Northern Quoll (*Dasyurus hallucatus*) Remote Camera and Trapping Survey in the Central and Eastern Chichester Ranges, Pilbara Region of Western Australia.

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Cover image: Hannah Anderson holding a male northern quoll caught at Quoll Knoll, photo by Brent Johnson.

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Summary

The Department of Parks and Wildlife (Parks and Wildlife) was commissioned by Roy Hill Pty Ltd (Roy Hill) to undertake an assessment for the presence of northern quolls within the eastern part of the Chichester Range in the Pilbara region of Western Australia.

This assessment was based on previous Roy Hill surveys, a desktop review of other investigations and an on-ground camera and trapping survey. During two previous Roy Hill surveys, the only evidence of quolls in this area was the collection of some old scats; no quolls were recorded on cameras, or trapped.

This latest survey effort covered approximately 4000km^2 with a total of 202 cage trap and 359 remote camera trapnights. It was 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. Five individual quolls were captured from two separate sites including one male and two females from the rock outcrop complex (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.

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 Range. 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. Quoll records increase further north and west of this study area. Parks and Wildlife monitoring of quolls at more westerly Chichester Range sites at Mt Florence and Python Pool shows higher abundances in these areas. The population in the east Chichester Range area appear to be highly fragmented with small breeding colonies occupying relatively isolated islands of suitable refuge and foraging habitat. Some sites that met all known criteria for suitable quoll habitat failed to produce evidence of quoll presence.

The presence of introduced predators such as feral cats and dogs throughout the survey areas was noted, and should be regarded as a matter of concern for quoll persistence.

The central and eastern portions of the Chichester Range do not appear to contain any single sizable population of northern quolls. Their distribution should be considered widespread but sparse across this portion of the range.

Future monitoring of the small breeding colony on and around the Quoll Knoll rocky complex should be considered in addition to future collaborations with the Parks and Wildlife regional monitoring program.

1 Objective

The purpose of this survey was to identify potential monitoring sites for northern quoll (*Dasyurus hallucatus*) and to provide further data to estimate the population and distribution of quolls within the Chichester Ranges. This is a requirement by Roy Hill to fulfil the requirements of Condition 3 of *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) approval 2011/5867. This survey was undertaken as part of Roy Hill's Northern Quoll Research Plan (NQRP) and information obtained would be incorporated into the Pilbara Northern Quoll regional monitoring project undertaken by Parks and Wildlife (Dunlop *et al*., 2014).

This report details the results of the continuation of baseline studies investigating the presence and distribution of northern quolls within the Chichester Range. The results of this and the previous Roy Hill surveys have been summarised and discussed.

2 Introduction

In 2005, the northern quoll (*Dasyurus hallucatus)* was listed as an Endangered species under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act* 1999 (EPBC Act) (DSEWPaC. 2011). This was due to an apparent decrease in northern quoll range. Several factors are likely to be contributing to this decline, such as the impacts of the invasive cane toad (*Rhinella marnia*), feral dog (*Canis lupus*) and cat (*Felis catus*), altered fire regimes, habitat destruction, and grazing from cattle (Braithwaite *et. al.* 1994; Hill and Ward, 2010). The distribution of the northern quoll formerly extended across the northern third of Australia. Now it occurs in smaller patches across this range in Queensland, Kimberley and Northern Territory and areas throughout the Pilbara of Western Australia (Braithwaite *et. al.* 1994). They 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). Northern quoll populations fluctuating on both annual and inter-annual cycles can confound population monitoring and survey effort. This variability is driven by both the reproductive biology of individuals and longer term cycles in response to regional stochastic processes such as rainfall, fire and related changes in prey item populations (How *et al.,* 2009).

Until recently, the Pilbara northern quoll population dynamics and demographics were the least understood of the regions of occurrence in Australia; however the increase in environmental impact assessment for the mining industry throughout the Pilbara has led to a significant increase in knowledge on the taxonomy and distribution of this species. Parks and Wildlife has also implemented a Pilbara wide quoll monitoring program (Dunlop *et al.,* 2014) to provide a regional context for more targeted population monitoring.

Roy Hill has the approval for the Roy Hill Rail Project to construct a railway line along a Special Rail Lease (SRL) from Roy Hill Mine (110km north of Newman) northwest to Port Hedland in the Pilbara region of Western Australia (Roy Hill 2014a, b). The project was referred to the Department of Sustainability, Environment, Water, Populations and Community (DSEWPaC) and conditions were imposed 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 (NQRP) in 2014.

The NQRP methodology required baseline survey by means of camera trapping to be undertaken in late 2013 and continued into 2014. The first two surveys (Parks and Wildlife October 2013 and Roy Hill November 2013 – February 2014) resulted in no photographs of northern quolls and the collection of limited faecal material in the eastern portion of the Chichester Range.

3 Methodology

A brief three day reconnaissance survey was undertaken in June 2014 by Parks and Wildlife for an extensive area from the Mine site north through the Chichester Ranges to CH 200 to identify possible sites in which to establish cameras and traps for the following trips. The August and September 2014 surveys followed two previous investigations (October 2013 and November 2013 to February 2014) undertaken in the eastern portion of the study area and to the north of the Roy Hill Mine. The current survey was conducted during August and September 2014 and undertaken in two phases.

Phase One (12 – 22 August 2014) continued westward from the previous work primarily utilising the Roy Hill SRL as a conduit through the Chichester Ranges. Phase Two (2 – 11 September 2014) extended the survey area west to parts of Mulga Downs and Hooley pastoral leases. Existing Parks and Wildlife monitoring and study sites exist at Millstream (Chichester National Park and Mt Florence) and Python Pool, and no attempt was made to duplicate effort in the western portion of the Chichester Ranges.

Remote motion sensitive cameras were deployed during both phases. Wire cage traps were utilised, during Phase Two at sites where quoll presence was indicated by either photograph or scat presence from Phase One. Cages were set with the aim to provide information on the numbers of individuals present and breeding status.

3.1 Site selection

A total of 25 sites were selected for camera surveillance following a reconnaissance (16 – 19 June 2014) for areas with suitable refuge sites and the most likely to support quolls (Figure 1, Table 1). 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 (Table 1). Previous mapping of potential northern quoll habitat along the SRL as provided by Terrestrial Ecosystems was also considered. Sites identified as “Heritage Areas” (as provided by Roy Hill or Mulga Downs) were avoided.

Many possible sites could not be investigated because of access limitations due to construction activity or railway formations creating a barrier to accessing old pastoral tracks. In some cases tracks simply did not exist. Additionally some prospective sites, shown on maps as elevated or possessing mesa type topographic features, were found to be merely steep hills with no suitable habitat.

3.2 Motion sensor cameras

Motion sensing cameras (Reconyx 900) were set to record activity between dusk and dawn (1800 and 0600 hrs) with three shots per trigger with 15 seconds between trigger events. The cameras were fixed to a tripod and located in a sheltered position such as rock overhang, rock crevice or cave (Figure 2). Baits consisting of peanut paste, fish oil, universal bait (oats, peanut paste and sardines) or combinations of the above was placed approximately 2-3m in front of the camera. The number of cameras deployed at each site varied depending on size of site and quantity of refuge habitat present (Table 1).

3.3 Cage traps

Three sites were selected for trapping where positive photographic or scat evidence supported quoll presence. Cage traps (45 cm x 17 cm x 17 cm, Sheffield Wire co, Welshpool WA) were deployed in a transect style with approximately 50m between traps, baited with peanut butter, oats and sardines. Traps were set in sheltered positions similar to the cameras or amongst thick riparian vegetation. All traps were covered with hessian secured with a rock. Traps were checked

within three hours of sunrise and all captures processed and released at point of capture immediately after all morphometrics were taken. Each individual quoll was implanted with a unique passive implanted transponder (PIT); Allflex® 12mm FD-X transponder (Allflex Australia, QLD, Australia), measured (head length, pes length, testes width, tail base diameter), weighed, sexed and checked for pouch young (Appendix 3). Ear tissue samples (approximately 2 mm) were taken from trapped animals and these will be incorporated into the northern quoll population genetic study being undertaken by Parks and Wildlife and Murdoch University.

3.4 Scats

Where possible both old and new scats were collected. Fresh scats were collected during cage trapping from trapped individual quolls with each scat placed into a clean zip-lock plastic bag and labelled with the date, site, trap number, microchip number and sex. These were placed in the fridge as soon as possible to preserve the scats. Scats found while searching at potential quoll habitat areas where recorded into the GPS, placed into a clean zip-lock plastic bag and labelled with the date and site. A total of 16 (nine old and seven fresh) scat specimens were collected. All scat specimens are currently stored at Woodvale Parks and Wildlife office in the fridge and will be dried and used for dietary analysis in the future.

3.5 Ecotoparasites

No ectoparasites were noticed on any of the captured quolls and hence none were collected during this survey program.

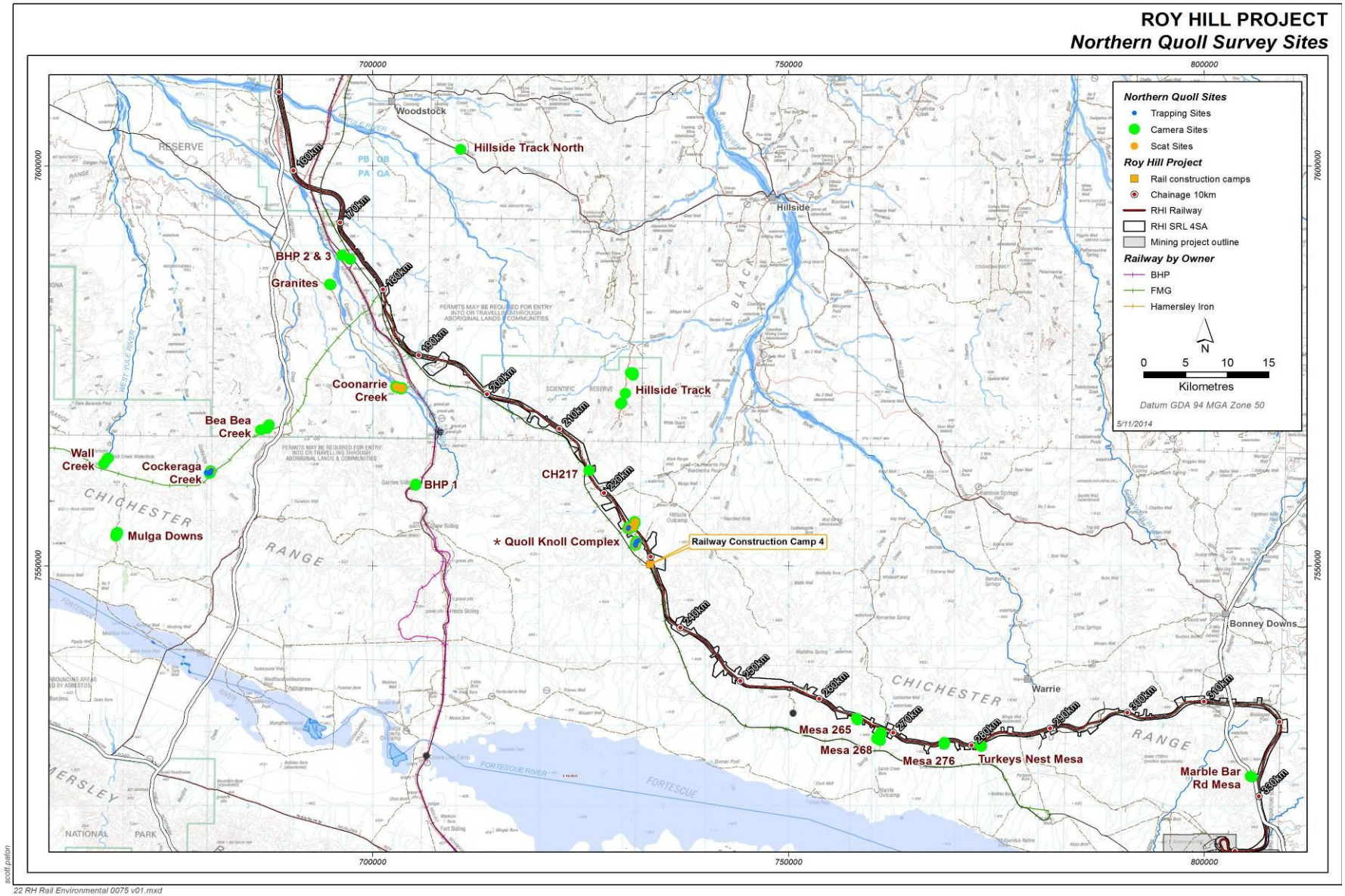

Figure 1. Sites in the Chichester Ranges which were camera trapped and/or cage trapped for northern quolls during the current study. (* for detailed site descriptions of Quoll Knoll Complex, see Figure 7)

Table 1. Location of each survey site and methods used

Figure 1 Reference	Site	Site Descriptions	Method*	Easting	Northing
		Phase 1			
Hillside Track	Hill side track	Weathered ironstone formation mesa with minimal vegetation on rock surfaces, edge of rock surrounded by *Triodia* sp.	Cameras (2), search	729966 729824	7570342 7570197
	Hill side track creek	Creek line adjacent to rocky ironstone wall with surrounding *Eucalyptus* sp., *Triodia* sp., and other shrubs.	Camera (1), search	730396	7571512
	Hill side track big bluff	Large laterictic mesa with numerous caves and crevices, with *Triodia* sp. on rock face, creek line at the base of the mesa with a mixed vegetation composition including dominant *Acacia* sp.	Cameras (5), search	731334 731325 731369 731332 731010	7573853 7573789 7573938 7574079 7310100
Hill Side Track North	Hill side track north	Granite boulders with minimal vegetation on rock face and *Triodia* sp. surrounding on flat plains.	Camera (1), search	710617	7602029
Quoll Knoll Complex	Quoll knoll north	Lateritic rocky outcrop with *Triodia* sp. and other shrub species surrounding, in the middle of mining disturbance.	Cameras (2), search	730791 730802	7554816 7554798
	Quoll knoll south	Two lateritic rocky outcrops (formed part of Quoll knoll north) with *Triodia* sp. and other shrub species surrounding, creek line at the base of the outcrops with a mixed vegetation composition including dominant *Acacia* sp.	Camera (2), search	730734 730704	7554685 7554605
	Mesa 228	Long lateritic ridge mesa, approximately 800m long, numerous caves and crevices with *Triodia* sp., *Eucalyptus* sp., and other shrubs surrounding and on top of ridge.	Cameras (7), search	731663 731692 731715 731728 731635 731640 731672	7552813 7552883 7552930 7553020 7552518 7552591 7552763
Mesa 265	Mesa 265-1	Weathered lateritic outcrop with *Triodia* sp. surrounding.	Camera (1), search	758214	7530881
	Mesa 265-2	Weathered lateritic mesa with *Triodia* sp. surrounding.	Camera (1), search	758326	7530686
Mesa 268	Mesa 268-1	Lateritic mesa, heavily vegetated with *Triodia* sp., *Acacia* sp., and other shrubs surrounding.	Camera (1), search	761042	7528117
	Mesa 268-2	Lateritic mesa with numerous caves, heavily vegetated with *Triodia* sp., *Acacia* sp., and other shrubs surrounding.	Cameras (6), search	760662 760713 760678 760729 760804 760827	7528324 7528339 7528415 7528505 7528511 7528560
	Mesa 268-3	Lateritic mesa with *Triodia* sp. surrounding.	Cameras (3), search	761112 761130 761107	7528926 7529024 7529131
Mesa 276	Mesa 276	Lateritic mesa with *Triodia* sp. and *Eucalyptus* sp. surrounding.	Cameras (4), search	768758 768743 768756 768780	7527648 7527717 7527802 7527883
Turkey Nest Mesa	Turkey nest mesa	Lateritic mesa with *Triodia* sp., and other shrubs surrounding, forms a group complex of mesas.	Cameras (4), search	773024 773178 773201 773203	7527496 7527508 7527421 7527373
Marble Bar Rd Mesa	Marble bar road mesa	Lateritic mesa close to Marble Bar Road with *Triodia* sp., and other shrubs (*Acacia* sp.) surrounding.	Cameras (4), search	805734 805653 805535 805591	7523544 7523578 7523657 7523608
BHP 1	BHP 1	Siltstone/ironstone gorge with a mixed vegetation complex including *Triodia* sp., Ecualyptus sp., *Acacia* sp., and other shrub/herb species. No water present in creek.	Cameras (3), search	705233 705204 705193	7560193 7560121 7560057

BHP 2 & 3	BHP 2	Granite tors with *Triodia* sp. surrounding.	Cameras (2), search	697321 697277	7588290 7588315
	BHP 3	Granite tors with *Triodia* sp. surrounding.	Cameras (2), search	696360 696335	7588772 7588820
Cockeraga Creek	Cockeraga creek	Scree slope of weathered rocky basalt with permanent pools of water in creek line at base of slope, mixed vegetation complex with *Triodia* sp., *Eucalyptus* sp., *Acacia* sp., *Melaleuca* sp., and other shrub species.	Cameras (2), search	680559 680544	7561783 7561839
Bea Bea Creek	Bea Bea creek	Weathered rocky basalt with permanent pools of water in creek line at base of rock, mixed vegetation complex with *Triodia* sp., *Eucalyptus* sp., *Acacia* sp., *Melaleuca* sp., and other shrub species.	Cameras (5), search	687593 687539 687367 687320 687247	7567587 7567531 7567182 7567171 7567174
	Bea Bea falls	Weathered basalt rock wall with water fall and permanent pools of water in creek line at base of rock, mixed vegetation complex with *Triodia* sp., *Eucalyptus* sp., *Acacia* sp., *Melaleuca* sp., and other shrub species.	Camera (1), search	686563	7566965
Granites	Granites	Granite tors with *Triodia* sp. surrounding.	Cameras (2), search	694862 695010	7585177 7585106
Phase 2					
CH217	CH217	Scree slope basalt ridge with *Triodia* sp. surrounding close to rail line formation.	Camera (2), search	726084 726047	7561868 7561863
Mulga Downs	Mulga downs	Weathered lateritic mesa with dense *Triodia* sp. surrounding.	Cameras (4), search	669215 669361 669240 669151	7554057 7554133 7553761 7553662
Wall Creek	Wall creek	Scree slope of weathered rocky basalt with numerous permanent pools of water in creek line at base of slope, mixed vegetation complex with *Triodia* sp., *Eucalyptus* sp., *Acacia* sp., *Melaleuca* sp., and other shrub species.	Cameras (3), search	667718 668027 668234	7562730 7563233 7563439
Coonarrie Creek	Coonarrie creek	Low granite outcrops and rockpools with a permanent billabong, with large *Melaleuca* sp. forest surrounding.	Cameras (10), search	703334 703402 703561 703502 703367 703080 703046 702953 702800 702844	7572200 7572223 7572219 7572079 7572104 7572231 7572276 7572299 7572400 7572258
Quoll Knoll Complex	Quartz ridge	Steep quartz rocky ridge forming part of lateritic ridge complex, *Triodia* sp. surrounding.	Cameras (5), search	731553 731543 731528	7555307 7555408 7555514
	Quoll knoll east	Lateritic rocky outcrop with *Triodia* sp. and other shrub species surrounding (forms part of Quoll Knoll complex).	Camera (1), search	731331	7554808
	Quoll knoll north	^see above for site descriptions in phase one	Traps (4)	730791	7554816
	Quoll knoll south		Traps (4)	730704	7554605
	Mesa 228		Traps (20)	731728	7553020
Cockeraga Creek	Cockeraga creek		Traps (30)	680544	7561839

* cameras = remote sensor cameras; trap = cage trap. Numbers in brackets indicate the number of cameras or cages used at each site

Figure 2. Example of a motion sensor camera set up on a tripod to detect northern quoll activity.

4 Results

A total of 357 camera and 202 cage trap nights were achieved over an area of approximately 4000km^2. Evidence of northern quolls was recorded at eight of the 28 sites (29% of sites, see Table 3). Quoll scats were observed at seven sites with current quoll presence at three of these sites confirmed by photographic evidence. One site (Hillside Track North) had camera only evidence (no scats or captures in traps). Multiple scats were found on Mesa 228 (Figure 4), however no quolls were recorded on camera or by subsequent trapping. Other sites with lesser amounts of scat material also provided no photographic confirmation of northern quoll presence.

Trapping was undertaken at Quoll Knoll north and south, Mesa 228 and Cockeraga Creek (Figure 1, Table 3 and Appendix 1 for Raw Trapping Data). The capture of one male and two female quolls at the Quoll Knoll complex correlated to the population size estimated from photographic analysis. Both females had significant pouch development suggesting they were in the later stages of pregnancy (Figure 3). Two of these individuals, were recaptured (male recaptured three times, one female recaptured once) during this trapping survey period on both sides of the Roy Hill railway construction light vehicle access road on Quoll Knoll north and south. Nearby (2.3km south east) trapping was unsuccessful at Mesa 228. Cockeraga Creek to the west of the Great Northern Highway yielded one male and one female quoll. This female was carrying six small pouch young (7mm crown to rump length) indicating recent births (Figure 3B). Microchip scanning indicated previous capture of this female by a third party. After further investigation it was ascertained that Ecologia Environment had undertaken trapping in this area as part of a fauna monitoring program for the Fortescue Metals Group (FMG) (Table 2).

Non-target native mammal species recorded either on camera or in traps included *Pseudantechinus* sp., Common Rock Rat (*Zyzomys argurus*), Black Rat (*Rattus rattus*), Rothschild's Rock-wallaby (*Petrogale rothschildi*), Short-beaked Echidna (*Tachyglossus aculeatus*) and Common Wallaroo (*Macropus robustus*). Bird species recorded on the cameras included willy wagtails (*Phipidura leucophrys*), crows (either torresian or little crow) and a Spotted Nightjar

(*Eurostopodus argus*). One reptile species, *Egernia formosa*, was captured in a cage trap at Cockeraga Creek.

Feral cats (*Felis catus*) were recorded on cameras from five sites and tracks were noted at several others (Figure 5). Canid scats and tracks were also commonly observed by the Parks and Wildlife survey team. Animal Pest Management Services (APMS) were conducting feral animal control program for Roy Hill during the same Parks and Wildlife survey period near the SRL and the Quoll Knoll and also noted cat tracks. Locations of cats recorded during this survey was provided to APMS.

Table 2. Details of female northern quoll trapped via Ecologia at Cockeraga Creek

NQ ID	Date	Capture/recapture	Sex	Site	Trap No.	Easting	Northing	Weight (g)	Short Pes (mm)	Head (mm)	Reproductive Status	Body Condition	WAM number
941000016202859	21/6/14	Capture	F	SR NQI1	C2	680761	7561840	380	32	71	Small individual	3.5	WAMTS326
	24/6/14	Recapture		SR NQI1	C3	680706	7561821						

A. B.

Figure 3. A: A female northern quoll being released after trapping; B: Photo showing very small pouch young of a female quoll (Photo credit: Judy Dunlop/ Parks and Wildlife). Both photos show quolls from other Parks and Wildlife surveys.

A. B.

Figure 4. A: Northern quoll scats found in rock crevices at site Mesa 228; B: Photo showing potential quoll habitat present at site Mesa 228.

Table 3. Results of camera and trapping at each site

Site	# camera nights	# trap nights	Quolls present	Scats present
Phase 1				
Hill side track	10	0	No	No
Hill side track creek	5	0	No	No
Hill side track big bluff	20	0	No	No
Hill side track north	5	0	Yes	No
Quoll knoll north	10	0	Yes	Yes
Quoll knoll south	10	0	Yes	Yes
Mesa 228	35	0	No	Yes
Mesa 265-1	8	0	No	No
Mesa 265-2	8	0	No	No
Mesa 268-1	6	0	No	No
Mesa 268-2	36	0	No	No
Mesa 268-3	18	0	No	No
Turkey nest mesa	24	0	No	No
Mesa 276	24	0	No	No
Marble bar road mesa	20	0	No	No
BHP 1	12	0	No	No
BHP 2	8	0	No	No
BHP 3	8	0	No	No
Cockeraga creek	6	0	Yes	Yes
Bea Bea creek	15	0	No	No
Bea Bea falls	3	0	No	No
Granites	6	0	No	No
Phase 2				
CH217	6	0	No	No
Quartz ridge	9	0	No	Yes
Quoll knoll east	3	0	No	Yes
Mulga downs	24	0	No	No
Wall creek	6	0	No	No
Coonarrie creek	20	0	No	Yes
Quoll knoll north	0	16	Yes	Yes
Quoll knoll south	0	16	Yes	Yes
Mesa 228	0	80	No	Yes
Cockeraga creek	0	90	Yes	Yes

A.

B.

C.

D.

Figure 5. Feral cat photographs recorded on the remote camera traps at different sites (A: Hill Side Track Big Bluff; B: Mesa 268-3; C: Mesa 276; D: Cockeraga Creek).

5 Discussion

5.1 Northern Quoll occurrence in the Chichester Range

The results from this survey were consistent with previous Roy Hill remote camera and scat searching studies. Information from this study confirms that northern quoll do not currently occur in any abundance in the east and central Chichester Range. Small isolated populations were found as this survey moved westwards from the SRL, with adult males and breeding females recorded from two sites (Quoll Knoll and Cockeraga Creek). The northern most camera record from this survey (Hill Side Track North) does not lie within what would be considered core Chichester Range and is not discussed here as it lies outside the scope of this survey area. The landforms at the two successful Chichester trapping sites were highly correlated to what has been widely accepted as preferred or suitable habitat for northern quolls. However other sites, such as Wall Creek, which possess similar or even potentially superior habitat failed to produce quoll evidence. Likewise numerous mesas with heavily weathered rocky or lateritic caps, providing a large quantity of refuge opportunity, produced limited evidence (i.e. very old or no scat evidence) of any extant quoll population.

Northern quoll records are broadly distributed across the Pilbara with several areas of localised abundance situated within 150km of the coast (Biota, 2009). While the majority of the records fall within the Chichester IBRA subregion, the south eastern Pilbara and the Chichester Range itself appears to be an area of lower abundance (Biota, 2010).

Discussion with Ecologia Environment on the results of the Fortescue Metals Group fauna monitoring along the Cloudbreak, Christmas Creek and Solomon 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*).

Extensive “grey” literature exists in the form of consultancy reports relating to mining activity (including existing rail corridors and extensions). A review of these reports suggest that habitat suitable for northern quolls is present within the Chichester Ranges, however capture and observation records (confirmed by records on NatureMap) indicate that this species is widely but sparsely distributed within the central and eastern portion of the Chichester range (Bamford, 2013). Parks and Wildlife regional monitoring results indicate a decline in quoll abundance away from the coast, towards the south-east of the Pilbara (DEC, 2012; J Dunlop *pers com Sept-2014*). Furthermore, extensive mining related survey effort in the east and south east of the Pilbara has returned few quoll records (Biota, 2009). Recent survey by Parks and Wildlife within the Hamersley Range to the south of this survey site, did not find any quolls in 2014. Monitoring sites in the western Chichester Range at Mt Florence, Python Pool and a post-graduate study at Millstream Chichester National Park have found larger populations of resident quolls (J Dunlop/J Lees *pers com Sept-2014*).

The results of this and other surveys indicate that the Pilbara quoll population is fragmented with many localised populations of varying density. Some of these may have in excess of 100 individuals, such as Poondano 30km south east of Port Hedland (Bamford, 2008). Others such as small outcrops like Quoll Knoll, or creeklines such as Cockeraga have two or three individuals. In regional context it is possible that individuals disperse southwards from the Abydos-Woodstock plain. This area contains numerous scattered granite tor piles providing significant refuge opportunity with the likelihood of small concentrations of northern quoll over a wider area with higher numbers around the extensive Wodgina granites 150km south of Port Hedland (Outback

Ecology, 2011). The ability of quolls to move between such refuge patches (connectedness) has rarely been studied and limited genetic investigation has been undertaken at a local level.

This survey sought to locate additional areas of potential sites of quoll occupation based on what is considered to be suitable refuge habitat, and to determine the population distribution across the survey area. Several highly prospective mesa formations, outcrops, scree slopes and rocky riparian zones were investigated yet many sites failed to return evidence of quoll presence. Sites such as Wall Creek with permanent water, rugose gorge walls, minimal disturbance, generally healthy vegetation and connectivity to the Mungaroona Range Nature Reserve wilderness had a high expectation of quoll presence (Figure 5). The absence of quolls from what could be considered a prime habitat site suggests either a natural very low abundance throughout the central and eastern Chichester Range, regardless of habitat suitability and refuge opportunity, or a possible population decline due to threatening processes such as predation by exotic carnivores, pastoral activity, changes to fire regimes and general loss of landscape productivity.

Cats, dogs and dingoes were present in the survey area and are a potential threat to persistence of the fragmented quoll populations in the eastern part of the Chichester Range. Even low levels of predation by introduced predators could result in the loss of the small and localised quoll populations.

Figure 6. Wall Creek showing scree slope of rocky riparian zones, potential quoll habitat.

5.2 Northern Quoll presence on the Roy Hill Special Rail Lease

The confirmation of a small breeding population of northern quolls at Quoll Knoll is significant in the context of this survey, and in the construction and management of the Roy Hill Special Rail Lease (SRL). This highly weathered and rugose rock outcrop complex is very small (approx. 250m x 50m) with a light vehicle access track located at a low point dividing the two rocky outcrops (Figure 6). This light vehicle assess track was noticed during the field trip to be heavily utilised during daylight hours and it is planned to be closed and rehabilitated when the railway line construction is complete (Samsung Environmental pers com September 2014), reducing the risk to quoll movement between the two rocky outcrops. A wide, heavy vehicle road is immediately north of Quoll Knoll servicing the construction activity of the railway formation, which lies parallel to the railway alignment and comprises a deep cutting and steep embankment. Large “borrow” pits lie immediately to the east of the outcrops. Other surrounding topographic features include lightly vegetated drainage lines and small hills/ridges to the north and north-east, both of which were sites where quoll scats (new and old) were recorded (Figure 7). A large mesa (Mesa 228) lies 2.3km to the south-east and this also had multiple scat (old and new) records (Figure 7).

The evidence of quoll activity in and around the Quoll Knoll sites suggests movement of resident quolls through this recently highly disturbed landscape. There is the potential for vehicle strike as a result of the construction activity taking place near this site. There is also a potential increased threat from opportunist predators. Introduced predators, such as dogs, cats and foxes, can be curious animals that investigate human inhabited areas (e.g. construction/mining areas) as they are attracted by water, noise and rubbish/food scraps. In addition, having open areas (i.e. roads, crib areas, railway line/expansions) can result in predators being more likely to roam open areas near bushland as it is easier to find prey items, for example in a natural environment, creek beds are frequently used (May *et. al.,* 1996, Stuart *et. al.,* 2002) as a thoroughfare by predators. Clearing large areas of vegetation also creates a fragmented and open landscape through which animals are required to cross when moving between refuge and foraging sites. This can expose them to an increase risk of predation (May *et. al.* 1996). Impact mitigation measures and monitoring of quolls at this site, including juvenile dispersal and recruitment, should be undertaken (see section 5.3 for recommendations).

Figure 7. Photo taken from Quoll Knoll south looking northwards showing Quoll Knoll north and the light vehicle access track dividing the two rocky outcrops is shown in the midground. The railway formation and HV track is located behind Quoll Knoll north. Other mesas and rock outcrops shown in the distance were searched during this survey.

5.3 Recommendations

It is recommended that where possible mitigation measures should be implemented during both the construction phase and railway operation phase, and monitoring of northern quolls at the Chichester sites which includes the quoll knoll area should be undertaken by Roy Hill.

5.3.1 Mitigation Measures

During the construction phase, recommended mitigation measures should be to:

- Apply strategic signage around the quoll knoll area including the heavy vehicle track warning drivers of quolls in the area;
- Provide information and education (e.g. posters at camps) to the workers so they are aware of northern quolls, and fauna (northern quolls) interaction is included in JHA's as to constantly remind workers of quolls in the area (especially night shift workers);
- Enforce appropriate speed limit (40 km) on all tracks in quoll knoll vicinity;
- Limit further vegetation clearance around quoll sites;
- Limit night works to reduce potential vehicle strike;
- Rehabilitate borrow pits immediately following closure and create artificial refuges using left over waste rock. Prescription to be developed asap for artificial refuge construction.

During railway operation, recommended mitigation measures should be to:

- Rehabilitate the LV track and borrow pits when appropriate, and create artificial refuges using rock debris waste from construction phase;
- Monitor Quoll Knoll with cameras supplemented with annual trapping to ensure quolls are still utilizing the area;
- Where possible worn or broken rail sleepers should be stocked-piled and utilized as artificial refuge in areas designated by Roy Hill environmental team;
- Fauna road kill reporting procedures to be implemented;
- Pest animal management procedures to be modified when contractors are operating in quoll habitat. This should include appropriate ethical considerations for trap use in line with Parks and Wildlife standard operating procedures.
- The 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;
    - 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.

5.3.2 Monitoring of Quolls

Quoll Knoll area

As previously suggested, Quoll Knoll and Mesa 228 should be incorporated as one monitoring site and be one of the long term monitoring sites as identified within the NQRP. Monitoring of the quoll knoll sites with remote cameras should be undertaken on a semi-continual basis. Annual cage trapping in May/June should also be implemented.

Cameras should be left in-situ (two per site x two sites: Quoll Knoll south and Quoll Knoll north) throughout the year to build a photo library for spot recognition of individual quolls. Cage trapping at both Quoll Knoll and Mesa 228 should follow the same survey methods as Parks and Wildlife's regional monitoring program for quolls (50 traps at 50m spacing, 2 transects, 4 nights), where possible.

Radiotracking of individuals at the quoll knoll sites would provide valuable data on small population dynamics in a disturbed landscape. In particular, radio tracking could investigate the movements of quolls over roads/railway lines to understand the impacts of this recently installed infrastructure. A project sited in this area could also have a focus on gaining an understanding on artificial refuge utilization after rehabilitation has been completed. This could possibly be done as a collaborated project (DPaW, relevant University and Roy Hill) with an honours student. Additional post-graduate studies could include investigations on culvert use by fauna.

Cockeraga Creek

It is recommended that Cockeraga Creek not be monitored by Roy Hill under the NQRP as it is already being monitored by Ecologia Environmental for FMG.

Survey – additional areas – Wall Creek

It is recommended that Wall Creek be surveyed more intensively for the presence of quolls using remote cameras. Any positive records should be followed up with a cage trapping survey. Despite no evidence found during this survey of quolls inhabiting the Wall Creek site, it offers high potential habitat and is a relatively extensive creek system which warrants further investigation.

If the additional surveys identify a resident population at Wall Creek, it is recommended that this be included in the NQRP as one of the two long term monitoring sites.

Other Northern Quoll Monitoring sites within Chichester Ranges

Parks and Wildlife have already identified a number of sites across the Pilbara as part of the regional monitoring program. Two sites lie within the Chichester Ranges (Millstream Chichester National Park and Mt Florence Station).

To fulfill the Chichester Range geographical provision in the Roy Hill EPBC 2010/5424 approval conditions, it is suggested that Roy Hill take (financial) responsibility for all Chichester sites under a joint arrangement that would meet both Roy Hill's objective and allow Parks and Wildlife to expand the geographic range of monitoring across the Chichester Ranges. This could fit into both the Roy Hill NQRP and the Parks and Wildlife regional monitoring frameworks. Parks and Wildlife can undertake monitoring and reporting responsibility under a contractual agreement with Roy Hill. This would allow the Parks and Wildlife team to investigate or expand to additional sites such as Poondano, Meentheena, Yandeyarra, Wall Creek or Spear Hill and increase the number of long term monitoring sites from ten (that comprises the regional northern quoll project) to fourteen sites.

5.3.3 Future Quoll Research

Scats

Scats collected from this field trip will be added to Parks and Wildlife collections.

There are currently ~100 Pilbara scat samples held by Parks and Wildlife and additional scats are being sourced from consultants. Dietary analysis will be undertaken as part of the regional northern quoll monitoring project.

Ectoparasites

No ectoparasites were collected or sighted during this survey however ectoparasites will be collected (when sighted) on future surveys for possible future studies.

Genetic Studies

Ear tissue samples (four samples collected on this survey) will form part of a broader collaborated project with Murdoch University (Peter Spencer), Parks and Wildlife and Western Australian Museum (WAM) investigating the genetic differences between Pilbara and Kimberley populations (and sub populations). Peter Spencer has completed the initial genetic analysis of northern quolls but lacks samples from a wide range of areas within the Pilbara. Parks and Wildlife will submit these collected samples to Murdoch University and future samples collected. Parks and Wildlife are currently obtaining tissue samples from consultants which will also be provided to Murdoch University.

Predictive Species Modelling

One of the key research priorities that emerged from the northern quoll workshop was to better map the northern quoll distribution in the Pilbara. A collaboration between Parks and Wildlife and Edith Cowan University has been set up to undertake predictive species distribution modeling based on historic data and data collected within this project.

Specific objectives are to:

a. Develop a predictive model of northern quoll habitat on a finer scale than is currently available based on a combination of Parks and Wildlife monitoring data, existing survey data, improved habitat data and dispersal estimates.

b. Incorporate known threats to this species, such as climate change, fire regimes, pastoralism, mining infrastructure and cane toads, into models to identify important future/core habitat.

c. Develop a data set that identifies areas of key/core habitat to support planning and mining offsets.

Distributional data collected in the 2013/2014 season from both the Parks and Wildlife regional monitoring program and this separate Roy Hill survey, will be used in conjunction with GIS layers and habitat data collected on the ground, to create a predicted distribution of northern quolls in the Pilbara. Un-surveyed sites with predicted high quoll populations and sites predicted to have no quolls will be ‘ground-truthed’ to test the models. It is suggested that the Roy Hill 2015 program could potentially ‘ground truth’ some of the predicted Chichester range areas to test the model.

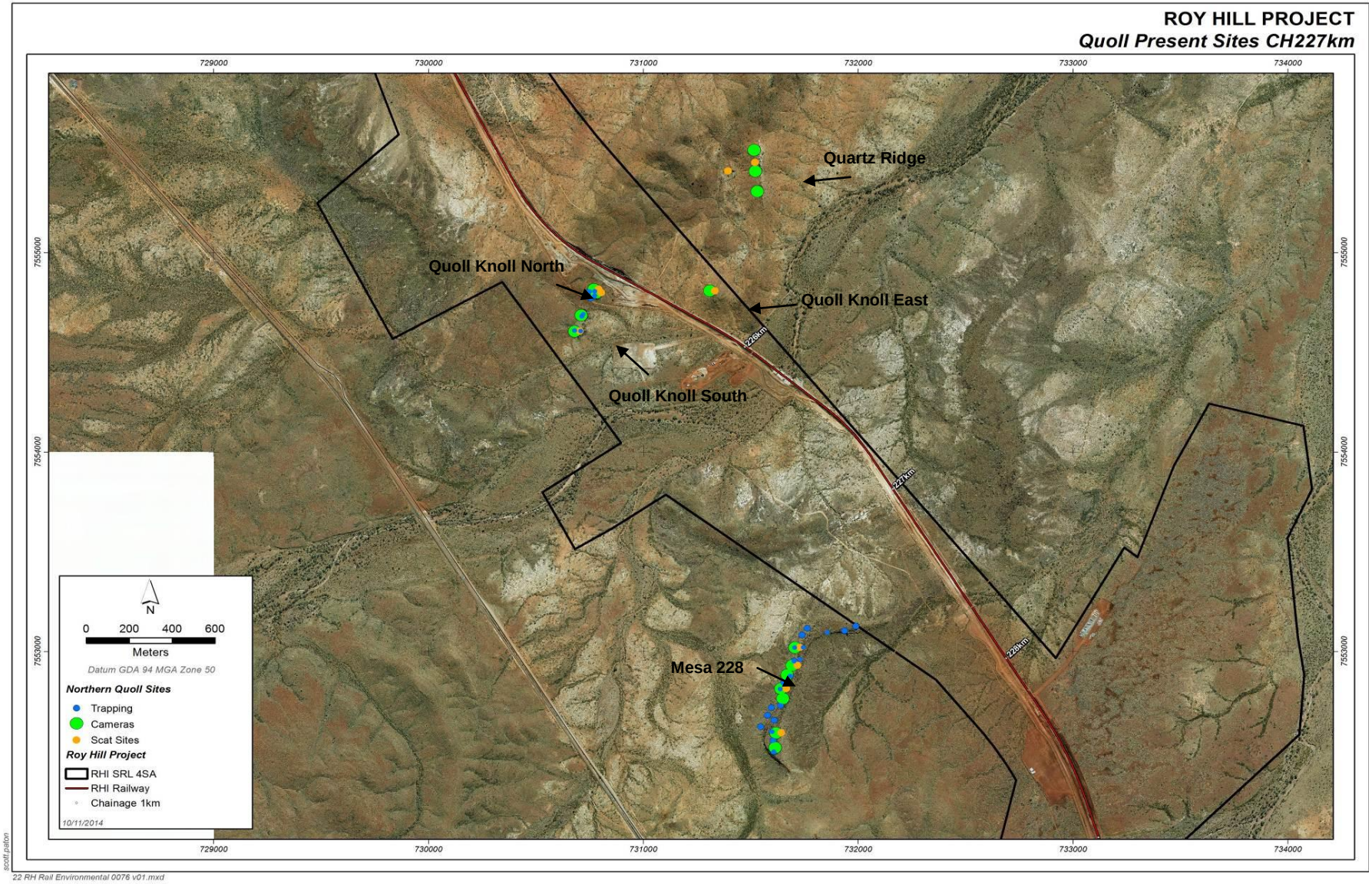

Figure 8. Sites surveyed in the Quoll Knoll rocky outcrop complex (sites include: Quoll Knoll South, North and East, Quartz Ridge and Mesa 228).

6 Conclusion

The consistency of results between multiple surveys undertaken across the Chichester Ranges for Roy Hill during 2013 and 2014 indicates that it is unlikely that there are any large populations of northern quolls within the central and eastern Chichester Range. It is likely large portions of these zones represent marginal habitat for northern quolls. The populations appear to be widely scattered with small “pockets” of several individuals in suitable habitat. Evidence shows that northern quoll breeding is occurring within these small populations. These small populations may be at almost undetectable levels with some patches occupied on an episodic basis during cycles of population expansion following periods of favourable climatic or other conditions. Opportunities for juvenile dispersal and recruitment from and between these suitable habitat patches is most likely occurring, however the presence of feral cats and dogs/dingoes may limit survivorship.

In the context of the NQRP it would be prudent to monitor the population and other aspects of the Quoll Knoll colony on the Special Rail Lease and to possibly investigate further north into the Wall Creek system toward, and into the southern Mungaroona Range area.

It is recommended that further discussions with Parks and Wildlife be held on collaboration and possible synergies, including expansion of the current ongoing monitoring within the Parks and Wildlife Pilbara northern quoll regional monitoring project, and the possibility of pursuing actions in the national recovery plan framework for northern quolls.

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Appendices

Appendix 1 Raw Trapping Data 2014

Date	Site	Trap #	Species	Sex	Pit tag #	N/R/RT^	Tot Wt/Bag Wt	Animal Wt (g)	Age	Pes L (mm)	Head L (mm)	Testes W (mm)	Pouch Young	Tail Diam (mm)	Scats taken	Tissue taken	Comments
4/09	Quoll Knoll South	QK-5	*Dasyurus hallucatus*	M	982000190543578	N	970/160	810	A	37	75	26.5		18.7	Yes	Yes	
4/09	Quoll Knoll South	QK-6	*Dasyurus hallucatus*	F	982000163698911	N	520/160	360	A	31.5	67.6		developed , no young	15	Yes	Yes	growth back of neck, 2x1cm
4/09	Mesa 228	Mesa 228-5	*Zyzomys argurus*	F	N/A	N							lactating 4 teats				
5/09	Quoll Knoll North	QK-1	*Dasyurus hallucatus*	F	982000163700079	N	520/180	340	A	31.8	66		developed, no young	11.7	Yes	Yes	
5/09	Quoll Knoll North	QK-2	*Dasyurus hallucatus*	F	982000163698911	RT			A								
5/09	Quoll Knoll South	QK-7	*Dasyurus hallucatus*	M	982000190543578	RT			A								
6/09	Quoll Knoll North	QK-1	*Dasyurus hallucatus*	M	982000190543578	RT			A								
7/09	see comments	see comments	*Dasyurus hallucatus*	M	982000190543578	RT			A								caught in cat trap in creek line
7/09	Mesa 228	Mesa 228-1	*Zyzomys argurus*		N/A	N											
7/09	Mesa 228	Mesa 228-5	*Zyzomys argurus*		N/A	RT											
7/09	Mesa 228	Mesa 228-13	*Zyzomys argurus*		N/A	N											
9/09	Cockeraga Creek	14	*Dasyurus hallucatus*	F	162028559	R	570/170	400	A	28.3	67.6		6 pouch young/7mm long		Yes	No	already chipped, Ecologia's survey site
9/09	Cockeraga Creek	4	*Egernia formosa*		N/A	N											
10/09	Cockeraga Creek	13	*Dasyurus hallucatus*	F	162028559	RT			A								
10/09	Cockeraga Creek	3	*Dasyurus hallucatus*	M	did not chip	N	720/170	550	A	33.5	73.5	19.5		12.5	Yes	Yes	site already being surveyed by Ecologia (D. Cancilla *pers com* September 2014)

^N/R/RT: N-new individual animal caught; R: recapture (caught in previous session), RT-retrap (caught already this session)

Appendix 2 Raw Data: Northern Quoll Habitat Survey

Trapping Site: Cockeraga Creek Habitat Survey

Site Name: Cockeraga Creek **Recorder/s:** Brent Johnson, Hannah Anderson

Date: 10/09/2014 **GPS datum:**50;**Coordinates:** 680559E, 7561783N

1. Landform Element^

Morphological type

C	Crest	F	Flat
U	Upper slope	V	Open depression (vale)
M	Mid slope	D	Closed depression
L	Lower slope	H	Hillock
S	Simple slope	R	Ridge

2. Rock Outcrop

Type: rocky basalt

Abundance

0	No bedrock exposed	0%
1	Very slightly rocky	<2%
2	Slightly rocky	2-10%
3	Rocky	10-20%
4	Very Rocky	20-50%
5	Rockland	>50%

3. Soil

Colour

R	Red	Y	Yellow	O	Orange
G	Grey	B	Brown	D	Dark

Type

1	Clay	5	Coarse sand
2	Fine silt	6	Fine gravel
3	Coarse silt	7	Coarse gravel
4	Fine sand	8	None; rock only

4. Ground Cover

% Cover leaf litter : 10-30%

% Cover bare ground: 10-30%

(including litter, rock cover and bare soil, excluding live vegetation)

5. Coarse Fragments on the Surface

Rock Abundance

0	No coarse fragments	0%
1	Very slightly; very few	<2%
2	Slightly; few	2-10%
3	No qualifier; common	10-20%
4	Moderately; many	20-50%
5	Very; abundant	50-90%
6	Extremely; very abundant	>90%

Rock Size

3	Gravelly	>60mm
4	Cobbly; or cobbles	60-200mm
5	Stony; stones	200-600mm
6	Bouldery; or boulders	600mm-2m
7	Large boulders	>2m

6. Land Surface

Disturbance of site

0 No effective disturbance

1 No effective disturbance except grazing by hoofed animals

2 Limited clearing

3 Extensive clearing

4 Highly disturbed, e.g. mining, urban

7. Evidence of Recent Fire

Frequency		Intensity	
0	Long unburnt	0	No damage
1	Several yrs since burn	1	Minor
2	Burnt before last rainfall	2	Some defoliated
3	Burnt after last rainfall	3	Most defoliated
		4	Unknown

Distance to nearest unburnt patch (>5ha)

1	<100m	2	100-500m
3	500m-1km	4	>1km

8. Nearby Water Bodies

1	Permanent	R	River
2	Seasonal	S	Soak/spring
3	Ephemeral	C	Creek
		P	Pool
		B	Bore/windmill/dam

Distance (m): 20-400m

9. Evidence of Feral/Introduced Species (please list)

- Feral cats

10. Site Photos (please attach)

See page 13

11. Vegetative growth Stage

1 Early regeneration

2 Advanced regeneration

3 Mature vegetation

4 Senescent phase

12. Native Fig (Ficus) Present

0 Absent

1 1-10 plants

2 >10 plants

Note: ^ the chosen question is either circled in red and underlined or both.

See next page for continued habitat survey for site Cockeraga Creek.

13. Vegetation (Cockeraga Creek Habitat Survey Continued…)

Please tick 1 box in each row, and record dominant species where known		**Absent**	**Isolated <2%**	**Very sparse 2-10%**	**Sparse 10-30%**	**Mid-dense 30-70%**	**Dense 70-100%**
TREES	**Dominant species:**	*Eucalyptus* sp.					
	>30m	✓					
	10-30m			✓			
	<10m						✓
MALLEES	**Dominant species:**	none					
	Over 8m	✓					
	Under 8m	✓					
SHRUBS	**Dominant species:**	*Meleauca* sp.; *Acacia* sp.					
	Over 2m					✓	
	1-2m	✓					
	Under 1m	✓					
HERBS & SEDGES	**Dominant species:**	*Solanum* sp.					
					✓		
GRASSES	**Dominant species:**	*Triodia* sp.					
	Hummock					✓	
	Tussock			✓			
	Bunch		✓				

14. Site map/photos (Cockeraga Creek Habitat Survey Continued…)

Trapping Site: Quoll Knoll Habitat Survey

Site Name: Quoll Knoll

Recorder/s: Brent Johnson, Hannah Anderson

Date: 06/09/2014

GPS datum:50;**Coordinates:** 730797E, 7554806N

1. Landform Element^

Morphological type

C	Crest	F	Flat
U	Upper slope	V	Open depression (vale)
M	Mid slope	D	Closed depression
L	Lower slope	H	Hillock
S	Simple slope	R	Ridge

2. Rock Outcrop

Type: granite

Abundance

0	No bedrock exposed	0%
1	Very slightly rocky	<2%
2	Slightly rocky	2-10%
3	Rocky	10-20%
4	Very Rocky	20-50%
5	Rockland	>50%

3. Soil

Colour

R	Red	Y	Yellow	O	Orange
G	Grey	B	Brown	D	Dark

Type

1	Clay	5	Coarse sand
2	Fine silt	6	Fine gravel
3	Coarse silt	7	Coarse gravel
4	Fine sand	8	None; rock only

4. Ground Cover

% Cover leaf litter : <2%

% Cover bare ground: 30-70%

(including litter, rock cover and bare soil, excluding live vegetation)

5. Coarse Fragments on the Surface

Rock Abundance

0	No coarse fragments	0%
1	Very slightly; very few	<2%
2	Slightly; few	2-10%
3	No qualifier; common	10-20%
4	Moderately; many	20-50%
5	Very; abundant	50-90%
6	Extremely; very abundant	>90%

Rock Size

3	Gravelly	>60mm
4	Cobbly; or cobbles	60-200mm
5	Stony; stones	200-600mm
6	Bouldery; or boulders	600mm-2m
7	Large boulders	>2m

6. Land Surface

Disturbance of site

0 No effective disturbance
1 No effective disturbance except grazing by hoofed animals
2 Limited clearing
3 Extensive clearing
4 Highly disturbed, e.g. mining, urban

7. Evidence of Recent Fire

Frequency		**Intensity**	
0	Long unburnt	0	No damage
1	Several yrs since burn	1	Minor
2	Burnt before last rainfall	2	Some defoliated
3	Burnt after last rainfall	3	Most defoliated
		4	Unknown

Distance to nearest unburnt patch (>5ha)

1	<100m	2	100-500m
3	500m-1km	4	>1km

8. Nearby Water Bodies

1	Permanent	R	River
2	Seasonal	S	Soak/spring
3	Ephemeral	C	Creek
		P	Pool
		B	Bore/windmill/dam

Distance (m): 150m

9. Evidence of Feral/Introduced Species (please list)

- Feral cat
- Feral dog

10. Site Photos (please attach)

See page 16

11. Vegetative growth Stage

1 Early regeneration
2 Advanced regeneration
3 Mature vegetation
4 Senescent phase

12. Native Fig (Ficus) Present

0 Absent
1 1-10 plants
2 >10 plants

Note: ^ the chosen question is either circled in red and underlined or both.

See next page for continued habitat survey for site Quoll Knoll.

13. Vegetation (Quoll Knoll Habitat Survey Continued…)

Please tick 1 box in each row, and record dominant species where known		**Absent**	**Isolated <2%**	**Very sparse 2-10%**	**Sparse 10-30%**	**Mid-dense 30-70%**	**Dense 70-100%**
TREES	**Dominant species:**	*Eucalyptus* sp.					
	>30m	✓					
	10-30m	✓					
	<10m		✓				
MALLEES	**Dominant species:**	none					
	Over 8m	✓					
	Under 8m	✓					
SHRUBS	**Dominant species:**	*Acacia* sp.					
	Over 2m	✓					
	1-2m	✓					
	Under 1m				✓		
HERBS & SEDGES	**Dominant species:**						
			✓				
GRASSES	**Dominant species:**	*Triodia* sp.					
	Hummock				✓		
	Tussock		✓				
	Bunch	✓					

14. Site map/photos (Quoll Knoll Habitat Survey Continued…)

Trapping Site: Mesa 228 Habitat Survey

Site Name: Mesa 228 **Recorder/s:** Brent Johnson, Hannah Anderson

Date: 06/09/2014 **GPS datum:**50;**Coordinates:** 731708E, 7552877N

1. Landform Element^

Morphological type

C	Crest	F	Flat
U	Upper slope	V	Open depression (vale)
M	Mid slope	D	Closed depression
L	Lower slope	H	Hillock
S	Simple slope	R	Ridge

2. Rock Outcrop

Type: Lateritic ironstone

Abundance

0	No bedrock exposed	0%
1	Very slightly rocky	<2%
2	Slightly rocky	2-10%
3	Rocky	10-20%
4	Very Rocky	20-50%
5	Rockland	>50%

3. Soil

Colour

R	Red	Y	Yellow	O	Orange
G	Grey	B	Brown	D	Dark

Type

1	Clay	5	Coarse sand
2	Fine silt	6	Fine gravel
3	Coarse silt	7	Coarse gravel
4	Fine sand	8	None; rock only

4. Ground Cover

% Cover leaf litter : <2%

% Cover bare ground: 30-70%

(including litter, rock cover and bare soil, excluding live vegetation)

5. Coarse Fragments on the Surface

Rock Abundance

0	No coarse fragments	0%
1	Very slightly; very few	<2%
2	Slightly; few	2-10%
3	No qualifier; common	10-20%
4	Moderately; many	20-50%
5	Very; abundant	50-90%
6	Extremely; very abundant	>90%

Rock Size

3	Gravelly	>60mm
4	Cobbly; or cobbles	60-200mm
5	Stony; stones	200-600mm
6	Bouldery; or boulders	600mm-2m
7	Large boulders	>2m

6. Land Surface

Disturbance of site

0 No effective disturbance

1 No effective disturbance except grazing by hoofed animals

2 Limited clearing

3 Extensive clearing

4 Highly disturbed, e.g. mining, urban

7. Evidence of Recent Fire

Frequency		Intensity	
0	Long unburnt	0	No damage
1	Several yrs since burn	1	Minor
2	Burnt before last rainfall	2	Some defoliated
3	Burnt after last rainfall	3	Most defoliated
		4	Unknown

Distance to nearest unburnt patch (>5ha)

1	<100m	2	100-500m
3	500m-1km	4	>1km

8. Nearby Water Bodies

1	Permanent	R	River
2	Seasonal	S	Soak/spring
3	Ephemeral	C	Creek
		P	Pool
		B	Bore/windmill/dam

Distance (m): 1500m

9. Evidence of Feral/Introduced Species (please list)

- Feral cat
- Feral dog

10. Site Photos (please attach)

See page 19

11. Vegetative growth Stage

1 Early regeneration

2 Advanced regeneration

3 Mature vegetation

4 Senescent phase

12. Native Fig (Ficus) Present

0 Absent

1 1-10 plants

2 >10 plants

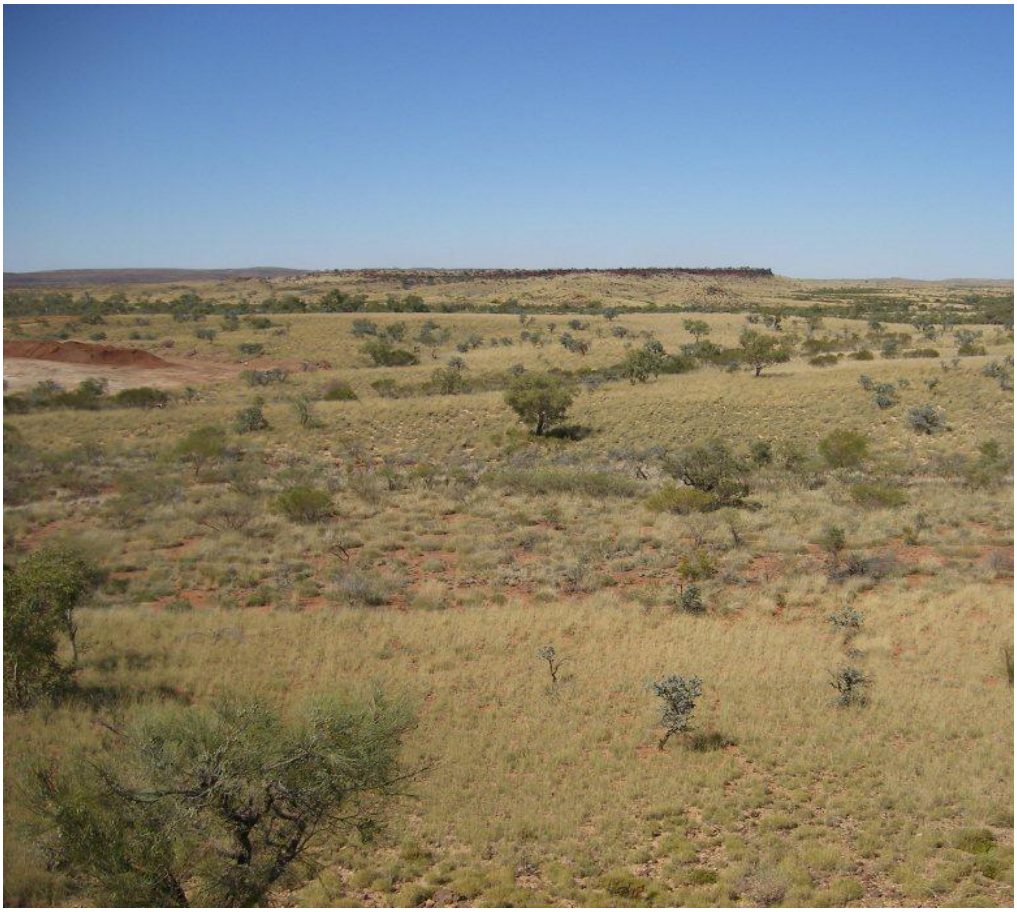
Note: ^ the chosen question is either circled in red and underlined or both.

See next page for continued habitat survey for site Mesa 228.

13. Vegetation (Mesa 228 Habitat Survey Continued…)

Please tick 1 box in each row, and record dominant species where known		**Absent**	**Isolated <2%**	**Very sparse 2-10%**	**Sparse 10-30%**	**Mid-dense 30-70%**	**Dense 70-100%**
TREES	**Dominant species:**	*Eucalyptus* sp.					
	>30m	✓					
	10-30m	✓					
	<10m			✓			
MALLEES	**Dominant species:**	none					
	Over 8m	✓					
	Under 8m	✓					
SHRUBS	**Dominant species:**	*Acacia* sp.; *Eremophila* sp.					
	Over 2m	✓					
	1-2m	✓					
	Under 1m				✓		
HERBS & SEDGES	**Dominant species:**	*Solanum* sp.					
			✓				
GRASSES	**Dominant species:**	*Triodia* sp.					
	Hummock					✓	
	Tussock			✓			
	Bunch		✓				

14. Site map/photos (Mesa 228 Habitat Survey Continued…)



Appendix 3 Additional Raw Data for All Field Sites

Date	Camera #	Site	Date Camera Retrieved	Data Reviewed	Other fauna present	Comments
13/08/2014	YP052, YP056	Hill side track	18/08/2014	18/08/2014	none	no photos
13/08/2014	YP058	Hill side track creek	18/08/2014	18/08/2014	none	no photos
13/08/2014	YP069, YP091, YP090, YP076, YP093	Hill side track big bluff	18/08/2014	18/08/2014	bird, kangaroo, feral cat, rodent	
13/08/2014	YP079	Hill side track north	18/08/2014	18/08/2014	kangaroo	
14/08/2014	YP073, YP081,	Quoll knoll north	19/08/2014	19/08/2014	rodent	
14/08/2014	YP074, YP082	Quoll knoll south	19/08/2014	19/08/2014		fresh scat found on 19/08
14/08/2014	YP112, YP075, YP080, YP094,YP084,YP106, YP092,	Mesa 228	19/08/2014	19/08/2014	rodent, echidna	
15/08/2014	YP083	Mesa 265-1	19/08/2014	19/08/2014		no photos
15/08/2014	YP118	Mesa 265-2	19/08/2014	19/08/2014		no photos
15/08/2014	YP089	Mesa 268-1	21/08/2014	21/08/2014	rodent	
15/08/2014	YP055, YP119,YP085,YP086, YP053, YP051,	Mesa 268-2	21/08/2014	21/08/2014	kangaroo, will wagtail	
15/08/2014	YP068,YP072,YP054,	Mesa 268-3	21/08/2014	21/08/2014	feral cat	
15/08/2014	YP062,YP065,YP057,YP 067	Turkey nest mesa	21/08/2014	21/08/2014	rodent	
15/08/2014	YP070, YP078,YP077,YP063,	Mesa 276	21/08/2014	21/08/2014	feral cat, kangaroo	
16/08/2014	YP066, YP071, YP088, YP059	Marble bar road mesa	21/08/2014	21/08/2014	rodent	
16/08/2014	YP064, YP061, YP087	BHP 1	20/08/2014	20/08/2014		no photos
16/08/2014	YP120, YP060	BHP 2	20/08/2014	20/08/2014	rodent	
16/08/2014	YP111, YP114	BHP 3	20/08/2014	20/08/2014		no photos
17/08/2014	YP116, YP110,	Cockeraga creek	20/08/2014	20/08/2014	feral cat	scats found 20/08
17/08/2014	YP107, YP108, YP100, YP117,YP097	Bea Bea creek	20/08/2014	20/08/2014	rodent	
17/08/2014	YP104	Bea Bea falls	20/08/2014	20/08/2014		no photos
17/08/2014	YP095, YP115	Granites	20/08/2014	20/08/2014	rodent	
03/09/2014	YP056'B, YP105'B'	CH217	06/09/2014	06/09/2014	echidna	
03/09/2014	YP102'B', YP098'B', YP103'B'	Quartz ridge	06/09/2014	06/09/2014		no photos
03/09/2014	YP099'B'	Quoll knoll east	06/09/2014	06/09/2014		no photos
04/09/2014	YP111'B', YP115'B', YP113'B', YP093'B'	Mulga downs	10/09/2014	10/09/2014		no photos
08/09/2014	YP104'B', YP061'B', YP095'B'	Wall creek	10/09/2014	10/09/2014	feral cat	
09/09/2014	YP090'B', YP099'C', YP103'C', YP098'B', YP105'C', YP120'B', YP092'B', YP096'B', YP056'C', YP102'C'	Coonarrie creek	11/09/2014	15/09/2014		no photos

Appendix 4 Northern Quoll Remote Camera Photos

Site: Hill side track north

Site: Quoll knoll north

Site: Cockeraga creek

Site: Cockeraga creek

Site: Quoll knoll south

Site: Quoll knoll south