Northern Quoll trapping surveys at Wall Creek and Mesa 228

Report prepared for Roy Hill Pty Ltd

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Abbreviations

ECU – Edith Cowan University

EPBC Act - Environmental Protection and Biodiversity Conservation Act 1999

GPS – Global Positioning System

NQRP – (Roy Hill's) Northern Quoll Research Plan

PIT – Passive Implant Transponder

RC4 – Rail Camp 4

SRL - Special Rail Lease

Summary

Following remote camera, scat and trap surveys for northern quolls (*Dasyurus hallucatus*) in the eastern part of the Chichester Ranges conducted in 2014, two sites were identified as potential additions to the Department of Parks & Wildlife Pilbara northern quoll regional program. These sites are Mesa 228 (including nearby Quoll Knoll), and Wall Creek. These sites were trapped according to the methods used in the regional program (200 cage trap nights over four consecutive nights, with traps set in two long transects in suitable habitat) in June and July of 2015. Additional traps were set at Quoll Knoll and the surrounding area as part of an Edith Cowan University honours project.

Four individual quolls were captured at the Mesa 228/Quoll Knoll sites (two females and two males), in addition to 17 individual common rock rats (*Zyzomys argurus*). At Wall Creek, one common rock rat and one house mouse (*Mus musculus*) were captured. No quolls were captured, and there was no evidence of quolls occurring at this site from scat searches and remote camera survey. Quolls have been recorded at other nearby sites included Coonarrie Creek, Bea Bea Creek and Cockeraga creek, located at 36.5 km, 19 km and 12.4km from Wall Creek respectively. Other fauna species recorded during this survey period are included in this report.

It is recommended that Roy Hill continue their fauna monitoring at the Quoll Knoll site, and impact mitigation measures (slow speed limit, road signs for awareness, cat trapping) in light of the road and rail infrastructure in this area. Although no quolls were captured at Wall Creek in 2015, due to the suitability and extent of habitat, and presence of quolls in nearby areas, it is proposed that monitoring in the form of camera survey or trapping occurs at this site in 2016.

1 Introduction

This report details the research undertaken by the Department of Parks and Wildlife (Parks & Wildlife) in 2015 on northern quoll populations and distribution within the Chichester Ranges. The research is part of Roy Hill's Northern Quoll Research Plan (NQRP) (100RH-3000-EN-REP-2033) as part of the requirements of Condition 3 of *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) approval 2011/5867. This work conducted in 2015 is a continuation of previous survey efforts throughout the area (Johnson and Anderson, 2014). The results of this and previous surveys are summarised and discussed.

1.1 Northern quoll Dasyurus hallucatus

The northern quoll is a medium-sized predatory marsupial, the smallest of Australia's four species of *Dasyurus* (Oakwood, 2002a). Northern quolls were once widely distributed from the Pilbara, Kimberley, across the Top End to southern Queensland, but have now contracted in distribution and density to several disjunct populations within their former range (Braithwaite and Griffiths, 1994). In 2005, the northern quoll was listed as an Endangered species under the Commonwealth's EPBC Act 1999 (Oakwood *et al.*, 2008; Department of Sustainability, 2011). This was due to an alarming decrease or complete collapse of some of the once locally abundant populations in Queensland and the Northern Territory, and a subsequent contraction of its range (Oakwood *et al.*, 2008). In particular, northern quolls have declined at a rapid rate in association with the spread of the introduced cane toad *Rhinella marina*, which poisons quolls in their predation attempts. Several other ecological factors are contributing to the decline of quolls and other medium sized mammal fauna, including predation by feral cat (*Felis catus*), wild dogs (*Canis lupus*), altered fire regimes, grazing and subsequent habitat modification by introduced herbivores, habitat loss and fragmentation, as well as the interactive effects between these (Braithwaite *et. al.* 1994; Hill and Ward, 2010; Woinarski et al., 2014).

Northern quolls inhabit a variety of areas, including rocky outcrops and ridges, rainforests, eucalypt forest and woodland, sandy lowlands, shrublands, grasslands, and desert (Department of Parks and Wildlife 2013; DSEWPaC 2011). In the Pilbara, northern quolls appear to depend primarily on complex rocky habitat than northern quolls in the Northern Territory or Queensland, where tree hollows and logs are more common (Oakwood, 1997). The ridges and mesas of channel-iron deposits and banded iron formations are often the primary focus of iron-ore extraction in the Hamersley Province (Morris and Ramanaidou, 2007), while granite outcrops are often quarried for road and rail beds. For this reason, Pilbara northern quolls are recognised as specially protected fauna within the EPBC (1999), due to the likelihood that the species will be impacted by the removal or alteration of habitat by mining activity and associated infrastructure development.

Although they are primarily carnivorous, feeding on invertebrates and small vertebrates, northern quolls will also opportunistically eat eggs and fleshy fruit or scavenge on roadkill or waste (Oakwood, 2002a; Radford, 2012). Northern quolls are sexually dimorphic, with males tending to be larger than females (Oakwood, 2002b). The species is the largest animal in the world to undergo suicidal reproduction (semelparity), whereby males experience immune system collapse and eventual death after an intense mating period (Oakwood *et al.*, 2001; Fisher *et al.*, 2013). This enables females to drive intense competition between males, and allow females and their young to have access to maximum food abundance during the period of pouch young development and dispersal (Fisher *et al.*, 2013). Females breed synchronously over a period of months, when 6-8 young are born, grow in the pouch and are deposited in dens after eight to nine weeks (Oakwood, 2002a).

While the biology and ecology of the northern quoll has been studied in the Northern Territory (Begg, 1981; Braithwaite and Griffiths, 1994; Oakwood, 1997; Oakwood, 2000; Oakwood, 2002b) and to a lesser extent in the Kimberley (Cook, 2010; How *et al.*, 2009; Schmitt *et al.*, 1989), few studies have been undertaken on northern quolls in the Pilbara. Due to the limited evidence available to allow for the creation of ecologically equivalent offsets (Department of Sustainability, Environment, Water, Population and Communities 2012) for the northern quoll in the Pilbara, a proportion of offset funds for this species has been directed towards scientific research. Parks and Wildlife has also implemented a Pilbara-wide quoll research program (Dunlop *et al.*, 2014) to provide a regional context for more targeted population research.

1.2 Roy Hill EPBC requirements

Roy Hill Infrastructure Pty Ltd (Roy Hill) has Commonwealth and WA Office of Environment Protection Authority approval for the Roy Hill Rail and Associated Infrastructure Project (the Rail Project) which comprises the construction and operation of a new heavy-haul standard gauge railway line approximately 344km in length connecting the Roy Hill Mine to Port Hedland, in the Pilbara Region of Western Australia. The Rail Project also incorporates the construction of support infrastructure such as a permanent access road running the length of the rail alignment, additional construction roads, bridges, passing sidings, workshops, borrow and ballast areas, lay down areas and four temporary construction workforce camps.

The project was referred to the Department of Sustainability, Environment, Water, Populations and Community (DSEWPaC) and conditions were imposed (EPBC 2011/5867) due to the impact on listed species under the EPBC Act, including the northern quoll. In response to this Roy Hill developed a Northern Quoll Research Plan (Roy Hill Holdings Pty Ltd, 2014).

The NQRP has been designed to align with the Parks & Wildlife Pilbara northern quoll regional research program (Dunlop *et al.*, 2014). The specific objectives of the NQRP include:

- To improve the understanding of the northern quoll distribution, ecology, and abundance and other demographic parameters in the Chichester Ranges and allow comparison with other studies in the Pilbara;
- To inform management for the conservation of northern quoll populations in and around mining sites and other developments in the Chichester Ranges; and
- To help clarify the taxonomic and conservation status of the Chichester Ranges northern quoll population.

1.3 Previous surveys

Considerable effort has been made in recent years by resource companies to determine the presence and extent of northern quolls within parts of the Chichester Ranges (Biota Environmental Sciences, 2005; Davis *et al.*, 2005; Ecologia Environment, 2008). A review of this research effort, plus the combined efforts of the Roy Hill investigations, indicates that quolls persist at very low or undetectable levels in this target area of the eastern Chichester Ranges (Roy Hill Holdings Pty Ltd, 2011). Quoll records increase further north and west of this study area (Coffey Environments, 2012; Rapallo, 2012). Fauna monitoring for the nearby Fortescue Metals Group rail corridors revealed very low capture rates of quolls increasing slightly when moving from east to west and northwest (D. Cancilla *pers com Sept 2014*). Parks and Wildlife have long-term monitoring sites at more westerly Chichester Range sites at Mt Florance and Python Pool within the Chichester Ranges.

In 2013 and 2014, Parks and Wildlife undertook quoll surveys in order to advise Roy Hill of the nearby populations, and identify potential sites to be monitored in the long-term. These included baited and unbaited motion sensing cameras, scat searches and cage trapping efforts (Figure 1). Surveys were undertaken in two phases combining searching and cage trapping with camera surveillance over 28 sites. Quoll scats were recorded at seven sites, and remote camera photographs of quolls were taken at three sites including one site where scats were not observed. Three individual quolls (one male and two females) were captured in 2014 from the rock outcrop complex known as Quoll Knoll within the Roy Hill Special Rail Lease (SRL). This colony, in the context of the broader low abundance of quolls in the Pilbara, is at or near the south-east limit of Pilbara quoll distribution and should be considered significant. The other successful trapping site was toward the western extent of the survey at Cockeraga Creek, however this site is part of the monitoring program being undertaken by Ecoscape Environmental Consultants for Fortescue Metals Group. The nearby gorge at Wall Creek was also put forward as a long-term monitoring option due to the permanent water, rugose gorge walls, minimal disturbance, generally healthy vegetation and connectivity to the Mungaroona Range Nature Reserve wilderness.

In summary, the populations of northern quolls in the eastern area of the Chichester Ranges appear to be highly fragmented with small breeding colonies occupying relatively isolated islands of suitable refuge and foraging habitat. Some sites that meet all known criteria for suitable quoll habitat failed to produce evidence of quoll presence.

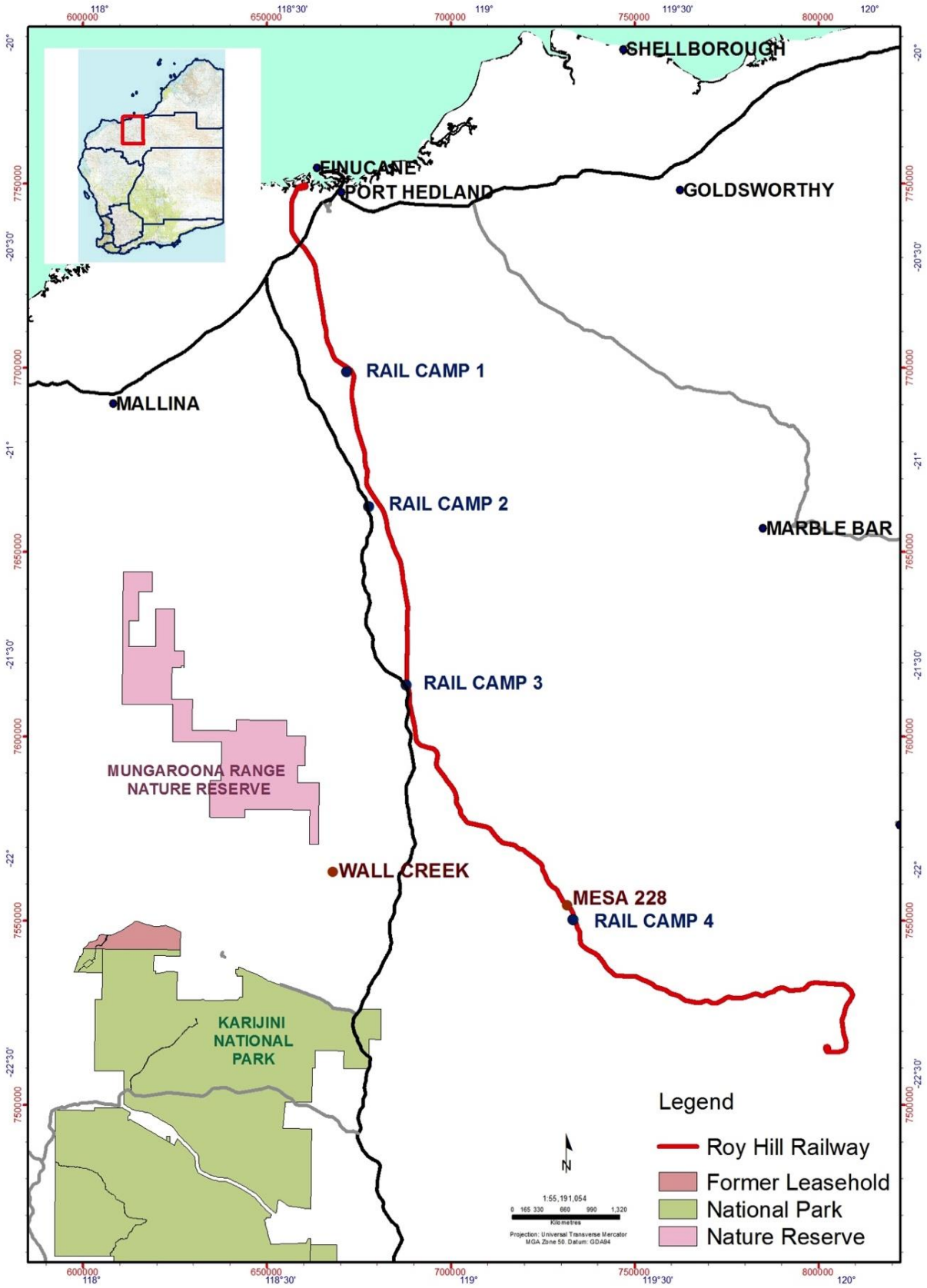

Figure 1. Map of the 2015 Roy Hill northern quoll trapping sites in the context of the Pilbara, showing Roy Hill Railway and Rail Camps.

1.4 Research collaboration with Edith Cowan University

Occurring simultaneously at the Mesa 228/Quoll Knoll site was the field work for Melinda Henderson's honours project, under the supervision of Dr Rob Davis and Dr Shaun Molloy (ECU) and Judy Dunlop (Parks & Wildlife). Although this work is not discussed in detail in this report, the goals and background for the research are included below for context.

The primary objectives of this work were to:

1) Determine home ranges of quolls and how these differed between different demographic groups
2) Quantify use of foraging habitats via passive GPS and use of den sites via VHF radiotracking
3) Determine interactions with linear infrastructure corridors.

Several northern quolls were fitted with GPS & VHF collars after being trapped in baited cage traps set at the study sites. The collars were set to record several fixes per night for each animal, in order to provide detailed information on movements throughout the entire night and will allow detailed habitat use to be characterised. Data collected over several days provide a longer-term dataset on movements including potential dispersal between populations and any interactions with the linear infrastructure corridors. Daytime den sites were also recorded by radiotracking the quolls to their locations on an opportunistic basis (Figure 7). Data regarding interactions with rail corridors will be inferred from GPS locations of animals, augmented with remote camera image data.

2 Methods

2.1 Site conditions

Climatic data were collated from the Wittenoom weather located 38 km from Wall creek and 95km from Mesa 228. The monthly averages of rainfall and temperature from 1951 to 2015 are shown in Figure 2. The project areas receive the most rainfall and highest temperatures in the months from December to March, temperatures and rainfall drop for the winter months with the lowest averages between April and October. Average rainfall and temperature during the study period (June and July 2015) are also displayed in Figure 2. The average temperatures for the study period fell within the long-term mean, however a lower than average rainfall (0mm) was received in June but an increased rainfall (24mm) was received in July.

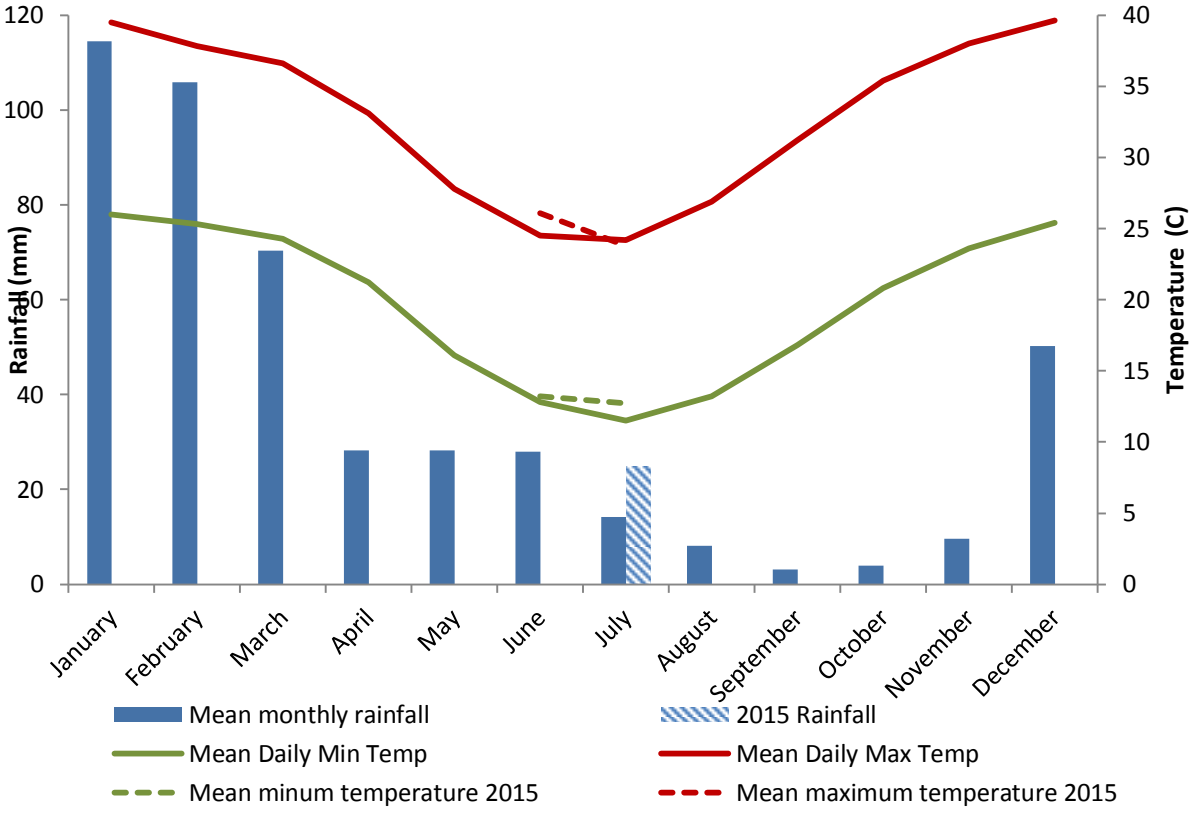

Figure 2.Climate data from Wittenoom weather station between 1951 and 2015 in solid colours. Climate data for the same location during the study period of June and July 2015 in broken colours.

2.2 Field effort

Four nights of trapping were undertaken at each site by two or three Parks and Wildlife staff. At Quoll knoll and Mesa 228, we worked in conjunction with two ECU staff. Surveys at Quoll knoll and Mesa 228 took place between June 15–24, including four nights of standard trapping plus additional radiotracking. Four nights of cage trapping and camera trapping were completed at Wall creek July 14–18. Surveys at Wall creek, Coonarrie creek, Bea Bea creek and Cockeraga Creek were conducted by three Parks and Wildlife staff between the dates of July 13–18. Approximately 10 person-hours of scat searches were completed at all sites.

2.3 Site selection

The sites of Wall Creek and Mesa 228 (Figure 1) were chosen as sites within the Chichester Ranges that could be included in the regional monitoring program based on surveys by Johnson and Anderson (2014). These surveys targeted areas within the eastern Chichester Ranges with suitable refuge sites and the most likely to support quolls Figure 3. Highly weathered lateritic, basalt, granite and ironstone outcrops in the form of mesa edges, cliff lines, tor fields (granite boulder piles) and small gorges exist in various size, quantity and spatial array throughout the target area and these, particularly when associated with drainage lines and waterholes, formed the prospective targets. Previous mapping of potential northern quoll habitat along the SRL as identified to Roy Hill was also considered (Roy Hill Holdings Pty Ltd, 2011). Existing Parks and Wildlife monitoring and study sites exist at Millstream-Chichester National Park and Mt Florance station, therefore no attempt was made to duplicate effort in the western portion of the Chichester Ranges.

The population of quolls identified at Quoll Knoll, approximately 1.5km from Mesa 228, was decided to be monitored at the same time as Mesa 228, but is not part of the standardized trapping protocol due to its small size.

2.3.1 Mesa 228 & Quoll Knoll

Mesa 228 (Figure 4, Figure 5) is a long lateritic ridge mesa, approximately 900m long with numerous caves and crevices along the upper breakaway ridge. Vegetation includes *Triodia* sp., *Eucalyptus* sp., and other shrubs surrounding and on top of ridge. The rocky knoll dubbed “Quoll Knoll” is approximately 1.5km to the north of Mesa 228, next to the Roy Hill rail line and a vehicular access track (see Figure 6, Figure 7). Quoll Knoll is a small (200m) lateritic outcrop of very large boulders, including two smaller sections on the south side of the vehicular track. Vegetation includes *Triodia* sp. and other shrub species surrounding, with a creek line at the base of the outcrops with a mixed vegetation composition including dominant *Acacia* species.

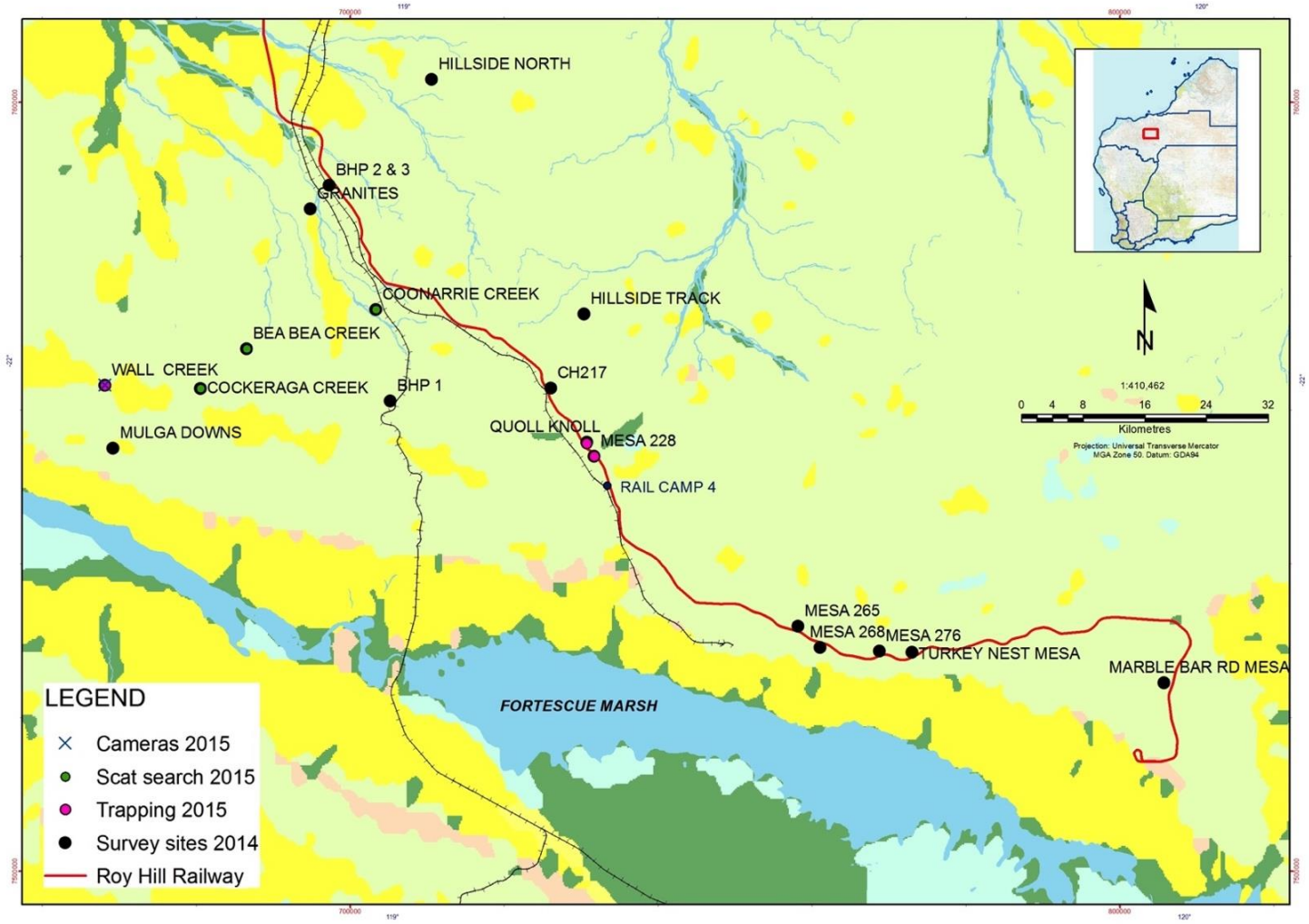

Figure 3. Map of the focus area of the eastern Chichester Range, with 2014 and 2015 survey efforts to detect northern quolls, *Dasyurus hallucatus*

Figure 4. Rocky breakaway habitat at Mesa 228 trapping transect

Figure 5. Extent of rocky breakaway ridge at Mesa 228.

Figure 6. View looking north from Quoll Knoll, showing the vehicle track running along the south-west side, and rail cutting that runs on the north-east side of the rocky knoll.

Figure 7. Melinda Henderson (Edith Cowan University) radiotracking a GPS & VHF collared northern quoll at “Quoll Knoll”

2.3.2 Wall Creek

Wall Creek on Hooley Station (Figure 8, Figure 9) is a long rocky gorge running approximately north-south, eventually feeding into the Yule River to the north. The gorge is shallower at the southern end and becomes deeper and more complex to the north. The habitat consists of a scree slope of weathered rocky basalt with numerous permanent pools of water in a creek line at base of the slope, mixed vegetation complex with *Triodia* sp., *Eucalyptus* sp., *Acacia* sp., *Melaleuca* sp., and other shrub species. The upper slopes of the gorge consists of an open woodland of *Triodia* sp. and mulga (*Acacia aneura* and related *Acacia* species).

*Figure 8.*Tumbledown breakaways and cliffs at Wall Creek trapping site. The rocky gorge continues several kilometers north, and feeds into the Yule River.

Figure 9. Permanent water and habitat present at Wall Creek trapping site.

2.4 Trapping

Trapping was undertaken at both Mesa 228 and Wall Creek, as per the standard regional monitoring protocol set out in Dunlop *et al.* (2014). Traps were set at Quoll Knoll and the surrounding rocky areas to survey for animals, as well as to assist with the honours project work in collaboration with Edith Cowan University; however standard protocol was not adhered to, due to the small size of this area. Animals were trapped using wire cage traps (45 cm x 17 cm x 17 cm, Sheffield Wire co, Welshpool WA) covered with hessian for shade and protection, baited with peanut butter, oats and sardines. Fifty traps were set at Mesa 228 and Wall Creek, spaced 50 m apart in two lines of 25 traps, with approximately 50 m between each transect. At Quoll Knoll, ten traps were spaced evenly encircling the two rocky outcrops. Traps were opened for four consecutive nights at each site, totaling 200 trap nights. Traps were checked and closed within three hours of sunrise each morning, rebaited and opened in the late afternoon.

All captured quolls were implanted with a subcutaneous microchip (PIT) for individual identification. Standard measurements collected from all captured quolls and other species included: body weight, short pes length, head length, age class, sex, body and reproductive condition. Animals were only measured on their first capture. Weights were sometimes re-measured on subsequent captures to ensure that animals were not losing body mass due to stress/lack of foraging during the trapping process. A small amount of ear tissue was collected from each individual at initial capture and stored in 100% ethanol for genetic analysis. Animals were examined for ectoparasites, especially around the ears, neck and genitals.

2.5 Motion sensing cameras

Motion sensing cameras (Reconyx PC900) were used as an additional method to trapping and scat survey in order to detect quoll presence. They were set to record activity at all times of day and night with five consecutive photographs per trigger. The cameras were fixed to a stable object such as a tripod, tree or rock. Baits consisting of peanut butter, oats, sardines and fish oil were smeared on rocks approximately 2-3m in front of the camera. Cameras were set approximately 100m apart, so the number of cameras deployed at each site varied depending on size of site and quantity of refuge habitat present.

2.6 Scat searches

Quoll and feral predator scat searches were undertaken at the trapping sites and several other areas on an opportunistic basis. Searches are undertaken with personnel spending several hours walking through likely habitat (breakaways, creek systems, mesas and ridges) examining rocky crevices and caves. Scats are collected and stored in a paper envelope with associated data (GPS location, date, species, collector). Once dry, scats are kept frozen until processed for dietary analysis.

In the Wall Creek area, searches were undertaken at the Wall Creek trapping site and for a kilometre extent either side, at Bea Bea Creek and Cockeraga Creek (Figure 3; Figure 10).

At Mesa 228, scat searches were undertaken at Mesa 228 and the mesa neighbouring it, at Quoll Knoll and the rocky areas on the other side of the road, as well as the FMG culvert close to Mesa 228 (a tributary of the Western Shaw River) and Coonarrie Creek (Figure 11).

2.7 Other fauna records

Other fauna were recorded opportunistically, observed during the time when setting or checking traps, driving between sites, and during scat search occasions.

Figure 10. Habitat at Cockeraga Creek, approximately 12km east of Wall Creek, where northern quoll presence was confirmed via scat search. This site is monitored by Ecoscape Environmental Consultants for Fortescue Metals Group

Figure 11. Rocky granite habitat with a substantial Meleleuca stand and permanent water at Coonarrie Creek. Quoll presence was confirmed at this location via scat search.

3 Results

A summary of the positive and negative detections of northern quolls for 2014 and 2015 is presented in Figure 12. All recorded quoll presences will be added to the publicly available NatureMap database and provided to Roy Hill.

3.1 Trapping

3.1.1 Mesa 228 & Quoll Knoll

One individual male quoll was captured at Mesa 228, and three individuals (two females, one male) were captured at Quoll Knoll (*Table 1*). In addition, 17 individual common rock rats were captured on 19 occasions over the 200 trap nights (9.5% trap success).

One female captured at Quoll Knoll was present at this location in 2014 (Johnson and Anderson, 2014), and potentially raised young here over the summer of 2014-2015. The second female captured at Quoll Knoll was a new capture/individual, not previously caught last year. Based on tooth wear and reproductive status she was classified as a first year animal. The male captured at Mesa 228 was a large individual, possibly in his second season. The animals at Quoll Knoll were captured on several occasions throughout the process of collaring and retrieving collars for the ECU honours project.

Ear tissue samples (three new samples collected on this survey) have been included in the regional samples to be analysed in the collaborative project between Murdoch University (Peter Spencer), Parks and Wildlife and Western Australian Museum investigating the genetic differences within Pilbara populations, and between Pilbara and the rest of Australia. Peter Spencer has completed the initial genetic analysis of northern quolls but is continuing to seek samples from poorly surveyed areas (Spencer *et al.*, 2013).

No ectoparasites were discovered on the animals.

Table 1. Northern quoll (*Dasyurus hallucatus*) individuals captured at Mesa 228 and Quoll Knoll. All animals were adult, and their age was estimated based on captures in previous years, body size and tooth wear. Additional trapping data is presented in Appendix 1 - Table 3.

Date	Location	GPS Coordinates	Sex	PIT	Weight	Age (years)
15-Jun-2015	Quoll Knoll	-22.0977, 119.2366	F	700079	380	2
15-Jun-2015	Quoll Knoll	-22.0966, 119.2371	F	955622	280	1
23-Jun-2015	Mesa 228	-22.11460, 11.9246	M	455294	650	2
14-Jul-2015	Quoll Knoll	-22.0966, 119.2371	M	044643	550	1

3.1.2 Wall Creek

One common rock rat and one house mouse were captured at Wall Creek. No quolls were captured at this location. Raw trapping data is presented in Appendix1 - *Table 4*. No evidence of feral cats was recorded, however a dingo was seen in the vicinity of the Wall Creek gorge. The Wall Creek site is on an active cattle station so domestic cattle were present at the site. Other fauna records are shown in Appendix 2 -*Table 7.*

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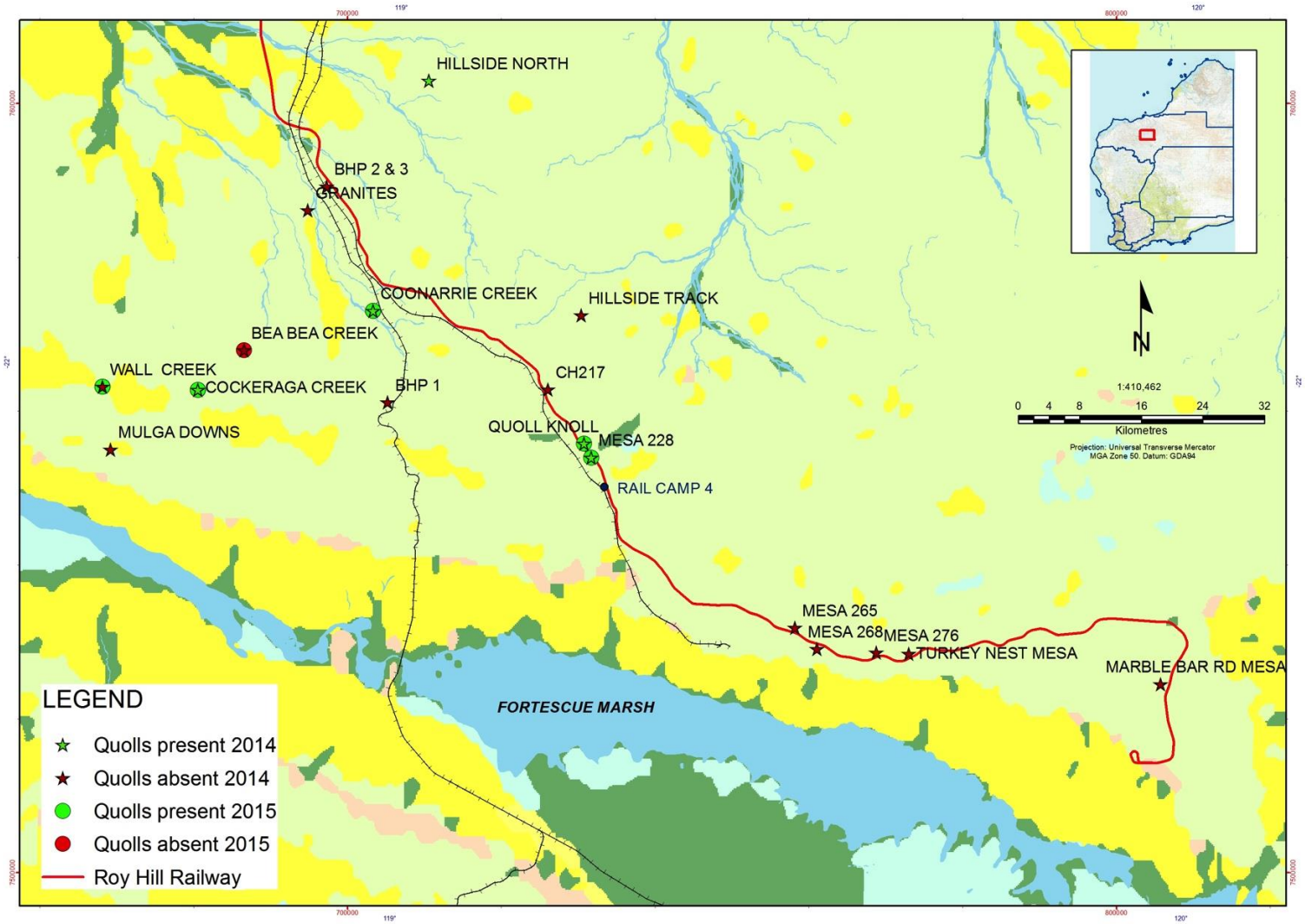

Figure 12. Northern quoll presence/absence records for 2014 and 2015 areas subject to survey based on evidence (scats and trap success) surveys.

3.2 Motion sensing cameras

A total of 64 camera trap nights at the Quoll Knoll/Mesa 228 site, and 20 camera trap nights at Wall Creek were analysed. Motion detecting cameras at Quoll Knoll captured images of the same individual quolls that were trapped. One image shows the larger female moving during daytime hours (Figure 13), other images show an individual utilising the road culvert infrastructure at the northern end of quoll knoll (Figure 14). Other species recorded at this location included common rock rats, domestic cattle (*Bos taurus*), Torresian crows (*Corvus orru*), and spinifex pigeons (*Geophaps plumifera*). At Mesa 228, Torresian crow and common rock rats were recorded over 32 camera nights. No northern quolls were photographed at this site.

No images of northern quolls, or any other species, were recorded at Wall Creek.

Figure 13. Daytime motion camera image of a Northern Quoll (*Dasyurus hallucatus*) from Quoll Knoll, at 3.26pm on 3/7/2015. Quolls are usually nocturnal but have been observed to move limited distances during the day. (Photo: M. Henderson)

Figure 14. Remote camera image of a northern quoll (*Dasyurus hallucatus*) from a road culvert at the northern end of Quoll Knoll. (Photo: M. Henderson)

3.3 Scat searches

Quoll scats were collected from Mesa 228, Quoll Knoll and the rocky surrounding areas near Wall Creek (Coonarrie Creek and Cockeraga Creek). Scat searches were undertaken for several kilometres along Wall Creek, and Bea Bea Falls and surrounds, but no evidence of quolls was found in these areas (Figure 12). A total of eight scat samples were collected and added to the collection, to be analysed at the end of the year. Initial results from analysis of scats collected in 2014 revealed quolls to be consuming a wide variety of vertebrate, invertebrate and plant material. The diet of northern quolls in the Pilbara appears to include small mammals (particularly *Z. argurus*), birds, reptiles and frogs, spiders, insects, figs and other seeds. Quolls are dietary opportunists; in coastal areas they were observed to consume crustaceans, and there were instances of quolls consuming what is presumed to be roadkill *Macropus rufus* and domestic cattle.

3.4 Other fauna records

Although other mammals or reptiles were not targeted, several opportunistic observations were recorded during these surveys. Table 6 in Appendix 2 details observations of all vertebrate fauna for Mesa 228/ Quoll Knoll, and Table 7 details those for Wall Creek. A total of 46 species were recorded from Mesa 228, including

39 bird species, five mammals and two reptiles. At Wall Creek, 52 species were recorded, including 47 bird species, four mammals and one reptile.

Feral cats (*Felis catus*) were present at Quoll Knoll prior to the survey based on camera trap evidence obtained by Roy Hill (on a camera deployed by Roy Hill), and one individual was captured by Animal Pest Management Services (who conducted feral animal control simultaneously with this trapping sessions at Quoll Knoll and Mesa 228). Cat tracks were also recorded in the creek system near Mesa 228. Canid scats were collected at Mesa 228 only. No feral cats or foxes (*Vulpes vulpes*) were recorded on cameras or via scat searches during this survey period. Domestic cattle were present at both sites.

A black-headed python (*Aspidites melanocephalus*) was sighted on the road near Rail Camp 4 (-22.13662304, 119.26521) on 21/6/2015 en route to trap setting (Figure 15). The animal was trapped on two sides by the bunding between the road and rail. It was removed to avoid vehicle injury and released at a nearby rock pile in the scrub (-22.13709, 119.264331).

Figure 15. A black-headed python (*Aspidites melanocephalus*) from near Roy Hill Rail Camp 4.

Several Pilbara pebble-mound mouse (*Pseudomys chapmani*) mounds were recorded during the survey at the base of slope at Mesa 228 (Figure 16). The locations and details of these are shown in Appendix 2 -Table 5. Mounds of Pilbara pebble-mound mice are typically inhabited by up to 12 individuals; several mature females, one or two mature males and a number of offspring (Anstee *et al.*, 1997). This species was previously listed on Schedule 1 of the Western Australian Wildlife Conservation Act (1950) due to a contraction in the southern portion of its range, however it was downgraded to Priority 4 in 1998 when it was found to be more

common than previously thought (Morris and Burbidge, 2008; Woinarski *et al.*, 2014a). Although this species is not currently listed as threatened, it frequently conflicts with iron ore developments due to similarities in preferences of geology and topography (Anstee and Armstrong, 2001) and local records may be important to consider.

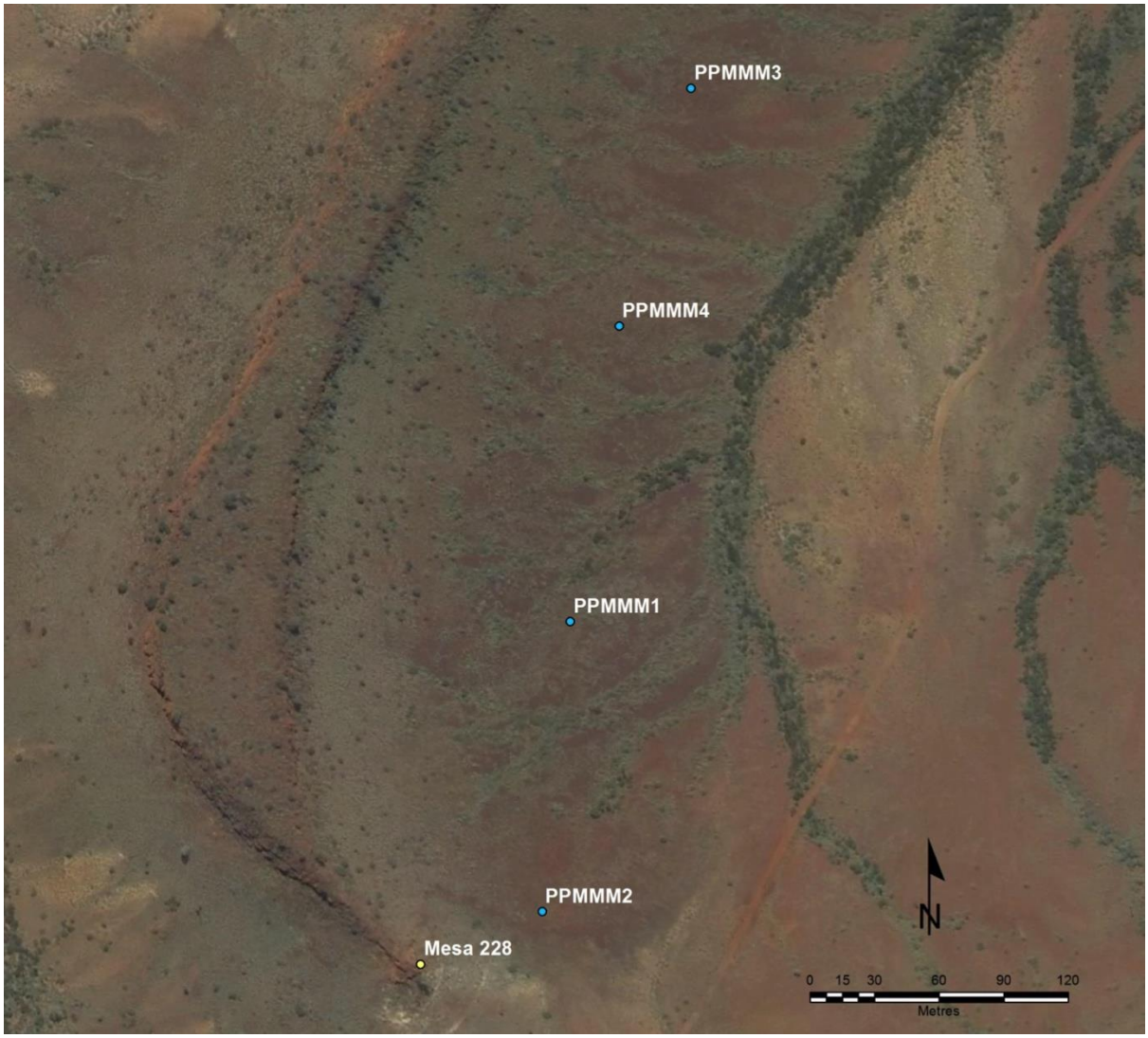

Figure 16. Locations of Pilbara pebble-mound mouse mounds (*Pseudomys chapmani*) along the base of the slope at Mesa 228. GPS coordinates for these are displayed in Appendix 2 - *Table 5*.

4 Discussion

The low capture rates of northern quolls at Mesa 228 (one individual) and Wall Creek (zero individuals) using standard monitoring protocols (Dunlop *et al.*, 2014) reinforce the previous assessments of small and scattered quoll populations in the eastern areas of the Chichester Range. It is likely that this area currently represents intermittent habitat for northern quolls, where small populations occupy areas of suitable habitat and undergo episodic breeding and dispersal in years of favourable conditions.

Genetic analysis of northern quolls from throughout the Pilbara region indicates that the entire Pilbara population is a single genetic cluster, although the Pilbara population remains genetically distinct from the Kimberley and other areas of Australia (Spencer *et al.*, 2013). This level of genetic mixing suggests that male dispersal occurs across long distances, maintaining genetic diversity throughout the region. Demographic data of animal behaviour (e.g. via radiotracking and GPS tracking) will enhance our understanding of how this movement occurs, and what areas of the landscape quolls are using to move between areas of suitable habitat. Females are thought to have more site fidelity that males (Oakwood, 2002b), possibly protecting suitable denning habitat for raising offspring. Males have been found to roam large distances, especially during the mating season when they may visit several females in one night. Daytime radiotracking of a population of northern quolls living in a line of mesas in the northern Pilbara showed males to be utilizing larger home range areas, and capable of traveling long distances (Astron Environmental Services, 2013). The mean core home range recorded in this northern Pilbara study was 8.2 ± 4.2 ha (max 15.8 ha) for females and 1002.6± 477.3 ha (max 2896.67 ha) for males (Astron Environmental Services, 2013).

It is unknown whether the current distribution of quolls across the Pilbara is representative of their preferred habitat, or is evident of areas with the most protection from threatening processes. For example, it is possible that feral predators such as cats prevent northern quolls from successfully utilising other suitable habitat such as rocky riverbeds, as they do in other parts of their range (Burnett and Zwar, 2009; Woinarski *et al.*, 2014b).

The presence of three individuals (*Table 1*) at the much smaller Quoll Knoll habitat, and the persistence of animals in this area from 2014, demonstrates the value of this population in a regional context. The quoll activity in and around Quoll Knoll sites across two years suggests persistence of resident quolls, despite being in a highly disturbed landscape. One adult female persisted from 2014 to 2015, and potentially raised young here. Their success is unknown, but the trapping in 2015 indicates that one other female is most likely resident in this area and could potentially be offspring from the adult female. We would expect all females to have established home ranges by June and be resident in their particular area, unlike males which can be

much more transient particularly coming into the breeding season. Nearby populations have been recorded at FMG's North Star and Solomon Rail to the north of Wall Creek (Fortescue Metals Group, 2010; Fortescue Metals Group, 2010; Ecologia Environment, 2012), but quoll records east of the Great Northern Highway are sparse.

Potential threats identified for this small population at the disturbed Quoll Knoll habitat include; vehicle strike, loss of access to foraging habitat due to the linear obstruction of the rail cutting, and the potential for increased predation (particularly by feral cats) due to clearing and presence of the road, which provides a pathway for feral animal movement. Mitigation measures recommended in Johnson and Anderson (2014), and their current relevant implementations are shown in Table 2 for the construction and operational phases of the rail development. Current levels of implementation of each measure are displayed in Table 2. These mitigation measures, plus monitoring and review of the population, may assist in the conservation of this population in a highly disturbed zone.

The support for an honours project assessing the home range and movement of quolls nearby to rail infrastructure will assist in answering questions about the impacts of development. Furthermore, reporting of roadkill will assist Roy Hill in assessing the direct impact of these infrastructure, and potential triggers for change in mitigation procedures.

5 Recommendations

Based on the previous survey in the Chichester Ranges by Parks & Wildlife, as well as data collected for other nearby locations, the following recommendations are proposed for Roy Hill to consider:

- Continue feral control at Quoll Knoll, and implement a twice-yearly program to target important phases of the northern quoll life cycle (denning of young Nov-Dec, dispersal of young Jan - Mar). Trapping during denning times should avoid catching females by setting traps a distance from dens
- Continue monitoring of quolls annually via standardised trapping, and opportunistically via motion cameras
- Continue implementation of previously recommended mitigation strategies (Table 2) including the deployment of a minimum of four cameras at Quoll Knoll and rocky ridge to the south side of the light vehicle track throughout the year
- Monitor Wall Creek and Mesa 228 in 2016, with the intent to reassess whether these sites should be retained in the regional program post 2016 survey
- Install permanent, reflective “Slow Speed” road signs at significant quoll sites along the rail access track (e.g. Quoll Knoll) to alert drivers of threatened fauna in the area. These should be installed on either side of the significant site to alert drivers from both directions.

Table 2. Recommendations from Johnson and Anderson (2014) to reduce impacts of Roy Hill rail construction, operation and associated activities on northern quolls in the area.

CONSTRUCTION PHASE	
Mitigation	**Implementation**
Apply strategic signage around the Quoll Knoll area including the light vehicle track warning drivers of quolls in the area	Signage erected at call-up points
Educate workers (especially night shift) at camps to raise awareness of quolls and other fauna	Camp and Site notices regularly advise of fauna interaction, particularly with northern quolls.
Enforce a 40k/h speed limit on tracks in vicinity of quoll knoll	Permanent signs to be erected. Temporary signs installed.
Limit further vegetation clearance around quoll sites	Ground disturbance permit process in place to limit vegetation clearance and Environmental team approval requirements.
Limit night works to reduce potential vehicle strike	No night works.
Rehabilitate borrow pits immediately following closure and create artificial refuges using left over waste rock.	Rehabilitation completed.
OPERATIONAL PHASE	
Mitigation	**Implementation**
Rehabilitate the LV track and borrow pits when appropriate, and create artificial refuges using rock debris waste from construction phase	LV track will not be rehabilitated. Rehabilitation of borrow pits completed.
Monitor Quoll Knoll with remote cameras, supplemented with annual trapping, to ensure quolls are still utilising the area	Underway and ongoing.

Creation of artificial refuge from rail sleepers in areas designated by Roy Hill environmental team	TBA once operation begins.
Fauna road kill reporting procedures to be implemented	Ongoing. Part of fauna procedures.
Pest animal management procedures to align with Parks and Wildlife standard operating procedures for trapping	Ongoing.
Location and timing of strategic pest animal baiting and trapping should follow Parks and Wildlife recommendations. These may include: • **Any trapping in the vicinity of known quoll habitat should be undertaken simultaneously with annual Parks and Wildlife monitoring where possible;** • **The revision of annual pest-management programs and target pest species should be considered following closure of the rail camps in the vicinity of the Quoll Knoll site.**	Underway.
Review images from cameras permanently located on Quoll Knoll. If feral animals identified, implement control program shortly thereafter. Target feral animal control program in November and April.	Underway and ongoing.

Appendices

Appendix 1. Trapping data

Table 3. Raw trapping data for Mesa 228/ Quoll Knoll. Pouch categories: U – undeveloped, D – developed, Y – pouch young, L – lactating. Capture type: N– new individual, R–recapture (caught in previous session), RT–retrap (caught already this session). Age classes: A – mature adult, A1 – mature adult in first breeding season, A2- mature adult in second or later breeding season

Date	Site	Trap	Species	Sex	N/R /RT	6 digit PIT	Weight (g)	Age	Head (mm)	Pes (mm)	Testes (mm)	Pouch	DNA	Comments
15-Jun-15	Quoll Knoll	QN4	*D.hallucatus*	F	R	700079	380	A2	63.8	30.5		D	Y	“Roller”
15-Jun-15	Quoll Knoll	QN3	*D.hallucatus*	F	N	955622	280	A1	62.7	28.5		U	Y	“Bobcat”
17-Jun-15	Quoll Knoll	QN4	*D.hallucatus*	F	RT	700079								collar check
18-Jun-15	Quoll Knoll	QN6	*D.hallucatus*	F	RT	700079								
19-Jun-15	Quoll Knoll	QN6	*D.hallucatus*	F	RT	700079								
19-Jun-15	Quoll Knoll	LN4	*D.hallucatus*	F	RT	955622								
20-Jun-15	Mesa 228	10S	*Z. argurus*	F	N		44	A	30.1	16.5			Y	Pregnant, half tail
20-Jun-15	Mesa 228	2N	*Z. argurus*	M	N		30		33.8	19.2			Y	
20-Jun-15	Mesa 228	4N	*Z. argurus*	M	N		50		29.7	17.6			Y	
20-Jun-15	Mesa 228	7N	*Z. argurus*	F	N		30		30.3	16.5			Y	
20-Jun-15	Mesa 228	10N	*Z. argurus*	F	N		40		36.1	18.1			Y	
20-Jun-15	Mesa 228	14N	*Z. argurus*	M	N		35		29.8	16.4			Y	
21-Jun-15	Mesa 228	23S	*Z. argurus*	F	N								Y	
21-Jun-15	Mesa 228	21N	*Z. argurus*		N		35	A						Escaped
21-Jun-15	Mesa 228	19N	*Z. argurus*	F	N		25	A	24	9			Y	No tail
21-Jun-15	Mesa 228	1S	*Z. argurus*		RT									

Date	Site	Trap	Species	Sex	N/R /RT	6 digit PIT	Weight (g)	Age	Head (mm)	Pes (mm)	Testes (mm)	Pouch	DNA	Comments
22-Jun-15	Mesa 228	10N	*Z. argurus*	F	N								Y	
22-Jun-15	Mesa 228	15N	*Z. argurus*	F	N								Y	
22-Jun-15	Mesa 228	24S	*Z. argurus*	M	N		20	A	23.8	9.6			Y	
22-Jun-15	Mesa 228	5S	*Z. argurus*	F	N			A	25.8	9.5			Y	Pregnant
22-Jun-15	Quoll Knoll	QN3	*D.hallucatus*	F	RT	955622								Caught in cat trap
23-Jun-15	Mesa 228	21S	*Z. argurus*		N									Escaped
23-Jun-15	Mesa 228	14S	*Z. argurus*	F	N			A	36	16.6			Y	Pregnant
23-Jun-15	Mesa 228	19N	*Z. argurus*		RT									
23-Jun-15	Mesa 228	16N	*Z. argurus*	F	N		53		32.4	17.7			Y	
23-Jun-15	Mesa 228	N12	*D.hallucatus*	M	N	455294	650	A2	65	15.3			Y	Collared “Dozer”
23-Jun-15	Quoll Knoll	QN3	*D.hallucatus*	F	RT	955622								
23-Jun-15	Mesa 228	15N	*Z. argurus*	M	N		43		32.2	18.2			Y	
24-Jun-15	Quoll Knoll	QN2	*D.hallucatus*	F	RT	700079								
24-Jun-15	Quoll Knoll	QN6	*D.hallucatus*	F	RT	955622								
01-Jul-15	Quoll Knoll	QN4	*D.hallucatus*	F	RT	955622								
14-Jul-15	Quoll Knoll	LN4	*D.hallucatus*	F	RT	955622	385							
14-Jul-15	Quoll Knoll	QN6	*D.hallucatus*	M	N	455294	550	A	71.6	36.5	22.6		Y	“Breaker”
15-Jul-15	Quoll Knoll	QN2	*D.hallucatus*	M	RT	455294								
15-Jul-15	Quoll Knoll	QN3	*D.hallucatus*	F	RT	700079	470	A				D		
15-Jul-15	Quoll Knoll	LN4	*D.hallucatus*	F	RT	955622								
16-Jul-15	Quoll Knoll	LN4	*D.hallucatus*	F	RT	700079								

Table 4. *Raw trapping data for Wall Creek on Hooley Station. Pouch categories: U – undeveloped, D – developed, Y – pouch young, L – lactating. Capture type: N– new individual, R–recapture (caught in previous session), RT–retrap (caught already this session)*

Date	Site	Trap	Species	Sex	N/R /RT	6 digit PIT	Weight (g)	Age	Head (mm)	Pes (mm)	Testes (mm)	Pouch	DNA	Comments
15-Jul-15	Wall Creek		*No captures*											
16-Jul-15	Wall Creek		*No captures*											
17-Jul-15	Wall Creek		*No captures*											
18-Jul-15	Wall Creek	15W	*Z. argurus*	F	N		51	A	33.8	16.7			Y	Pregnant
18-Jul-15	Wall Creek	9W	*M. musculus*	F	N		16	A	23.8	12			N	Pregnant

Appendix 2: Fauna Records

Table 5. Locations and activity status of Pilbara Pebble-Mound Mouse mounds near Mesa 228.

Name	Species	Latitude	Longitude	Status
PPMMM1	*Pseudomys chapmani*	-22.1165	119.2466	Active
PPMMM2	*Pseudomys chapmani*	-22.1177	119.2465	Active
PPMMM3	*Pseudomys chapmani*	-22.1143	119.2471	Active
PPMMM4	*Pseudomys chapmani*	-22.1153	119.2468	Inactive

Table 6. Observations of vertebrate fauna at Mesa 228/Quoll Knoll during the field surveys. Detection methods: O – opportunistic sighting, C – remote camera record, T – trapped animal, S – scats or other signs. For birds, date refers to first day sighted.

Common name	Taxonomic name	Date	Detection method	Location
REPTILES				
Perentie	*Varanus giganteus*	20/06/15	O	Near RC4
Black-headed Python	*Aspidites melanocephalus*	21/06/15	O	Near RC4
BIRDS				
Pacific Black Duck	*Anas superciliosa*	21/06/15	O	Coonarrie Creek
Crested Pigeon	*Ocyphaps lophotes*	19/06/15	O	Mesa 228 area
Spinifex Pigeon	*Geophaps plumifera*	20/06/15	O C	Mesa 228 area
Diamond Dove	*Geopelia cuneata*	20/06/15	O	Mesa 228 area
White-necked Heron	*Ardea pacifica*	21/06/15	O	Coonarrie Creek
Whistling Kite	*Haliastur sphenurus*	19/06/15	O	Mesa 228 area
Black Kite	*Milvus migrans*	23/06/15	O	Mesa 228 area
Wedge-tailed Eagle	*Aquila audax*	20/06/15	O	Mesa 228 area
Little Eagle	*Hieraaetus morphnoides*	20/06/15	O	Mesa 228 area
Nankeen Kestrel	*Falco cenchroides*	19/06/15	O	Mesa 228 area
Australian Bustard	*Ardeotis australis*	21/06/15	O	Mesa 228 area
Black-fronted Dotterel	*Elseyornis melanops*	21/06/15	O	Coonarrie Creek
Little Button-quail	*Turnix velox*	20/06/15	O	Mesa 228 area
Little Corella	*Cacatua sanguinea*	24/06/15	O	Mesa 228 area
Cockatiel	*Nymphicus hollandicus*	19/06/15	O	Mesa 228 area
Budgerigar	*Melopsittacus undulatus*	19/06/15	O	Mesa 228 area

Common name	Taxonomic name	Date	Detection method	Location
Horsfield's Bronze Cuckoo	*Chalcites basalis*	20/06/15	O	Mesa 228 area
Pallid Cuckoo	*Cacomantis pallidus*	20/06/15	O	Mesa 228 area
Blue-winged Kookaburra	*Dacelo leachii*	21/06/15	O	RC4
Variegated Fairy-wren	*Malurus lamberti*	20/06/15	O	Mesa 228 area
Striated Grasswren	*Amytornis striatus*	21/06/15	O	Mesa 228 area
Red-browed Pardalote	*Pardalotus rubricatus*	22/06/15	O	Mesa 228 area
Singing Honeyeater	*Lichenostomus virescens*	19/06/15	O	Mesa 228 area
White-plumed Honeyeater	*Lichenostomus penicillatus*	21/06/15	O	Coonarrie Creek
Yellow-throated Miner	*Manorina flavigula*	19/06/15	O	Mesa 228 area
Crimson Chat	*Epthianura tricolor*	19/06/15	O	Mesa 228 area
Brown honeyeater	*Lichmera indistincta*	20/06/15	O	Mesa 228 area
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	19/06/15	O	Mesa 228 area
White-winged Triller	*Lalage sueurii*	19/06/15	O	Mesa 228 area
Masked Woodswallow	*Artamus personatus*	20/06/15	O	Mesa 228 area
Pied butcherbird	*Cracticus nigrogularis*	20/06/15	O	Mesa 228 area
Australian Magpie	*Craticus tibicen*	21/06/15	O	Mesa 228 area
Willie Wagtail	*Rhipidura leucophrys*	19/06/15	O	Mesa 228 area
Torresian Crow	*Corvus orru*	19/06/15	O C	Mesa 228 area
Magpie-lark	*Grallina cyanoleuca*	19/06/15	O	Mesa 228 area
Australian Reed- warbler	*Acrocephalus australis*	21/06/15	O	Coonarrie Creek
Fairy Martin	*Petrochelidon ariel*	19/06/15	O	Mesa 228 area
Zebra Finch	*Taeniopygia guttata*	20/06/15	O	Mesa 228 area
Painted Finch	*Emblema pictum*	22/06/15	O C	Mesa 228 area

Common name	Taxonomic name	Date	Detection method	Location
MAMMALS				
Northern quoll	*Dasyurus hallucatus*	All	T S C	Mesa 228, Quoll Knoll
Euro	*Macropus robustus*	19/06/15	C	Quoll Knoll
Common rock-rat	*Zyzomys argurus*	All	T C	Mesa 228, Quoll Knoll
Pilbara pebble-mound mouse	*Pseudomys chapmani*	24/06/15	O	Mesa 228; see Table 5, Figure 16
Cattle	*Bos taurus*	19/06/15	S C	Near Quoll Knoll

Table 7. *Observations of vertebrate fauna at Wall Creek during the field survey. Detection methods included O – opportunistic sighting, C – remote camera record, T – trapped animal, S – scats or other signs. For birds, date refers to first day sighted.*

Common name	Taxonomic name	Date	Detection method	Location
REPTILES				
Yellow-faced whip snake	*Demansia psammophis*	15/07/15	O	Wall Creek
BIRDS				
Pacific Black Duck	*Anas superciliosa*	17/07/15	O	Hooley Station
Australasian Grebe	*Tachybaptus novaehollandiae*	17/07/15	O	Hooley Station
Crested Pigeon	*Ocyphaps lophotes*	13/07/15	O	Hooley Station
Spinifex Pigeon	*Geophaps plumifera*	14/07/15	O	Hooley Station
Diamond Dove	*Geopelia cuneata*	14/07/15	O	Hooley Station
Australian Owlet-nightjar	*Aegotheles cristatus*	14/07/15	O	Hooley Station
White-necked Heron	*Ardea pacifica*	14/07/15	O	Hooley Station
Straw-necked Ibis	*Threskiornis spinicollis*	13/07/15	O	Hooley Station
Whistling Kite	*Haliastur sphenurus*	14/07/15	O	Hooley Station
Wedge-tailed Eagle	*Aquila audax*	16/07/15	O	Hooley Station
Nankeen Kestrel	*Falco cenchroides*	13/07/15	O	Hooley Station
Brown Falcon	*Falco berigora*	16/07/15	O	Hooley Station
Australian Bustard	*Ardeotis australis*	13/07/15	O	Hooley Station
Black-fronted Dotterel	*Elseyornis melanops*	14/07/15	O	Hooley Station
Galah	*Eolophus roseicapilla*	14/07/15	O	Hooley Station
Little Corella	*Cacatua sanguinea*	17/07/15	O	Hooley Station
Australian Ringneck	*Barnardius zonarius*	14/07/15	O	Hooley Station
Budgerigar	*Melopsittacus undulatus*	14/07/15	O	Hooley Station

Common name	Taxonomic name	Date	Detection method	Location
Pallid Cuckoo	*Cacomantis pallidus*	14/07/15	O	Hooley Station
Blue-winged Kookaburra	*Dacelo leachii*	14/07/15	O	Hooley Station
Western Bowerbird	*Ptilonorhyncus guttatus*	14/07/15	O	Hooley Station
Variegated Fairy-wren	*Malurus lamberti*	14/07/15	O	Hooley Station
Weebill	*Smicrornis brevirostris*	14/07/15	O	Hooley Station
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	16/07/15	O	Hooley Station
Red-browed Pardalote	*Pardalotus rubricatus*	17/07/15	O	Hooley Station
White-plumed Honeyeater	*Lichenostomus penicillatus*	14/07/15	O	Hooley Station
Yellow-throated Miner	*Manorina flavigula*	13/07/15	O	Hooley Station
Crimson Chat	*Epthianura tricolor*	17/07/15	O	Hooley Station
Brown Honeyeater	*Lichmera indistincta*	15/07/15	O	Hooley Station
Ground Cuckoo-shrike	*Coracina maxima*	16/07/15	O	Hooley Station
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	14/07/15	O	Hooley Station
White-winged Triller	*Lalage sueurii*	15/07/15	O	Hooley Station
Rufous Whistler	*Pachycephala rufiventris*	17/07/15	O	Hooley Station
Grey Shrike-thrush	*Colluricincla harmonica*	15/07/15	O	Hooley Station
Masked Woodswallow	*Artamus personatus*	15/07/15	O	Hooley Station
Black-faced Woodswallow	*Artamus cinereus*	14/07/15	O	Hooley Station
Pied Butcherbird	*Cracticus nigrogularis*	14/07/15	O	Hooley Station
Australian Magpie	*Cracticus tibicen*	14/07/15	O	Hooley Station
Willie Wagtail	*Rhipidura leucophrys*	14/07/15	O	Hooley Station
Torresian Crow	*Corvus orru*	14/07/15	O	Hooley Station

Common name	Taxonomic name	Date	Detection method	Location
Magpie-lark	*Grallina cyanoleuca*	13/07/15	O	Hooley Station
Brown Songlark	*Cincloramphus cruralis*	14/07/15	O	Hooley Station
Welcome Swallow	*Hirundo neoxena*	15/07/15	O	Hooley Station
Fairy Martin	*Petrochelidon ariel*	14/07/15	O	Hooley Station
Zebra Finch	*Taeniopygia guttata*	14/07/15	O	Hooley Station
Painted Finch	*Emblema pictum*	15/07/15	O	Hooley Station
Australasian Pipit	*Anthus novaeseelandiae*	13/07/15	O	Hooley Station
MAMMALS				
Common rock-rat	*Zyzomys argurus*	18/07/15	T	Wall Creek
House mouse	*Mus musculus*	18/07/15	T	Wall Creek
Dingo	*Canis dingo*	15/07/15	O	Hooley Station
Cattle	*Bos taurus*	All	O S	Wall Creek

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