	21	8	18		47	59	26	19		104
	Diplodactylus pulcher	28	9	16		53	34	12	7		53	51	24	17		92
	Gehyra variegata	65	21	48		134	16	2	83		101	72	28	125		225
	Heteronotia binoei	9	2	67		78	5	2	47		54	14	2	71		87
	Luciaium maini	10	1			11	9	4	1		14	19	12			31
	Lucasium squarrosum	13	3	1		17	6	5	1		12	19	10	1		30
	Oedura reticulata	6	5	1		12		1			1	4	8			12
	Rhynochoedura ornata	15	14	2		31	16	5	2		23	24	11	1		36
	Strophurus assimilis											3	1			4
	Strophurus strophurus						1		1		2		1	1	1	3
	Underwoodisaursis milii			1		1			3		3	1		15		16
Pygopodidae	*Delma australis*		2	2		4	7	2	2		11	8	1	2		11
	Delma bulteri	1				1		1			1	1	1	1		3
	Lialis burtonis	1		1		2								5		5
	Pygopus nigriceps	7	2	21		30	3	3	20		26	3		12		15

	Years	2008					2011					2013				
Family	Species	Bucket	Pipe	Funnel	Box trap	Total	Bucket	Pipe	Funnel	Box trap	Total	Bucket	Pipe	Funnel	Box trap	Total
Scinidae	*Cryptoblepharus buchananii*	8	9	3		20	3	3	4		10	6	10	2		18
	Ctenotus mimetes													2		2
	Ctenotus pantherinus			1		1	3	1	5		9	2	2	12		16
	Ctenotus schomburgkii	115	44	67	1	227	122	69	141		332	84	43	52		179
	Ctenotus severus	5	5	13		23		2	6		8			17		17
	Ctenotus uber								1		1					
	Egernia depressa	8	4	31		43	1		9		10	4	1	19		24
	Eremiascincus richardsonii	3	6	3		12	12	5	7		24	11	8	10		29
	Lerista gerrardii		2			2	16	7	7		30	10		1		11
	Lerista kingi	26	7	16		49	25	8	6		39	46	24	15		85
	Liopholis inornata	25	28	3		56	31	30	8		69	44	28	8		80
	Menentia greyii	41	6	19		66	60	10	18		88	73	27	33		133
	Morethia butleri	6		2		8	12		14		26	10	5	12		27
	Tiliqua occipitalis			2	1	3	1	1	5	3	10			8	1	9
Varanidae	*Varanus caudolineatus*	8	1	5		14	6	4	1		11	5		3		8
	Varanus gouldii	4	6	8	3	21		4	4	1	9	1	6	5	2	14
	Varanus panoptes			2		2		2			2	1	5	4	1	11
	Varanus tristis		3	3		6	3	5	4		12			10		10
	Subtotal	461	208	369	5	1043	421	196	433	4	1066	596	296	501	6	1399
Snakes																
Boidae	*Antaresia stimsoni*			1		1			1		1			1		1
Typhlopidae	*Ramphotyphlops australis*	4		1		5						1	1			2
	Ramphotyphlops bicolor											2	2			4
	Ramphotyphlops bituberculatus	1				1	1				1	2	4			6
	Ramphotyphlops hamatus											1	1	4		6
	Ramphotyphlops waitii	2		2		4	1	2			3	10	5			15
Elapidae	*Brachyurophis fasciolata*								1		1					
	Brachyurophis semifasciata	4		2		6	3	2	2		7	11	9	8		28
	Demansia psammophis			2		2										
	Furina ornata			1		1						1		1		2
	Neelaps bimaculatus													3		3
	Parasuta monachus	4		4		8			2		2	2	4	2		8
	Pseudechis australis			3		3			1	1	2	1		1		2
	Pseudonaja mengdeni			2		2		1	4		5	1		1		2
	Pseudonaja modesta								1		1	1		3		4
	Simoselaps bertholdi	4	1	2		7			3		3	8	5	13		26
	Suta fasciata	1		1		2	1		1		2					
	Subtotal	19	1	25	0	45	6	5	16	1	28	40	31	36	0	107
Total		**522**	**301**	**398**	**20**	**1241**	**480**	**344**	**453**	**24**	**1313**	**661**	**357**	**540**	**41**	**1599**

Table 5. Asymptotes for species accumulation curves and estimates of species richness for the combined data for control and impact sites for each of the habitat types

	2008				2011				2013			
	#species	Asymptote	# species at 500 individuals	# species at 1000 individuals	#species	Asymptote	# species at 500 individuals	# species at 1000 individuals	#species	Asymptote	# species at 500 individuals	# species at 1000 individuals
Eucalypt woodland control	37	8274	40.6	47.1	30	45.6	31.4	33.8	36	820	36.7	41.9
Eucalypt woodland impact	32	39.8	34.5	36.7	32	34.9	33.3	34.4	39	69.7	41.6	46.0
Sand plain control	23	128.2	28.7	33.4	27	42.7	30.2	33.7	31	484	35.4	40.5
Sand plain impact	29	9529	39.9	47.6	24	47.7	27.7	30.6	28	23334	32.9	37.8
Ridge control (orig.)	15	28.3	25.1	27.3	15	54568	41.5	61.3	16	52.0	36.7	44.2
Ridge control (new)									22	25.7	25.7	25.7
Ridge impact	17	31.5	28.4	30.6	13	22.7	20.6	21.6	18	6354	40.3	55.0

3.6 Diversity, similarity and evenness

Morisita-Horn similarity scores are shown for control and impact sites in Table 6. Scores of 0.80 and higher are shown in bold indicating a high level of similarity between fauna assemblages.

As expected, fauna assemblages between control and impact sites for the sand plain and eucalypt woodland were reasonably similar, and more so than those on the ridges. There is a reasonable level of similarity between the existing and new control sites on the ridge (i.e. 0.72). However, the similarity between the original control sites and the impact sites on the ridges is much higher (0.80) than the similarity between the new control sites and the impact sites (0.58).

Table 6. Morisita-Horn similarity scores for the combined control and impact sites for each of the three habitat types

Survey areas	Ridge Control (orig)	Ridge Control (new)	Sand Plain Control	Eucalypt Woodland Impact	Ridge Impact	Sand Plain Impact
2008						
Eucalypt Woodland Control	0.23		0.54	0.77	0.39	0.45
Ridge Control			0.06	0.23	**0.84**	0.11
Sand Plain Control				0.84	0.09	0.71
Eucalypt Woodland Impact					0.31	0.49
Ridge Impact						0.17
2011						
Eucalypt Woodland Control	0.21		0.58	**0.80**	0.46	0.59
Ridge Control			0.04	0.15	0.70	0.02
Sand Plain Control				**0.87**	0.26	0.72
Eucalypt Woodland Impact					0.38	0.64
Ridge Impact						0.20
2013						
Eucalypt Woodland Control	0.41	0.54	0.59	**0.88**	0.54	0.56
Ridge Control (orig)		0.72	0.18	0.41	**0.80**	0.09
Ridge Control (new)			0.33	0.54	0.58	0.29
Sand Plain Control				0.59	0.25	**0.88**
Eucalypt Woodland Impact					0.54	0.56
Ridge Impact						0.10

Fisher's alpha diversity scores, species richness and evenness scores for each of the sand plain and eucalypt woodland sites are shown in Table 7. As indicated above there is no significant difference among Fisher's diversity score for 2008, 2011 and 2013, however, it is apparent that species richness, diversity and evenness varied appreciably among sites. The eucalypt woodland supports a higher species richness and a greater number of animals were caught in the eucalypt woodland than on the sand plain.

Table 7. Fisher's alpha, recorded species richness and evenness scores for each of the sites on the sand plain and eucalypt woodland

		2008			2011			2013		
Habitat	Site	Fisher's Alpha	Evenness	Species Richness	Fisher's Alpha	Evenness	Species Richness	Fisher's Alpha	Evenness	Species Richness
Eucalypt Woodland	1	12.41	0.97	21	7.49	0.92	15	7.52	0.95	20
	2	9.60	0.97	21	7.57	0.97	17	11.44	0.97	23
	3	8.63	0.96	20	7.73	0.94	20	7.12	0.91	20
	4	7.97	0.90	20	10.28	0.96	19	8.20	0.89	17
	5	10.80	0.96	20	7.84	0.93	18	9.47	0.94	24
	6	4.30	0.81	13	6.70	0.87	17	12.17	0.96	22
	7	7.21	0.75	17	7.08	0.75	18	6.72	0.82	16
	8	11.69	0.96	20	9.26	0.96	20	13.75	0.95	24
	9	14.15	0.94	20	8.03	0.97	15	15.91	0.97	24
	10	10.79	0.96	19	7.58	0.94	16	12.07	0.97	26
Sand Plain	1	6.17	0.95	12	7.49	0.80	15	5.81	0.93	15
	2	8.72	0.95	13	7.57	0.68	17	13.10	0.95	21
	3	8.16	0.96	13	7.73	0.88	16	6.97	0.94	15
	4	9.95	0.95	17	10.28	0.87	12	7.57	0.96	17
	5	7.13	0.95	13	7.84	0.90	10	6.61	0.86	12
	6	3.73	0.90	9	6.70	0.96	9	7.78	0.98	16
	7	10.09	0.95	18	7.08	0.96	14	7.74	0.96	15
	8	10.22	0.94	14	9.26	0.90	17	7.90	0.91	16
	9	5.63	0.87	13	8.03	0.92	16	6.33	0.92	13
	10	6.97	0.78	15	7.58	0.94	14	5.93	0.95	14
Ridge control								6.14	0.82	16
Ridge control new								8.53	0.94	22
Ridge impact								6.40	0.79	18

3.7 New species recorded

Six species were trapped during the 2013 survey that had not been trapped during previous surveys (Table 3). Rabbit (*Oryctolagus cuniculus*) and echidna (*Tachyglossus aculeatus*) diggings and scats were evident in a number of areas during this and previous surveys, however, this is the first occasion in which they had been caught. It was a surprise to catch two rabbits in aluminium box traps on the new control ridge. Echidnas are occasionally caught in pit-traps.

Strophurus assimilis was caught in the eucalypt woodland, *Ctenotus mimetes* was caught on the new control ridge and the sand plain and *Ramphotyphlops bicolor* and *Ramphotyphlops hamatus* were caught in the eucalypt woodland, and *R. hamatus* was also caught on both control ridge sites. None of these species had previously been recorded during monitoring surveys.

3.8 Species not recorded

Antechinomys laniger (Kultarr) and *Smithopsis gilberti* (Gilbert's Dunnart) were only caught in 2008. Kultarr is either relatively rare or difficult to trap and dunnart numbers are known to fluctuate based on the available resources in arid areas (Dickman et al. 2001), so these variations are explainable. *Diporiphora amphiboluroides, Ctenophorus reticulatus* and *Demansia psammophis* were only caught in 2008. A single *Brachyurophis fasciolata* was caught during the 2011 survey and *Pseudechis australis* was caught in sand plain sites in 2008 (3) and 2011 (2) but not in 2013.

3.9 RDI scores

Initially, we have compared the original banded ironstone ridge control sites with the new banded ironstone ridge control sites as it is proposed that Iron Hill South, on which the original control sites are located, will be disturbed. A score of 76.4 (Table 8) indicates that there was a moderate similarity between the fauna assemblage on these two sites (Table 1).

Table 8. Comparison of the original and new ridge control sites using the RHI score

	Maximum weighted score	Ridge control (orig.)	Ridge control (new)
Abundance		99	99
Recorded species richness		19	17
Log series diversity	25		22.24
Evenness	25		20.14
Similarity	25		18.25
S_R	25		22.79
Diversity parameter	100		83.42
Assemblage composition parameter	100		88.40
Ecological parameter	100		47.74
Weighted scores			
Diversity parameter			26.69
Assemblage composition parameter			38.01
Ecological parameter			11.93
Overall score for each site	**100**		**76.64**

A summary of the calculations for the RDI scores and the final scores for the 2013 survey are shown in Table 9 along with the same data for the 2008 and 2011 surveys.

Table 9. Summary of RDI scores for the three habitat types for 2008, 2011 and 2013

		2008						2011						2013							
		Undisturbed site captures			Impact site captures			Undisturbed site captures			Impact site captures			Undisturbed site captures				Impact site captures			
	Maximum weighted score	Eucalypt Control	Ridge Control	Sand Plain Control	Eucalypt Woodland Impact	Ridge Impact	Sand Plain Impact	Eucalypt Control	Ridge Control	Sand Plain Control	Eucalypt Woodland Impact	Ridge Impact	Sand Plain Impact	Eucalypt Control	Ridge Control (orig.)	Ridge Control (new)	Sand Plain Control	Eucalypt Woodland Impact	Ridge Control (orig.)	Ridge Control (new)	Sand Plain Impact
Abundance		314	91	190	280	84	129	289	68	240	271	52	174	438	76	99	238	327	99	99	229
Recorded species richness		34	15	21	27	17	22	26	13	23	28	13	19	33	15	19	25	36	19	17	23
Log series diversity	25				21.64	20.48	22.09				20.29	22.21	24.70					22.25	24.32	22.91	23.75
Evenness	25				23.63	21.56	21.20				20.45	19.95	17.06					23.71	23.90	19.09	24.18
Similarity	25				19.23	21.05	17.63				20.00	17.50	17.75					22.00	24.32	22.91	22.50
S_R	25				22.59	23.00	22.91				23.78	23.32	23.77					23.22	23.90	19.09	24.10
Diversity parameter	100				87.09	86.09	83.82				84.52	82.98	83.29					91.17	72.13	61.09	94.53
Assemblage composition parameter	100				79.48	77.35	76.58				81.99	66.65	81.60					82.29	87.46	98.70	93.67
Ecological parameter	100				85.99	85.98	77.71				89.07	80.43	70.83					76.46	75.42	48.78	76.82
Weighted scores																					
Diversity parameter					27.87	27.55	26.82				27.05	26.55	26.65					29.18	23.08	19.55	30.25
Assemblage composition parameter					34.18	33.26	32.93				35.25	28.66	35.09					35.39	37.61	42.44	40.28
Ecological parameter					21.50	21.49	19.43				22.27	20.11	17.71					19.11	18.85	12.20	19.21
Overall score for each site	**100**				**83.54**	**82.30**	**79.18**				**84.57**	**75.32**	**79.45**					**83.68**	**79.55**	**74.19**	**89.73**

TERRESTRIAL ECOSYSTEMS

3.10 Notable observations

3.10.1 Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)

Major Mitchell's Cockatoo (Plate 3) were seen on at five least occasions during the fauna survey. Dates and locations are shown in Table 10.These birds were seen foraging in the *Eucalyptus* sp. and understorey shrubs for a while, then they would move to an adjacent area to continue foraging.

Table 10. The location of Major Mitchell's Cockatoo sightings

Date	Nearest site	Number
27/10/13	E1	2
28/10/13	E2, E3	2
30/10/13	E2, E3	2
2/11/13	E4	2
7/11/13	E3, E4	2

Plate 3. Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)

3.10.2 Western Spiny-tailed Skink (*Egernia stokesii badia*)

Western Spiny-tailed Skinks (Plate 4) were recorded at two locations and scats (Plate 5) found at numerous locations (Table 11).

Table 11. Western Spiny-tailed Skink records

Seen	UTM Easting	UTM Northing
Animal	518061	6729008
Animal	518076	6728995

Plate 4. Western Spiny-tailed Skink (*Egernia stokesii badia*)

Plate 5. Western Spiny-tailed Skink scats

3.10.3 Woolley's Pseudantechinus (*Pseudantechinus woolleyae*)

A single Woolley's Pseudantechinus was caught in an aluminium box trap at Iron Hill South.

3.10.4 Malleefowl (*Leipoa ocellata*)

A Malleefowl was seen crossing the road at UTM 50 517910E 6724495N on 24 October at 10:00am.

3.10.5 Rainbow bee-eaters (*Merops ornatus*)

Rainbow Bee-eaters were frequently seen across many sites in the eucalypt woodland.

3.10.6 White-browed Babbler (*Pomatostomus superciliosus*)

White-browed Babblers were regularly heard calling across many sites, but mostly in the eucalypt woodland.

3.10.7 Peregrine Falcon (*Falco peregrinus*)

A Peregrine Falcon was seen on 2/11/2013 near the top of Iron Hill South (UTM 50 516808 6725187) during the clearing of traps in the morning.

3.10.8 Crested Bellbird (*Oreoica gutturalis*)

Crested Bellbirds were heard across most sites and observed on the Impact Ridge and near Sand Plain site 6.

3.10.9 Feral animals

Cat tracks and scats were observed on the control ridge, eucalypt woodland and the sand plain sites during the fauna survey.

4 DISCUSSION

4.1 Adequacy of the data

Species accumulation curves for the sand plain and the eucalypt woodland sites (Graph 1 and Table 5) indicated that there are sufficient data to provide an understanding of the fauna assemblages in these habitats and calculate robust RDI scores for these areas (i.e. all of the relatively abundant species have been caught). However, as indicated in section 3.5, additional survey effort would have increased the number of species recorded in each habitat type. It should be noted that the sand plain impact sites were installed in 2011, so a direct comparison with data for 2008 should be undertaken with caution.

The number of individuals caught in the control, new control and impact sites on the banded ironstone ridges (i.e. 77, 104 and 100, respectively) was higher than in the previous two surveys (Table 3); however, it was still inadequate to provide a reliable RDI score. The trapping effort along the ridges was restricted to the use of funnel and aluminium box traps due to an earlier decision to minimise impacts of two species of declared rare flora.

Ambient temperature and rainfall significantly affects the number of individuals and the relative abundance of each species caught. This is particularly obvious for reptiles where higher numbers are caught in the hotter conditions (Thompson et al. 2010) and a major rainfall event reduces the number of mammals and reptiles caught. Therefore, based on temperature alone it might have been expected that more reptiles would have been caught in the 2008 survey and the least number in the 2011 survey. However, there are obviously other factors influencing the abundance of both reptiles and mammals, as the highest number of mammals where caught during the 2011 survey and approximately 30% more reptiles were caught in 2013 than in the two previous surveys.

4.2 Fauna assemblages

The purpose of establishing impact and control survey sites was to enable changes in the fauna assemblage at impact sites to be detected in the context of significant seasonal and year-to-year variations in the vertebrate fauna assemblage. Given the current distance mining activity and infrastructure are from impact sites on the sand plain and in particular in the eucalypt woodland, impact and control sites should be considered as relatively undisturbed fauna habitats. Impacts from vegetation clearing, noise, vibration, light overspill and vehicle movement in assessed areas were likely to be minor.

Of interest, 12 *Notomys mitchellii* were caught in 2008, and 21 *N. mitchellii* and a single *Notomys alexis* were caught in 2011. In 2013, 18 *N. alexis* and 7 *N. mitchellii* were caught. The reason for this fluctuation maybe due to closing the original sand plain impact sites and opening up new replacement sites in a slightly different location. This site is on the southern geographic boundary for *N. alexis* and the northern boundary for *N. mitchellii* (Van Dyck and Strahan 2008).

Recording *S. assimilis*, *R. bicolor* and *R. hamatus* in the eucalypt woodland, and *Ctenotus mimetes* on the new control ridge and the sand plain added to the species list for the mining tenement. These four species have been recorded in other surveys in adjacent areas, so their presence was not a surprise, but it is interesting that they have not been caught during previous surveys. The number of large snakes caught was less than during previous surveys. In 2008, three *P. australis* and two *P. mengdeni* were caught and in 2011 two *P. australis* and five *P. mengdeni* were caught, but only two *P. mengdeni* were caught in 2013. This may be due to sampling error, or it could reflect a reduction in the number of these larger, widely-foraging snakes.

4.3 Rehabilitation and Degradation Index

A comparison of the original and the new control sites for the banded ironstone ridge yielded a RDI score of 76.6. This is lower that the scores that compares the eucalypt woodland and sand plain impact and control sites but it is similar to the previous score for the comparison between the ridge impact and control sites. This result indicates there are differences in the fauna assemblage between these two control sites. However, sample sizes of 99 are also small which would contribute to this low RDI score.

The RDI scores for the eucalypt woodland area remained high and similar to scores obtained in 2008 and 2011 (i.e. 83.54 for 2008, 84.57 for 2011 and 83.68 for 2013). This should be expected as there is no obvious indication that the mining operations have impacted on the control or the impact sites.

The sand plain RDI scores for 2008 and 2011 were similar (i.e. 79.18 and 79.45) suggesting that there had been little change and the new sand plain impact sites had made very little difference as a control site in assessing changes in the fauna assemblage at the impact sites. The RDI score for the sand plain has now

increased to 89.73 which is a high and difficult to achieve score. Surveys undertaken in the same habitat and at adjacent locations seldom achieve such a high score (Thompson 2004). All three sub parameters (i.e. diversity, assemblage composition and ecological groups) have all increased. It is difficult to know how significant this difference is, as there are no error or standard deviation scores attached to each RDI score. This increase could have been a result of the higher number of animals caught in the sand plain impact sites (i.e. 174 to 229). Either way, these data indicate that there is little difference between the impact and control sites in the trappable vertebrate fauna assemblage for the sand plain.

The relatively low number of individuals caught on the impact and control ridge sites results in a high sampling error which translates into a less reliable RDI score. If the same sites were surveyed again in the following weeks, the RDI score could be appreciably different when there is no actual change in the fauna assemblage.

The RDI scores presented for the eucalypt woodland and sand plain sites are considered to be robust enough to act as an indication of change and for ongoing monitoring.

4.4 Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)

The Ministerial approval statement 753 for the Mt Gibson mine contained multiple requirements. Section 12 of this approval required the preparation of a Mine Site Fauna Management Plan, and this plan was to indicate how the mine was to manage and monitor conservation significant fauna potentially in the mining area. One of these species was Major Mitchell's Cockatoo (*Lophochroa leadbeateri*).

Major Mitchell's Cockatoo has a geographic distribution that borders on the boundary of the wheatbelt north of Southern Cross and extends to north of Geraldton. There are records of Major Mitchell's Cockatoo throughout much of inland Western Australia as far north as Broome (Rowley and Chapman 1991). More recently, Johnstone and Storr (1998) indicated the southernmost geographical distribution of Major Mitchell's Cockatoo in the vicinity of the wheatbelt included a crescent shaped area north of Southern Cross to include Lake Moore and Lake Barlee.

Major Mitchell's Cockatoo were recorded in the Mount Gibson area by Prof Harry Recher (pers. comm.), Hart, Simpson and Associates (2000), Dell (2001) and Burbidge et al. (1989). They were not seen during the fauna survey of the area by ATA Environmental (2004) or during the first baseline vertebrate fauna monitoring survey undertaken in 2008 (Coffey Environments 2008). Burbidge et al. (1989) recorded them breeding in the area.

Major Mitchell's Cockatoo were seen on five occasions during the 2011 fauna survey and on five occasions during this survey. Given that a pair of birds was regularly seen in the vicinity of eucalypt woodland sites E1 – E4 and was seen in the same area in 2011, it is probable that this is a breeding pair and they have a nest and chicks in the general vicinity.

4.5 Western Spiny-tailed Skink (*Egernia stokesii badia*)

The Ministerial approval statement 753 for the Mt Gibson mine contained multiple requirements. Section 12 of this approval required the preparation of a Mine Site Fauna Management Plan, and this plan was to indicate how the mine was to manage and monitor conservation significant fauna potentially in the mining area. One of these species was Western Spiny-tailed Skink (*Egernia stokesii badia*).

Two *Egernia stokesii badia* were located and multiple scats were found in surrounding areas. These Western Spiny-tailed Skinks were found during a brief search (< 15 min) of the area between the trapping lines and walking back to the vehicle parked on the track adjacent to the State Barrier Fence. Given the ease with which they were found, it is highly probable that there are multiple other small colonies in the areas around the mining operations that have hollow logs, in particular York Gums and fallen timber.

4.6 Woolley's Pseudantechinus (*Pseudantechinus woolleyae*)

During the first vertebrate fauna monitoring survey in 2008 a single Woolley's Pseudantechinus was caught in a pipe in the no longer used sand plain impact site but was not caught on Iron Hill South. During the December 2011 survey, 13 individuals were caught on Iron Hill South indicating that their numbers had increased in this area in the last couple of years. Three of these were juveniles indicating that they had bred in the previous spring. During the October-November survey in 2013, a single individual was caught with pouch young, suggesting that they continue to breed and persist in the area.

Woolley (2008) reported that this Pseudantechinus are found in the arid Pilbara, Ashburton, Murchison and Little Sandy Desert regions, and it seems to favour rocky habitats with various vegetation associations. It has

not been caught in other surveys in the region (Burbidge et al. 1989, Hart Simpson and Associates 2000, Schmitz 2001).

4.7 Appreciable difference in species relative abundance

There were considerable differences in the trapped fauna assemblage compared with surveys undertaken in 2008 and 2011. The current survey was undertaken in October-November, whereas, the 2008 and 2011 surveys were undertaken in January and December respectively. Daily minimum and maximum ambient daily temperatures were higher in the 2008 survey, but lower in the 2011 survey, so these differences could account for some of the variation in the captured fauna assemblage. There was a substantial rain event during the 2008 survey which would have reduced the number of captures.

There are numerous species that are relatively rare in the surveyed area. *Ctenotus mimetes* was captured to the east of the eucalypt woodland sites during a survey in 2005 (Anom. 2005) and was captured in the surveys of White Wells (Burbidge et al. 1989) and Mt Gibson Station (Schmitz 2001), so it is present in adjacent areas but it was caught for the first time during the 2013 survey in the fauna monitoring program. *Brachyurophis fasciolata*, *Ctenotus uber*, *Diporiphora amphiboluroides* and *Antechinomys laniger* have all been caught on one occasion during the monitoring surveys but have not been caught in other surveys in adjacent areas. *Demansia psammophis* was caught on two occasions in the 2008 but has not been caught since or recorded in surveys in adjacent areas. *Strophurus assimilis* had not been caught in previous surveys or in surveys in adjacent areas, but was caught on four occasions during the 2013 survey.

5 SUMMARY

5.1 Mining impacts on vertebrate fauna

5.1.1 Eucalypt woodland

Impact sites in the eucalypt woodland were selected to be close to the boundary of the proposed co-disposal waste dump that will be built in the area. Currently, the eucalypt impact and control sites are relatively undisturbed, so until the adjacent area is impacted, surveys in this area will continue to collect baseline data.

The RDI score for the eucalypt woodland area is similar to those calculated in 2008 and 2011 and there is no obvious evidence that mining activity is impacting on fauna assemblages in adjacent areas.

5.1.2 Sand plain

The RDI score for the sand plain area is higher than those calculated in 2008 and 2011 and there is no obvious evidence that mining activity is impacting on fauna assemblages in adjacent areas. This higher score may in part reflect an increase in the number of animals caught in the sand impact. Such a score will be difficult to achieve in subsequent surveys.

5.1.3 Banded ironstone ridge

The RDI score for the existing and new ridge control sites is 76.6 indicating that it is a reasonable replacement should the existing ridge control site be impacted. The RDI scores calculated for all banded ironstone ridges will have a lower reliability than the eucalypt woodland and sand plain areas due to the lower number of individuals caught. Within this context, there was no obvious indication that the vertebrate fauna on the impact hill sites had changed appreciably relative to the control sites.

5.2 Conservation significant species

The Ministerial approval statement 753 for the Mt Gibson mine contained multiple requirements. Section 12 of this approval require that the proponent manage and monitor numerous conservation significant fauna potentially in the mining area. These species included Major Mitchell's Cockatoo, Western Spiny-tailed Skinks, Peregrine Falcon and Rainbow Bee-eaters, all of which were recorded during this survey.

5.2.1 Malleefowl

Seeing Malleefowl while driving the tracks is generally a good indication that there is a reasonable number of Malleefowl in the area. A management plan is in place for Malleefowl that requires annual monitoring.

5.2.2 Major Mitchell's Cockatoo

Based on observations of Major Mitchell's Cockatoo during this and the 2011 monitoring surveys, it is probable that at least one pair of these birds are nesting in the eucalypt woodland to the south of the existing mining operations.

5.2.3 Western Spiny-tailed Skinks

There are likely to be multiple small colonies of Western Spiny-tailed Skinks in the eucalypt woodland that support large hollow logs, particularly to the south of the existing mining operations.

5.2.4 Woolley's Pseudantechinus

Although not listed as a threatened species, Woolley's Pseudantechinus has been caught on Iron Hill South (i.e. original ridge control site) and a single individual was caught on the sand plain during the 2008 survey. The trapped numbers have fluctuated but they have been recorded during surveys in 2008, 2011 and 2013. This species predominantly lives on rugged stony areas, but is occasionally caught on sand plains, which is the situation at Mt Gibson. The source population of Woolley's Pseudantechinus is possibly confined to Iron Hill South.

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TERRESTRIAL ECOSYSTEMS

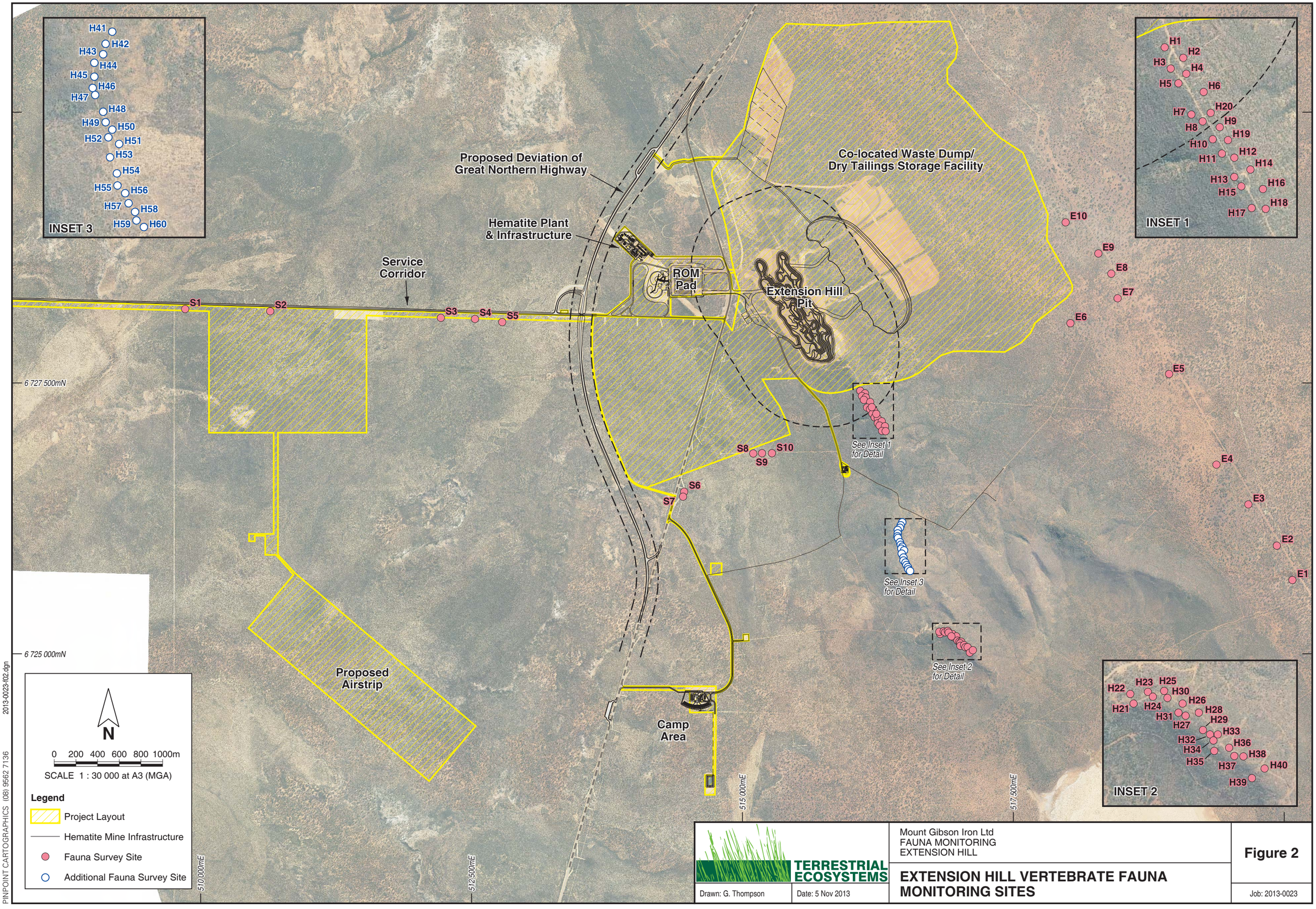
Mount Gibson Iron Ltd
FAUNA MONITORING
EXTENSION HILL

REGIONAL LOCATION

Figure 1

Drawn: G. Thompson | Date: 5 Nov 2013 | Job: 2013-0023

PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-0023-f01.dgn


INSET 3
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INSET 1
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H17
Proposed Deviation of Great Northern Highway
Hematite Plant & Infrastructure
Service Corridor
Co-located Waste Dump/ Dry Tailings Storage Facility
ROM Pad
Extension Hill Pit
S1
S2
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S4
S5
S6
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See Inset 1 for Detail
See Inset 3 for Detail
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Proposed Airstrip
Camp Area
INSET 2
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H40
H39
6 727 500mN
6 725 000mN
510 000mE
512 500mE
515 000mE
517 500mE
N
0 200 400 600 800 1000m
SCALE 1 : 30 000 at A3 (MGA)
Legend
Project Layout
Hematite Mine Infrastructure
Fauna Survey Site
Additional Fauna Survey Site
2013-0023-f02.dgn
PINPOINT CARTOGRAPHICS (08) 9562 7136
TERRESTRIAL ECOSYSTEMS
Drawn: G. Thompson
Date: 5 Nov 2013
Mount Gibson Iron Ltd
FAUNA MONITORING
EXTENSION HILL
EXTENSION HILL VERTEBRATE FAUNA MONITORING SITES
Figure 2
Job: 2013-0023

Appendix A
Coordinates of survey sites

Appendix A. Coordinates of survey sites

Site name	UTM Zone	UTM Easting	UTM Northing
E1	50	520075	6725681
E2	50	519932	6725999
E3	50	519668	6726379
E4	50	519375	6726746
E5	50	518937	6727583
E6	50	518027	6728052
E7	50	518462	6728282
E8	50	518404	6728509
E9	50	518285	6728696
E10	50	517982	6728982
S1	50	509856	6728182
S2	50	510642	6728163
S3	50	512216	6728102
S4	50	512531	6728092
S5	50	512783	6728062
S6	50	514463	6726496
S7	50	514451	6726450
S8	50	515099	6726850
S9	50	515181	6726852
S10	50	515273	6726852
H1	50	516088	6727428
H2	50	516131	6727404
H3	50	516102	6727379
H4	50	516138	6727367
H5	50	516120	6727345
H6	50	516178	6727325
H7	50	516150	6727273
H8	50	516176	6727257
H9	50	516215	6727244
H10	50	516199	6727216
H11	50	516220	6727183
H12	50	516249	6727173
H13	50	516249	6727129
H14	50	516286	6727146
H15	50	516265	6727107
H16	50	516315	6727101
H17	50	516289	6727057
H18	50	516321	6727055
H19	50	516234	6727214
H20	50	516194	6727277
H21	50	516825	6725182
H22	50	516817	6725204

Site name	UTM Zone	UTM Easting	UTM Northing
H23	50	516858	6725209
H24	50	516869	6725198
H25	50	516895	6725211
H26	50	516938	6725182
H27	50	516945	6725154
H28	50	516975	6725161
H29	50	516985	6725121
H30	50	516903	6725195
H31	50	516928	6725161
H32	50	517001	6725111
H33	50	517019	6725111
H34	50	517009	6725097
H35	50	517011	6725073
H36	50	517045	6725080
H37	50	517057	6725061
H38	50	517078	6725060
H39	50	517098	6725010
H40	50	517127	6725032
H41	50	516475	6726215
H42	50	516460	6726187
H43	50	516454	6726163
H44	50	516434	6726143
H45	50	516434	6726111
H46	50	516430	6726085
H47	50	516436	6726069
H48	50	516454	6726030
H49	50	516460	6726006
H50	50	516475	6725989
H51	50	516491	6725956
H52	50	516466	6725971
H53	50	516470	6725925
H54	50	516486	6725888
H55	50	516487	6725860
H56	50	516505	6725842
H57	50	516513	6725819
H58	50	516528	6725799
H59	50	516531	6725779
H60	50	516548	6725764