Department of Sustainability and Environment

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Michael Johnston, Frank Gigliotti, Michael O'Donoghue, Mark Holdsworth, Sue Robinson, Ash Herrod and Kylie Eklom.

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Front cover photo: Feral cat with mouse photographed at an audio lure monitor site by an automated camera.

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Procedures and equipment used in the pen trials are described and approved by DSE Animal Ethics Committee protocol no. 07/22.

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Summary

Poison baits, known as Curiosity®, that contained the toxicant paraminopropiophenone (PAPP) were distributed from the air over a 150 km^2 area of the Pantapinna Plain, Flinders Ranges National Park (South Australia). Twenty feral cats (*Felis catus*) had previously been trapped, fitted with radio-telemetry collars and released within the field site. Two of these cats died following consumption of Curiosity® bait(s) while one other had died prior to bait application. A further two cats were later confirmed to have consumed some or all of a bait but survived.

Replicated spotlight surveys conducted prior to and following bait application indicated that the overall feral cat population had decreased by 50%. Analysis of data collected with automated cameras indicated that there had been a 16% decrease in occupancy during the post-baiting survey. The actual decrease in the feral cat population is expected to fall within the range indicated by these indices.

An irruption in populations of plague locust (*Chortoicetes terminifera*) and then house mice (*Mus musculus*) in the months preceding this study is thought to have to led to an increase in and then subsequently sustained the feral cat population. Analysis of dietary items identified in the stomachs and scats of feral cats indicated that house mice were the dietary staple. Feral cats prefer live prey with optimal consumption of baits occurring during periods of food stress. The abundance of live prey at this study site may have contributed to the apparent low levels of bait uptake by feral cats.

Populations of non-target bird species were assessed prior to and following baiting using counts along a driven transect as well as five minute point counts. Decreases were observed in counts of species such as the wedge-tailed eagle (*Aquila audax*) however it is considered that as these birds are highly mobile in the landscape with their presence on the site linked to food availability.

Laboratory assessments of the bait and toxicant conducted following the field trial indicated that the baits used were 'fit for purpose', i.e. accurate dosing of PAPP per bait, baits palatable etc. Similarly, pen trials conducted with captive feral cats demonstrated that baits used in the field trial were efficacious.

Land managers intending to undertake management of feral cat populations using baiting should be aware of the abundance of prey populations prior to applying baits. Optimal efficacy will be achieved using an attractive and palatable bait that is distributed during a period when alternative food sources are minimised.

1 Background

1.1 Introduction

Feral cats (*Felis catus*) are classified as those cats that live and reproduce in the wild and survive by hunting or scavenging (DEWHA 2008). Populations of feral cats are distributed across all Australian states, territories and many offshore islands (Abbott and Burbidge 1995; Dickman 1996). Predation by feral cats is nominated as a cause of decline for over eighty Australian listed wildlife species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Cats are known to predate a wide range of small to medium wildlife species; invertebrates, birds, reptiles and mammals, with body mass 10 g – 3.5 kg, but may also compete for resources such as food and den sites with native species (Dickman 1996).

The Australian Government has funded the development of a poison bait for use in managing feral cat populations in a collaborative research program between the Western Australian and Victorian State Governments. The project seeks to obtain registration for the 'Curiosity®' bait as an agricultural chemical that will provide managers of conservation estate with a bait product that can be aerially delivered and assist in the management of feral cat populations. A key difference between the 'Curiosity®' bait product and conventional baits is that the toxicant compound is housed within an encapsulated pellet that minimises the potential for exposure of many native species that may also consume the bait. This approach reduces the exposure of non-target native species by exploiting different feeding behaviours exhibited by feral cats compared to native species (Marks et al. 2006; Hetherington et al. 2007). The Curiosity® bait is based on the Eradicat® bait but has been modified such that the pH of the meat is slightly alkaline (approximately pH 7.5). This modification assists in retaining the robust character of the encapsulated pellet for a period of more than ten days.

Field efficacy trials of the Curiosity® bait are a necessary component of product evaluation undertaken for registration of agricultural chemicals. A demonstration of product efficacy is required at sites representative of where the product may be used following registration. Previous trials using the toxicant have been undertaken on French Island, Victoria (Johnston et al. 2011); Christmas Island, Indian Ocean Territory (Johnston et al. 2010a), Dirk Hartog Island, Western Australia (Johnston et al. 2010b), Tasman Island, Tasmania (Norbury and Saunders 2011); Cape Arid, Western Australia (Algar et al., pers. comm.) and Wilsons Promontory, Victoria (Johnston 2012). These field studies were initially undertaken at island sites that were relatively 'uncomplicated' in terms of the hazard that the bait presented to, and minimal competition for baits existed from, resident non-target species. Subsequent studies were undertaken at mainland sites that are intended to be representative of sites in terms of climatic zone (i.e. temperate, arid, tropical) and resident wildlife species where the Curiosity® bait, may be used. Sites were initially nominated by respective state government conservation agencies with the field trials being undertaken as necessary resources became available.

The toxicant used in these studies was para-aminopropiophenone (PAPP). This compound oxidises haemoglobin to methaemoglobin which is unable to transport oxygen (Scawin et al. 1984; Savarie et al. 1983). Toxicosis in feral cats is characterised by increasing lethargy leading to unconsciousness and death (Johnston, unpublished data).

1.2 Site description

This study was undertaken on the Pantapinna Plain, near Oraparinna (31.36°S, 138.718°E) in the Flinders Ranges National Park, South Australia (Figure 1). The site is considered semi-arid receiving an average annual rainfall of 321 mm (range: 126 - 591 mm) (Bureau of Meteorology) since 1985. Higher than average rainfall (563 mm) was recorded for January - December 2010 at the Oraparinna gauge.

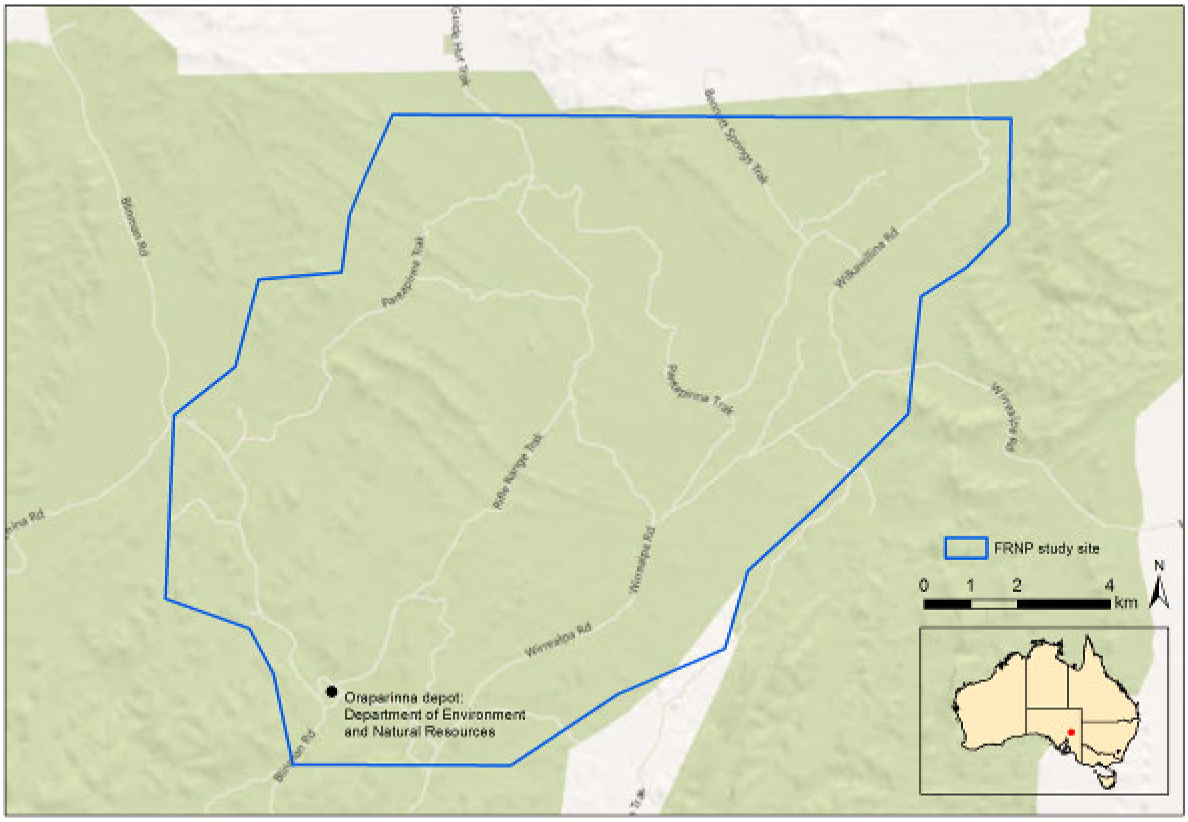

Figure 1. Location of study site within the Flinders Ranges National Park.

Vegetation in the site has been classified into a number of key groupings; tussock grasslands, arid and semi-arid low acacia woodlands and shrublands with chenopods, mallee heath and shrublands, casuarina and allocasuarina woodlands (DENR 2011). The latter is dominated by stands of northern cypress-pine (*Callitris glaucophyla*) while drainage lines have mature stands of river red gum (*Eucalyptus camaldulensis*). Numerous exotic grass and shrub species have become widely established following historical grazing enterprises across the site (Morelli 1996).

This area forms part of the *Bounceback* project managed by the South Australia Department of Environment and Natural Resources (DENR) and has been subjected to extensive pest plant and animal control programs since 1992 (DEH 2006). Broadscale baiting for red foxes (*Vulpes vulpes*) began in 1994 while intensive control for European rabbits (*Oryctolagus cuniculus*) was initiated in 1999. Similarly, feral goats (*Capra hircus*) have been reduced to very low levels over broadscale areas relative to measured populations at similar 'no control' sites (DEH 2006). Feral cats have been opportunistically shot by DENR staff, contractors and organised groups of volunteers throughout the study area as part of the *Bounceback* project over this time. However, this practice was temporarily halted within the study area during March-August 2011 to assist with conduct of the present study.

An irruption of house mouse (*Mus musculus*) and plague locust (*Chortoicetes terminifera*) populations had been recorded throughout the site in March-May 2011 and October-November 2010 respectively (M. Trebilcock pers. comm.).

1.3 Objectives

The overriding aim of the project was to collect data that will contribute to the registration of Curiosity® bait as an agricultural chemical. This was undertaken by addressing three key deliverables that were specifically aimed at assessing the efficacy of the Curiosity® bait at a semi-arid mainland site.

1. Trap 10-20 feral cats in the trial area and monitor their survival using VHF and/or GPS collars after baiting.
2. Aerially deploy Curiosity® baits at a rate of 50 baits /km^2.
3. Undertake monitoring of the resident feral cat population pre- and post-baiting to determine abundance and survival using at least two indices.

2 Methods

2.1 Project timing

Field trips to the site were made in three blocks. The initial visit took place March 20-27, 2011 ('Pilot study') and was undertaken to determine whether sufficient feral cats were present at the site. The conduct of the main body of work was undertaken July 27 – August 10, 2011 ('Field study'). A final visit, October 30 – November 7, 2011, was made to recover GPS datalogger collars following their pre-determined drop-off from cats that survived the baiting program ('GPS collar recovery').

2.2 Pilot study

A pilot study was undertaken in order to assess whether there were sufficient feral cats present in the site in order to make the conduct of the larger study worthwhile. The decision to proceed was made largely on observational data collected using spotlight surveys and to a lesser extent use of remote cameras. Discussion with local DENR rangers and a contract shooter was also undertaken. No attempt was made to identify individual cats in the pilot study.

The spotlight survey was undertaken over a variable route covering an average of 44.5 kms (±5 kms, total 178 kms) in length throughout the site on four sequential nights. A 100 W halogen spotlight (Lightforce 240, Australia) was utilised and the locations where cats were observed were recorded using a GPS device.

Automated cameras (11 x Scoutguard 550V (HCO, China) and 15 x Reconyx HC600, Wisconsin, USA) were also installed throughout the site as an additional detection technique. All cameras were located on the side of tracks at 1 km intervals and operated for 4 nights. A scent lure comprising tuna oil smeared on an absorbent cloth was provided at each site. Cameras were aimed to photograph animals investigating the lure and / or travelling along the track.

2.3 Field study

Multiple techniques were used to monitor the population abundance of feral cats at the site prior to and following application of Curiosity® baits. Repeated spotlight surveys were undertaken given that the vegetation across the site was generally low and open, i.e. suitable for spotlighting (see 2.3.1). The use of automated cameras that incorporated an audio lure facilitated collection of presence data on feral cats (see 2.3.3).

2.3.1 Spotlight surveys

A 52 km survey transect (Figure 2) within the study area was driven on six nights prior to and following baiting with a count made of the number of cats and rabbits seen, i.e. a total of 312 km during each monitoring period. An experienced observer (Michael Johnston) stood in the rear of a 4WD utility tray that was driven at a speed of 20-25 kmh^{-1} and was equipped with a 35 w High Intensity Discharge (HID) spotlight (Lightforce 240, modified by All Point Services Pty Ltd, Victoria) connected directly to the vehicle battery, a GPS and electronic compass (Garmin GPS62s, Olathe, USA) and a digital laser rangefinder (Leupold RX-II, Beaverton, USA). The same observer undertook each survey to ensure that consistent spotlight searching was achieved and used a portable UHF radio to communicate with the driver / navigator inside the car. When a cat was sighted, the observer requested the driver to stop the car to allow the bearing and range of where the animal was first seen to be determined. These details were reported to the navigator who recorded this information using the

'Man Overboard' feature in Oziexplorer software (D and L Software Pty Ltd, Australia). The number of rabbits observed along the transect were also counted but not geographically located.

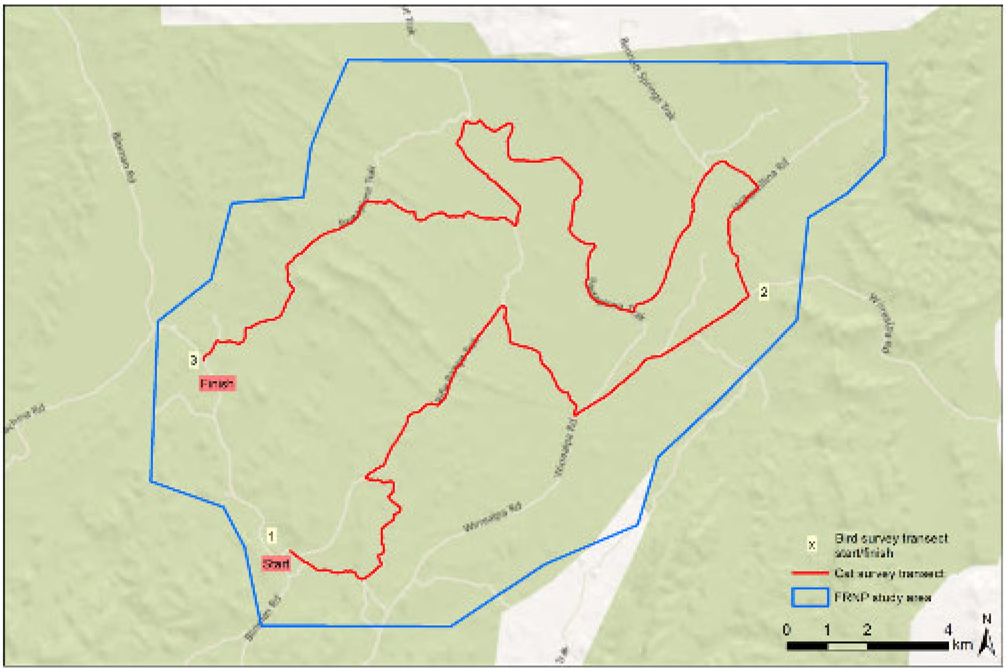

Figure 2. Route used for 52 km spotlight and bird surveys.

A separate 30.3 km survey transect was driven on three sequential nights to collect data on the number of rabbits that would allow comparison with historical rabbit abundance surveys undertaken by the *Bounceback* project staff (Figure 3). A different observer (Tim Gentles) undertook the spotlight search using the same equipment as described above.

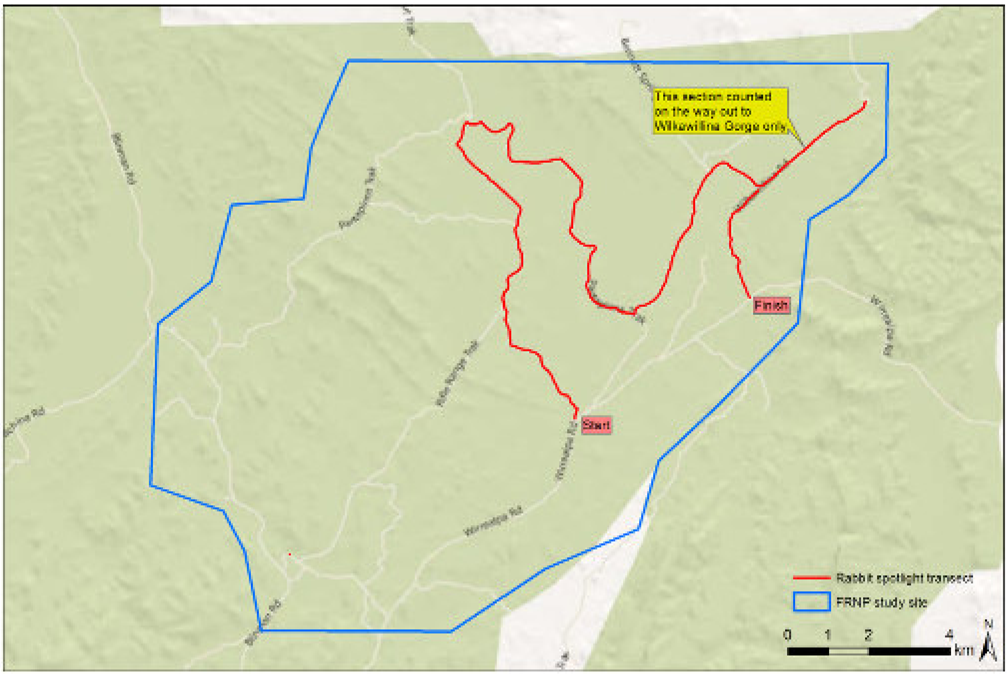

Figure 3. Route used for 30 km spotlight count for rabbits.

2.3.2 Radio-collared animals

Feral cats were trapped using rubber-padded leghold traps (Duke #1.5, West Point, USA). These traps were modified prior to use with stronger base plates, additional swivels and were waxed and dyed by Outfoxed Pest Control (Victoria). These traps were set in pairs in 'walk-through' sets spaced at 500 m intervals throughout the study site. Cat faeces and urine, sourced from domestic animals, was used as the lure at all trap sets.

Trapped feral cats were restrained with a catch pole and covered with a blanket. The cats were released from the trap(s), transferred into a hessian sack and labelled with site identifier. Once all traps had been cleared, the cats were then transported to the Oraparinna depot for processing. A dose of sedative (Dormitor, Pfizer; or Zoletil 100, Virbac) was administered into the cat's thigh according to label prescriptions. The eyes of cats sedated with Dormitor were kept covered during collaring procedures. The sex and body mass of animals was determined and recorded.

Twenty radio transmitting collars were available for use in this study, comprising;

- 7 GPS datalogger / VHF 173 MHz collars manufactured by Sirtrack Ltd, (Havelock North, NZ). These collars weighed 140 g and were configured to record a GPS location every 3 hours with an automated collar drop-off timed for 0100 hrs on November 1, 2011.
- 3 VHF only collars transmitting at 173 MHz (Sirtrack Ltd). These collars weighed 40 g.
- 10 VHF only collars transmitting at 151 MHz (Titley Electronics, Ballina, Australia). These collars weighed 30 g.
- 3 additional collars were fabricated on site using a length of flexible reflective polymer material and sewn together with cotton. These collars did not have a VHF transmitter but were intended to enable identification during spotlighting and/or camera surveys.

Reflective tape was fixed to all transmitter collars but did not aid identification during spotlighting surveys due to poor adhesion to the collar.

All Sirtrack Ltd. manufactured collars included a mortality sensor that doubled the transmission rate if the cat did not move over a period of ten hours.

The fur of each animal was also clipped with an identifying mark on each side of the body using electronic animal clippers and / or blunt-ended scissors.

When procedures were completed, cats that were sedated with Domitor were recovered using Anti-Sedan (Pfizer) at label recommended rates. The cat that was sedated with Zoletil was allowed to recover naturally. Animals were released at the capture location when recovery was complete.

2.3.3 Site occupancy using automated cameras

Automated cameras (Reconyx Inc., Wisconsin, USA) were installed at 48 locations throughout the study area to assess presence of feral cats within the study area prior to and following baiting (Figure 4). Camera locations were determined using a semi-randomised process in which each 1 km^2 grid cell was numbered (1-99). A camera was allocated to every second cell. A series of random three digit X and Y axis numbers, generated from the program 'R', were fitted against each cell to form a complete geographic UTM reference. An audio lure (Feline Audio Phonic, Westcare Industries, Nedlands, Australia) was placed at each site and operated for a period of five nights during each monitoring session. Cameras remained operational throughout the entire 'Field study' period. All cameras were configured to record three photos at every motion detection with no pause between detections.

Four additional cameras were placed at 'on-track' locations at sites where they were readily serviced. These were used to collect data on the species responsible for removing baits (Figure 4). A Curiosity®

bait was placed in view of these cameras on July 20 and replaced if taken. Cats photographed by these cameras were not included in the site occupancy analysis.

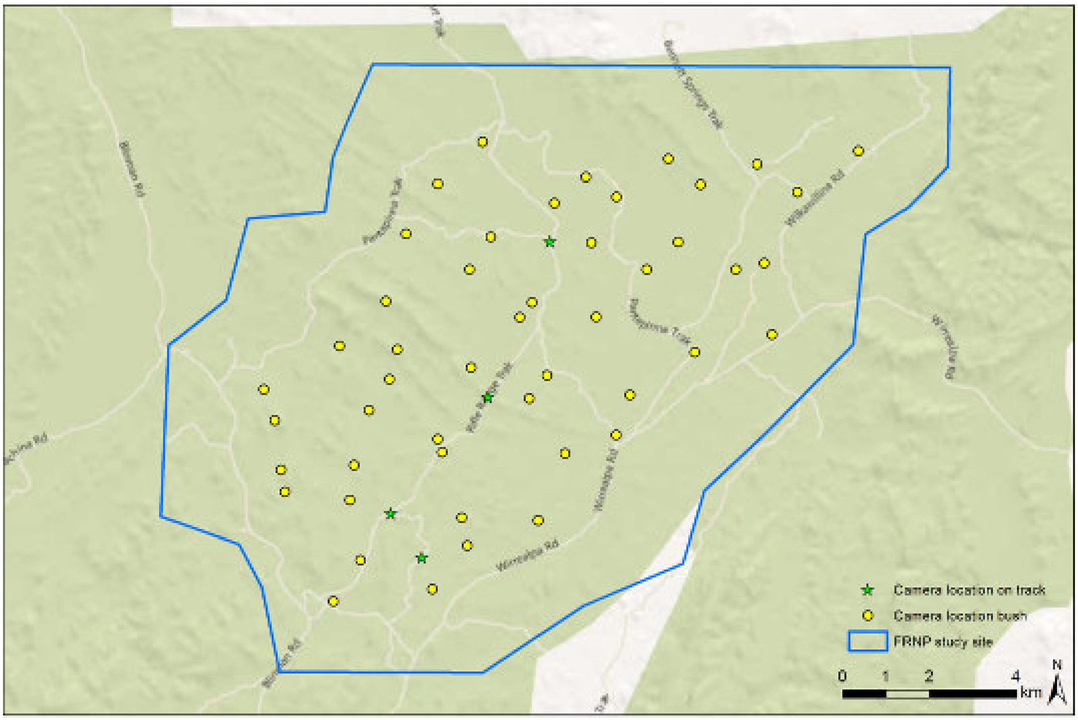

Figure 4. Location of 48 randomly located automated cameras and 4 on-track cameras.

The camera was mounted on a stake facing south and the surrounding vegetation at each site trimmed to minimise photographs of only moving vegetation. Cameras used were either Reconyx semi-covert LED HC500 (12 units) or Reconyx covert HC600 (36 units).

At the time of installation, all cameras were test-fired to confirm functionality and correctness of aim. A series of set-up photos were taken in which a white board was held in front of the camera such that the location details and date were recorded.

All photographs were reviewed with the species that been photographed identified (Figure 5). The presence and / or absence of a species at each site on a daily basis was entered into a Microsoft Excel worksheet (i.e. 1= present, 0 = not present, NA= camera not active). This analysis did not account for multiple individuals recorded at the same site on the same day (Figure 6).

Figure 5. Examples of images from automated camera with audio lure at site 9

Each species was modelled using a dynamic occupancy model to estimate the occupancy and detection rates as well as colonisation and local extinction rates (MacKenzie et al. 2002; MacKenzie et al. 2006). The activation of the audio lures was considered as a factor affecting detection rates. Thus any change in occupancy after the Curiosity® baits were available is modelled with 'colonisation' and local 'extinction'. Colonisation refers to previously unoccupied sites becoming occupied, while local extinction refers to previously occupied sites becoming unoccupied. The software package "unmarked" (Fiske and Chandler 2011) in 'R' (R Development Core Team 2011) was used to conduct the analysis. The "goodness-of-fit" for each model was checked using a parametric bootstrap to compare the observed and fitted data. The statistical analysis did not include data from the four cameras located at 'on-track' locations given that different lures were used at these sites.

Figure 6. The 'Occupancy' analysis did not differentiate between single or multiple cat observations.

2.3.4 Non-target fauna surveys

Surveys of bird species observed on site were undertaken to collect data on the impact of the baiting on non-target fauna. These surveys were undertaken using several different methods.

- Count of individual birds from carnivorous species that may consume Curiosity® baits (i.e. raptors, corvids) seen as a vehicle was driven at 20-25 kmh^{-1} along the 52 km transect on six days prior to and following baiting. The start / finish location and direction of travel was cycled between three sites to allow for variations in bird behaviour that occur throughout the day (Figure 2). A Student's T-test was used to analyse this data.
- A skilled observer identified all birds visually or by vocalisation during a five minute point count survey. These surveys took place at 5 km intervals along the driven transect with the vehicle switched off and observer outside the vehicle. A repeated measures ANOVA analysis was conducted for each carnivorous species as well as the summed counts for this guild of birds.
- A species list was generated for all bird species observed during the study.

Incidental observations of other potentially bait consuming species such as reptiles, birds and mammals were also recorded and contributed to assessment of impact on non-target species (Figure 7).

Figure 7. Incidental observations of non-target wildlife species, a) Central bearded dragon (*Pogona vitticeps*) photographed 2 November, b) Australian raven (*Corvus coronoides*) removing bait from camera 'BAIT1'.

2.3.5 Baiting

All baits were produced by Scientec Research in the period between January and April 2010[1]. Baits were manufactured using a recipe modified from that used to make Eradicat® baits. Baits are composed of 70% minced kangaroo meat, 20% chicken fat, and 10% digest and flavour enhancers (Patent No. 781829). The pH of mince meat used in the Curiosity baits is buffered to 7.5 using calcium carbonate to reduce premature degradation of the Hard Shell Delivery Vehicle (HSDV) containing the toxicant. One encapsulated HSDV containing a formulation of ~80 mg para-aminopropiophenone (PAPP) was manually inserted into each bait. Baits were cryovaced into bags of 200 and stored frozen prior to use in this study.

Baits were transported to the field site (June 27 – 28, 2011) in a domestic chest freezer and stored frozen until July 18. All baits were then removed from the freezer and allowed to thaw overnight on a series of racks arranged in an insect proof shed at the Oraparinna depot. Bait racks were placed in the sun on July 19 and then placed in a covered trailer for 1-2 minutes where a gas jet heater was used to direct heat onto the baits (Figure 8). This completed the thawing process and 'sweated' the baits leading to the leaching of aromatic chicken fats from out of the sausage skin.

Figure 8. Thawing and sweating of Curiosity® baits.

Baits were loaded into the rear of a Bell JetRanger III helicopter. This aircraft was fitted with stainless steel bait box and drop chute which directed baits out the door to exit sufficiently below the aircraft to avoid contact with the tail rotor (Figure 9). Baits were applied across the 150 km^2 site at a rate of 50 per square km. Flight lines were loaded into the on-board GPS device (Garmin 296). A large face digital clock that was configured to countdown four seconds repetitively was fixed in view of the bombardier. The bombardier sat in the rear of the helicopter and manually dropped two baits down the chute every four seconds. This aircraft did not have an automated bait logging equipment fitted which meant that the bombardier called 'drop' on release of baits over the intercom. The navigator then recorded this location on a Panasonic Toughbook CF-19 computer using the 'Man Overboard' feature on the OziExplorer moving map software. The pilot maintained verbal communications with the bombardier to advise of entry into no-bait areas or the start and end of transects.

[1] Baits used were sourced from Scientec batch numbers 5325, 5327, 5328, 5330, 5309, 5335, 5336, 5340, 5346, 5351, 5352, 5355 and 5358.

Figure 9. Bait box with drop chute and Curiosity® baits prior to application.

A practice baiting exercise was conducted on July 18 over the Oraparinna airstrip to confirm that the procedures and data recording systems were functioning correctly and additionally to determine the pattern of bait spread on ground. Non-toxic baits made with red coloured skins (to improve visibility) were used for this exercise. Pairs of baits were labelled alphabetically using flagging tape and held together with a tooth pick during transport. The bombardier separated the baits, dropped them and simultaneously called 'drop' over the intercom. Two passes of the airstrip were made with the aircraft at 50 m and 100 m altitude with the helicopter flying at an airspeed of 40 knots. The runway was then searched and the location of each bait recorded using a GPS and the distance between pairs of baits recorded with a tape measure. Data was analysed in ArcView 3.3 (ESRI, Redlands, USA).

Toxic baits were applied on July 19 with the helicopter operating at approximately 40 knots and at a height of 100 m above ground height (Figure 10). Flight lines including no-bait areas were generated in OziExplorer software and had been pre-loaded into the aircraft navigation system. The application of toxic baits was undertaken between 1000 – 1530 hrs.

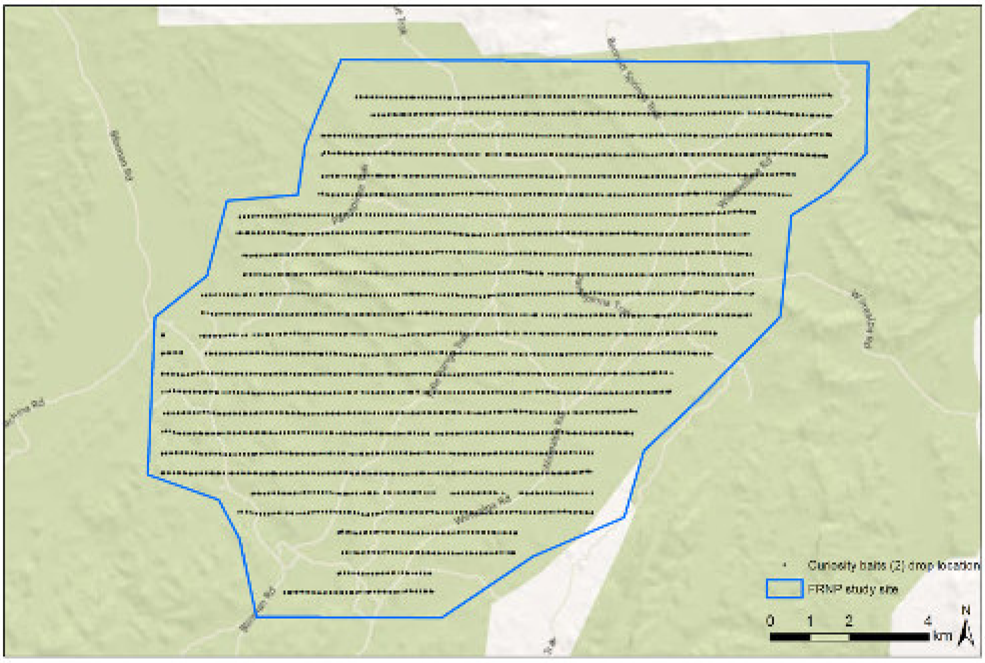

Figure 10. Location of baits dropped from helicopter on July 19. Each point represents the location of two dropped baits.

Fifty randomly selected baits that had not been aerially deployed were used to test the attractiveness of baits and robustness of the HSDV following field application. These were placed in a large wire mesh cage on July 21 (Figure 11). The cage was placed inside a fenced exclosure where it was protected from access by animals other than invertebrates but remained subject to weather. Five baits were withdrawn daily and sectioned to inspect the HSDV with observations made of the hardness of the polymer and whether any leakage of toxicant had occurred.

Figure 11. Cage used to house 'bait stability' samples and assessment of samples

2.3.6 Post-baiting monitoring

Monitoring of collared animals was initiated on July 20 and continued for nine days using radio telemetry techniques. Collars that were transmitting 'mortality mode' were recovered. The sites were photographed and a GPS location generated. Carcasses were removed from the site and were weighed prior to conducting a post mortem. The colour of soft tissues in the mouth (tongue and gums) were noted as pale tissues are indicative of hypoxia caused by PAPP intoxication. The stomach contents were also removed, inspected and photographed with observations made as to the amount and type of material in the stomach.

The direction (i.e. bearing) of radio-collared cats that were still alive was recorded using radio-telemetry techniques and a magnetic compass (Silva) from at least two locations daily between July 20 – 29.

2.3.7 Supplementary baiting

Additional toxic baits were placed around any radio-collared cat still alive a week after aerial baiting. This was done on one occasion between July 25 – 28, 2011. The location of the cat was determined using radio-telemetry techniques and the 'probable den' site estimated and approached to approximately 50 m distance. Ten baits were then placed in GPS recorded positions to encircle the den site at that ~50 m radius. Care was taken to avoid disturbing the cat.

2.3.8 Scat collections

Scats were photographed *in situ* and collected in plastic ziplock bags labelled with a site identifier. These were stored frozen on-site and then forwarded to B. Triggs (Genoa, Victoria) for identification of species of origin and dietary items contained within the scat(s). Techniques used for this analysis are described in Brunner and Triggs (2002). No attempt was made to determine the age of scats. Similar

techniques were used for identification of items found in stomach contents removed from cats that had been recovered from the field.

2.3.9 Recovery of surviving cats

Attempts were made to kill and recover feral cats fitted with VHF-only collars at the conclusion of the post-baiting monitoring period in August. These cats were located using radio-telemetry techniques and were either shot or fumigated if found to be in a den site suitable for this procedure. Fumigation of the warren was undertaken using the procedure described in Sharp and Saunders (2004). Cats found to be using den sites unsuitable for fumigation such as boulder piles and caves were actively hunted at night using radio-telemetry and spotlight techniques. The cats were located, approached and shot using a .222 centrefire rifle (Sako, Finland). Cats fitted with functional GPS datalogger collars were not hunted. The collars from these cats were preset to automatically drop off the cat on November 1, 2011 and were recovered after this date.

Cats that were killed were labelled, bagged and stored frozen until a dissection was undertaken several weeks later when the carcasses were thawed, weighed and stomach contents removed. Facial whiskers were plucked from each side of the face and examined for presence of Rhodamine B dye marking using techniques described in Fisher (1998) and Fisher et al. (1999). The Curiosity® toxicant pellet contains 1% Rhodamine B and conducting this analysis permits identification of cats that were exposed to baits but survived. Reference samples were also assessed from owned pet cats that had consumed known doses of dye. The stomach contents of the feral cats were collected with all items identified.

2.3.10 Weather

A weather station (Measurement Engineering Australia) is located within the field site on the Pantapinna Plain and collects basic data such as maximum, minimum and average temperature as well as rainfall (mm). The Bureau of Meteorology maintains a rainfall recording station at Oraparinna (#19107) and publishes data on the internet (www.bom.gov.au).

The weather was generally cool with clear skies during the period when baits were available (Table 1). No rain was recorded during the period July 19 – 26 with 0.2 ml recorded on July 27. No further rain fell until August 6. Typically the nights were cold with frosts experienced on the mornings of the July 19, 21, 22, 27.

2.3.11 Pen trials

Eleven feral cats were sourced from Victorian contract trappers and were used in pen trials to assess efficacy of the baits. Cats were housed individually in a pen and provided with a Curiosity® bait that had not been used in the field study, i.e. had been transported to the field site, thawed, sweated, loaded in the helicopter and was refrozen and stored frozen until use in these pen trials. A video monitoring system enabled review of the cat during the trial with the times of key events, such as bait consumption, collapse and death, being noted.

Table 1. Temperatures on the Pantapinna Plain when baits were available in July 2011.

Date	Minimum Temp. ºC	Daily Average Temp. ºC	Maximum Temp ºC
19 July	-1.3	6.1	14.4
20 July	-0.3	6	13
21 July	-0.6	5.4	13.9
22 July	-3.5	5.2	15.3
23 July	-0.8	6.7	16.3
24 July	2.6	9.7	17.6
25 July	3.4	9.4	17.8
26 July	0.4	9.4	16.1
27 July	-1.3	6.4	15.8
28 July	-1.4	7.5	16.8
29 July	0.4	8.8	18.3
30 July	10.4	15	22

2.3.12 Bait assay

Ten baits were assayed to determine the quantity and purity of the toxicant from the combined production runs from unused samples returned from this trial. These samples were randomly selected from those baits which were returned from the field, albeit they had been subjected to all conditions experienced by baits deployed in-the-field, i.e. transported frozen, thawed, sweated, and air-lifted for deployment. Following return to the depot, these unused baits were re-frozen and retained in frozen storage until returned for analysis.

Reverse Phase – High Pressure Liquid Chromatography analysis of HSDV samples was conducted according to Scientec Test Method # 801a (Laboratory Test Method for RP-HPLC analysis of para-aminopropiophenone [PAPP(.HCl)]). In summary, the method entails:

- a known mass of HSDV (drug-core) formulation being dissolved in a fixed volume of solvent;
- an aliquot being analysed; and
- the purity and 'active load' calculated using a standard Beer-Lambert curve.

The method for analysis of PAPP using RP-HPLC allows determination of (i) the material identity, (ii) batch compliance, and (iii) storage stability of the 'active'. This method is applicable to formulations containing both PAPP and PAPP.HCl. It should be noted that although applicable to analysis of both PAPP and PAPP.HCl, in the solvent(s) used for analysis, the free base and the HCl salt are both converted to the trifluoroacetate (*"TFA"* or *"CF_3COO^-"*) salt.

2.3.13 GPS collar recovery

The GPS datalogger collars were pre-programmed to automatically drop off the cats at 0100 hrs on November 1. Radio telemetry techniques were utilised to search for and recover the GPS collars within

the study site. A helicopter (Robinson R-44 Raven, Torrance, USA), fitted with two yagi antennae was used in addition to ground-based searches (Figure 12).

Figure 12. Helicopter fitted with antennae used to assist recovery of dropped GPS collars.

Cat carcasses were recovered from a contract shooter who was working within the study site. Stomachs and cheeks were removed from these animals and stored frozen until analysis of stomach contents and whiskers assessed for presence of Rhodamine B dye was undertaken. Predator scats were also collected when they were encountered from within the study area.

3 Results

3.1 Pilot study

Feral cats were observed at 25 locations throughout the site during spotlight surveys and at an additional four sites by automated camera (Figure 13). A cat with four kittens 'at foot' was observed on March 22. A fox was observed on three occasions during these surveys.

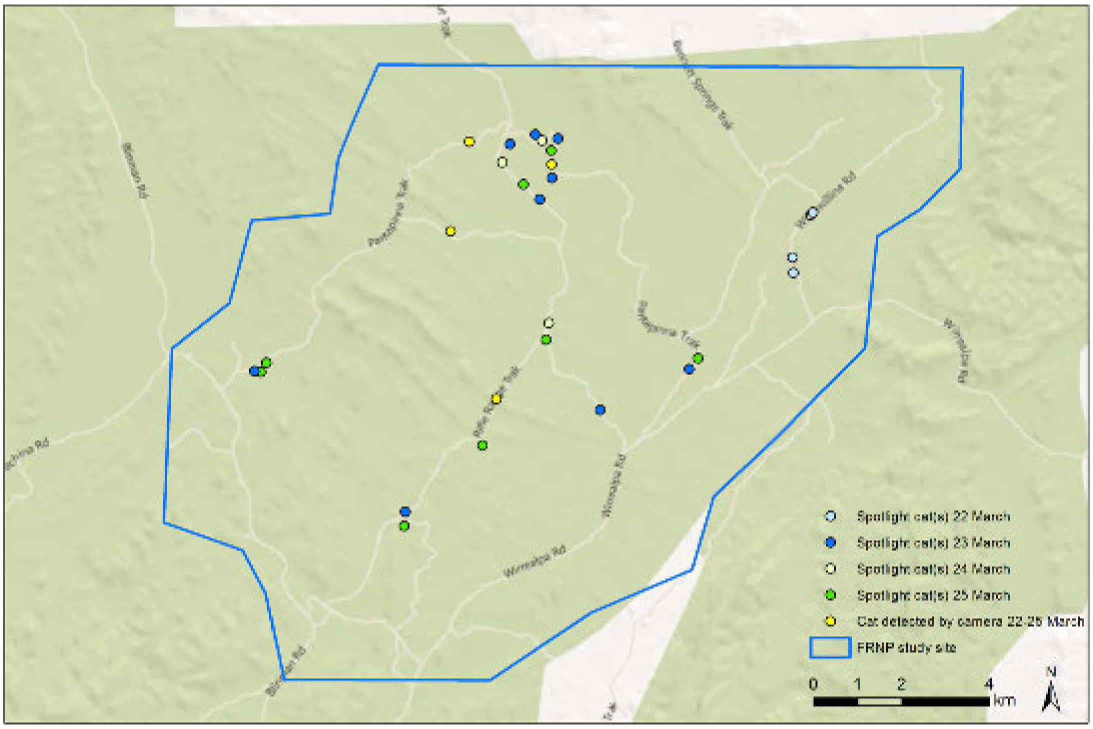

Figure 13. Locations where feral cats were observed during spotlight surveys and detected by automated camera during the pilot study.

Three individual hopping mice (*Notomys* spp.) were observed during spotlight surveys and one of these was photographed (Figure 14). The animal was not caught and as such a confirmed identification is not possible, however it is thought to be a dusky hopping mouse (*Notomys fuscus*). One individual was observed on March 24 (approximate location 31.314890ºS, 138.809656ºE) and two on March 25 (31.313055ºS 138.776124ºE photographed animal) and 31.289554ºS 138.745970ºE.

Figure 14. One of three hopping mice (*Notomys* spp.) observed during the pilot study.

3.2 Field study

3.2.1 Non-toxic baiting

Eighteen pairs of baits (of 26 dropped) were located on the airstrip after the practice baiting exercise comprising nine pairs at each flight height. Baits were an average of 20 m (range 8 – 39 m) and 57 m (range 48-73 m) from the release location when flying at 50 m and 100 m height above ground level respectively. These figures will include some error associated with the ~5 m accuracy of conventional GPS receivers and time required to undertake manual logging of bait drops. The average distance apart of the paired baits was 5.4 and 3.0 m for the 50 and 100 m flight heights respectively.

3.2.2 Trapping and fate of radio-collared feral cats

A total of 23 feral cats were trapped over 211 trap-set nights, i.e. the number of sets active per night as distinguished from the number of traps (Table 2, Figure 15). Twenty of these cats were fitted with collars that included a VHF transmitter.

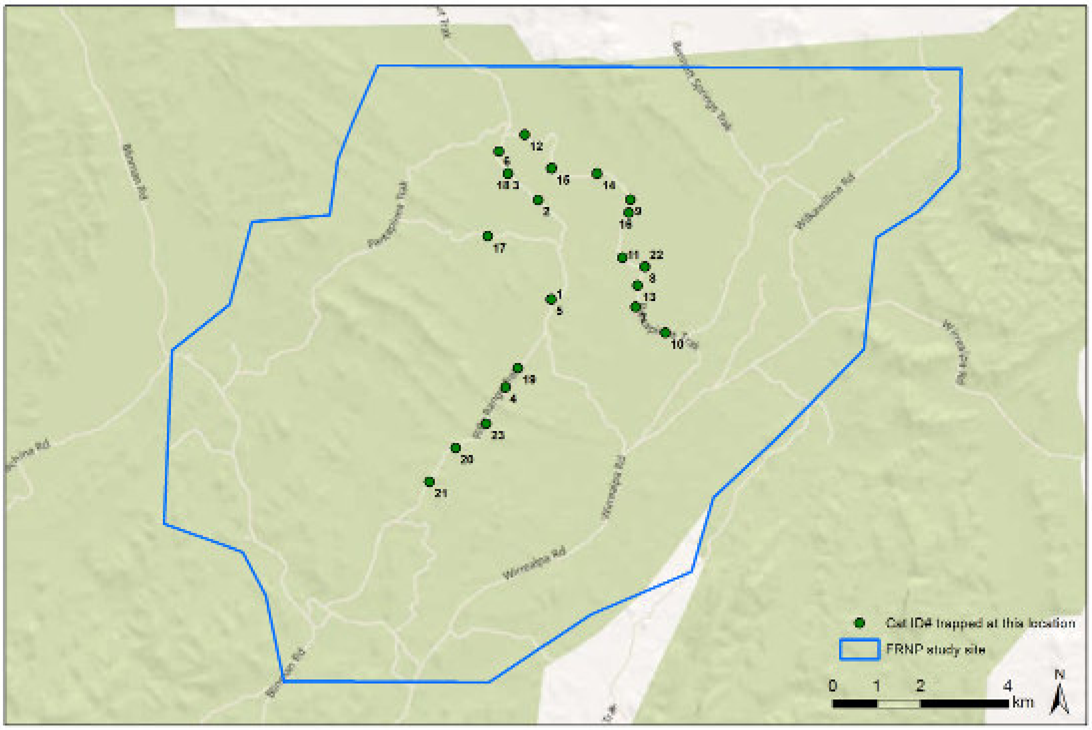

Figure 15. Locations where feral cats were trapped within the study site.

One VHF collared cat was found to have died prior to application of baits while another was not detected following release. It was not possible to determine status (alive/dead) of the three cats fitted with collars fabricated from reflective tape. Therefore, 18 collared cats were known to be alive when baits were applied on the July 19.

Table 2. Details of trapped and collared feral cats at Flinders Ranges National Park. Note that presence of Rhodamine B dye in whiskers is indicative of exposure to encapsulated toxicant.

Cat ID and transmitter frequency (MHz)	Date	Morphometrics	Type of collar fitted and (recovered)	Fate at end of project	Rhodamine B dye present / absent
1 – 5400	June 6	3.5kg ♀ tabby	VHF (Yes)	Fumigated	No
2 – 6590	June 6	3.0kg ♀ tabby	VHF (Yes)	Fumigated	No
3 – 3410	June 6	2.5kg ♀ tabby	VHF (Yes)	Shot	Yes
4 – 0080	June 7	4.5kg ♂ tabby	GPS (Yes)	Alive	Unknown
5 – 3980	June 7	3.0kg ♂ tabby	VHF (Yes)	Fumigated	No
6 – 7010	June 7	3.2kg ♀ tabby	VHF (Yes)	Fumigated	No
7 – 0470	June 8	3.8kg ♂ tabby	GPS (Yes)	Alive	Unknown
8 – 3780	June 8	3.5kg ♂ ginger	GPS (No)	Unknown	Unknown
9 – 4590	June 8	2.6kg ♀ tabby	VHF (Yes)	Shot	No
10 – 7403	June 8	3.6kg ♂ ginger	VHF (No)	Hunted & escaped	Unknown
11 – 8212	June 8	3.0kg ♂ tabby	VHF (Yes)	Poisoned by Curiosity bait	Yes
12 – 5013	June 8	1.6kg ♀ tabby	VHF (Yes)	Fumigated	No
13 – 1580	June 9	4.5kg ♂ tabby	GPS (Yes)	Alive	Unknown
14 – 3580	June 9	4.6kg ♂ tabby	GPS (Yes)	Alive	Unknown
15 – 0990	June 10	4.5kg ♂ ginger	GPS (Yes)	Shot	No
16 – 5990	June 10	4.1kg ♂ ginger	VHF (Yes)	Poisoned by Curiosity bait	Yes
17 – 5580	June 10	3.7kg ♂ tabby	VHF (No)	Hunted & escaped	Unknown
18 – 0890	June 10	3.7kg ♂ tabby	GPS (Yes)	Alive	Unknown
19 – 6200	June 10	2.8kg ♂ tabby	VHF (Yes)	Died before baiting	No
20 – 6013	June 10	3.4kg ♀ tabby	VHF (Yes)	Shot	Yes
21 - reflective	June 10	2.7kg ♀ tabby	Reflective (No)	Unknown	Unknown
22 - reflective	June 10	1.7kg ♂ ginger	Reflective (No)	Unknown	Unknown
23 - reflective	June 10	2.2kg ♀ tabby	Reflective (No)	Unknown	Unknown

The GPS functions on the collar fitted to Cat 15 were not working and as such this collar was used as a VHF only device. Two other GPS collars were found to be unusable and were not fitted.

Two collared cats were confirmed to have died following consumption of Curiosity® bait (Figure 16). Five uncollared cats were shot during the 'field study' period. Two of these cats were shot on June 23 in an adjoining unbaited area approximately 970 and 4700 metres from the closest aerial bait transect respectively. This was undertaken to provide an indication of cat diet. The remaining three cats were shot within the study area during hunting for VHF collared cats at the end of the post-bait survey (August 6-8). None of these five cats was found to have Rhodamine B banding in their whiskers.

The addition of supplementary baits did not lead to any additional deaths of collared cats.

Figure 16. Cat 16 (5990) at site of death with consumption of Curiosity bait confirmed by pigmentation of gums and presence of Rhodamine B dye in stomach (indicated by arrow).

3.2.3 Cat activity after baiting

The location data for five cats fitted with GPS collars for the period July 20-22 is shown with reference to the locations where baits were dropped from the aircraft on July 19 (Figure 17). This data indicates that each cat was active within the baited area, crossed bait transects and therefore should have encountered baits when the baits would have been at their most attractive and palatable. Note that all four cats that consumed bait were fitted with VHF only collars.

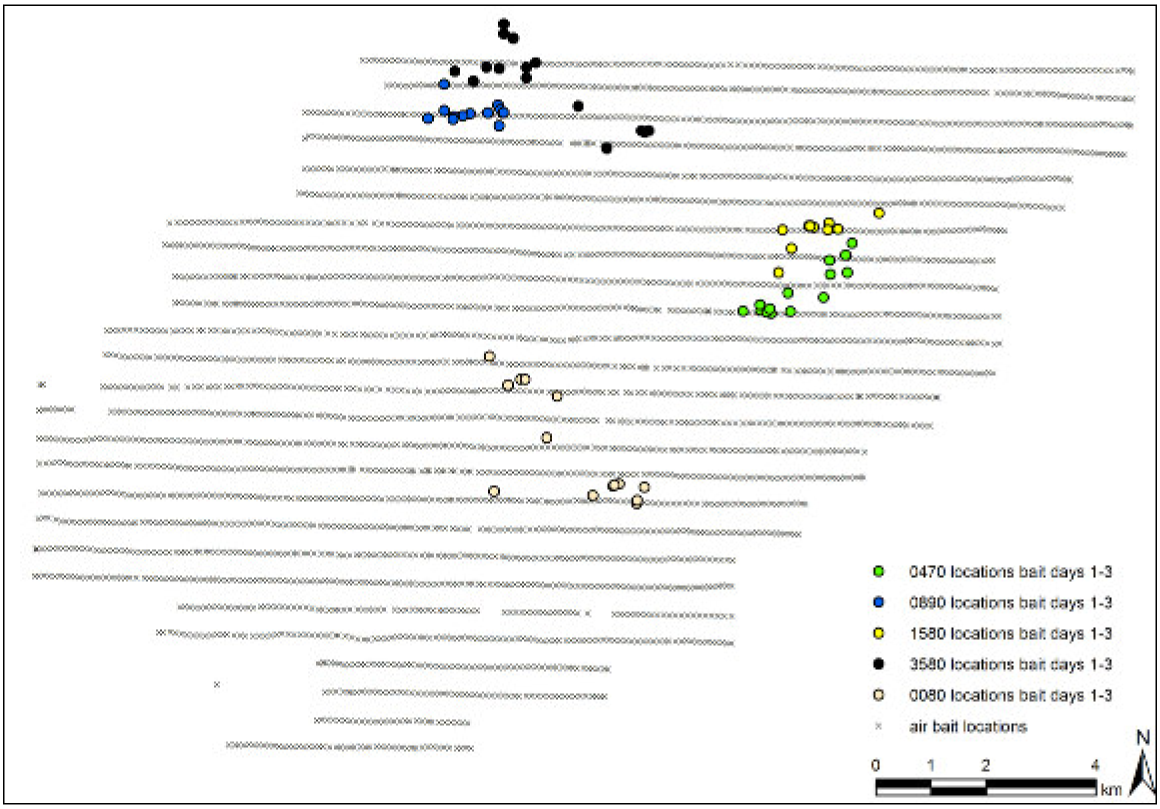

Figure 17. Location of feral cats fitted with GPS collars with reference to baited transects in the 3 days following baiting.

3.2.4 Spotlight surveys

The mean number of cats sighted per spotlight km post-baiting was significantly lower than the pre-baiting spotlight index ($t = 4.65$, $df = 8$, $p = 0.002$; Table 3, Figure 18). None of the cats fitted with collars fabricated from reflective tape were seen during the post-baiting survey. Attempts to determine whether cats observed during this latter survey period were collared were frustrated by overwhelming electrical interference to the VHF receiver generated by the spotlight. A resolution to this would have required disconnecting the spotlight from the vehicle battery every time a cat was sighted.

The rabbit counts remained relatively stable throughout the field study along the 52 km survey route (Table 3).

Table 3. Cats and rabbits observed during each of the 52 km spotlight surveys.

Pre-baiting				Post-baiting		
Date	**Cat**	**Rabbit**		**Date**	**Cat**	**Rabbit**
29 June	16	22		30 July	6	38
30 June	13	33		31 July	6	32
1 July	21	40		1 August	9	38
3 July	13	31		2 August	11	22
4 July	14	52		3 August	6	34
11 July	12	32		4 August	6	32
Mean (st dev)	14.8 (±3.3)	29.5 (±10.1)		Mean (st dev)	7.3 (±2.1)	32.6 (±5.8)

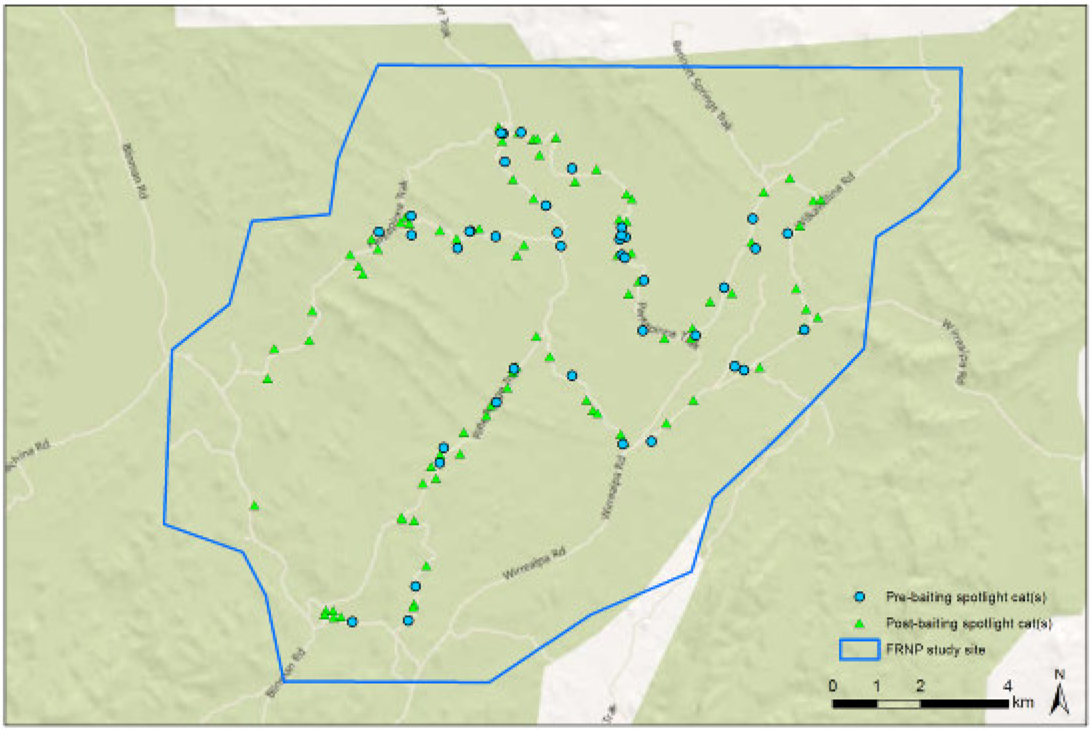

Figure 18. Location of feral cats sighted during pre-bait and post-bait surveys.

3.2.5 Detection of site occupancy using automated cameras

The occupancy rate of feral cats throughout the site was reduced after the application of the Curiosity® baits (Appendix 1). As expected, the audio lures had a significant effect on the estimated detection rate, increasing it from 6.46% to an 18.73% per day. Occupancy rates were estimated to be 92.3% (81.2 – 100%) prior to baiting, and 82.0% (62.8 – 100%) following baiting. The rate of local 'extinction' of feral cats was significant (p-value = 0.011) and estimated to be 15.97%. That means, on

average, after the Curiosity® baits were applied, roughly 16% of the sites that were occupied, were no longer occupied by feral cats.

Red fox detections were limited (n=8), however, the analysis showed that detection rates significantly (*p*-value = 0.026) increased when the audio lures were used (from 1.07% to 11.01%) and colonisation was also significant (*p*-value = 0.028) and estimated to be 15.7%. That means, on average, after the Curiosity® baits were applied, roughly 16% of the sites that were unoccupied, were now occupied by red foxes. The low number of fox detections in the pre-bait monitoring period meant that a little increase, in real terms, led to a statistically significant increase.

European rabbits (23.1%), euros (*Macropus robustus)* (12.7%), and red kangaroos (*Macropus rufus*) (22.1%) all had significant local 'extinction' estimates, while emus (*Dromaius novaehollandiae*) (18.8%) have a significant colonisation estimate. Several species' detection rates decreased while the audio lures were in use, namely European rabbit, grey kangaroos (*Macropus fuliginosus*) and red kangaroos. Dingoes, magpies, ravens and barn owls all showed no significant difference with or without audio lures active and pre or post baiting. However, with dingoes only present on two days, it is unlikely that any significant result would be found. The "bootstrapped χ^2 Goodness-of-Fit" relates to the bootstrapped probability that the χ^2 statistic would be larger than the observed statistic, given the model was true. The models for red fox and magpies were the only models to show significantly poor "goodness-of-fit". For each species the parameters of the model were estimated. The *p*-values relate to the null hypothesis that the parameters true value is zero. The estimated occupancy rates across all sites was estimated by the model pre and post application of the Curiosity® baits.

3.2.6 Feral cat diet

Eighty-one predator scats were located within the study site during the July-August period (Figure 19). Sixty of these scats were identified as cat scats. House mice items, such as hair, teeth, or bones were found in 97% of these scats and were clearly a dietary staple for feral cats at this time. Rabbit remains were identified in 20% of all scats but only two scats consisted solely of rabbit. Birds (20%), reptiles (8%) and invertebrates (5%) were observed less frequently in the scat record.

Thirty scats were located during November. House mice items were found as the sole species represented in 43% of these scats while a further 23% contained both mice and rabbit remains. Thirty per cent of these scats contained rabbit remains only and one scat contained reptile material only. No native mammal remains were detected in any of the feral cat scats collected in the entire study.

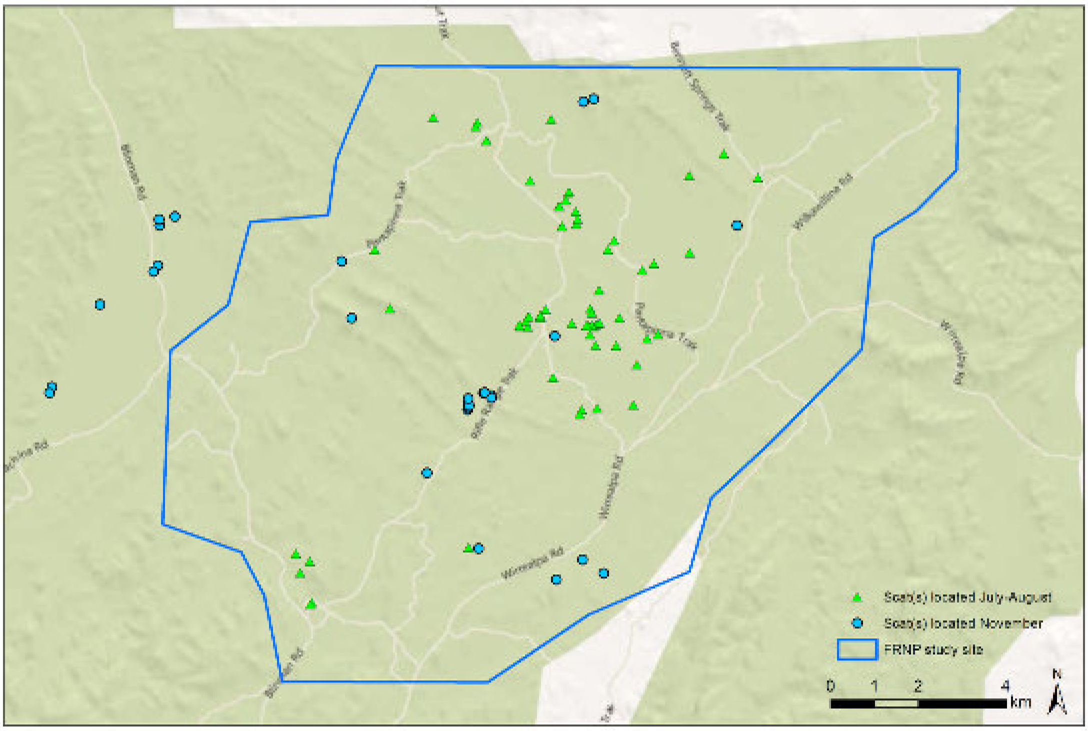

Figure 19. Location of scats recovered during July-August and November.

The prey species identified in the stomach contents of all cats recovered is reported in Table 4. Many items were in the early stages of digestion and this permitted a minimum number of individuals to be described. No insects or reptiles were identified in the stomachs collected during July-August. Both cats (11 and 16) that died following consumption of Curiosity® bait had prey items in their stomachs.

Table 4. Minimum number of prey and species identified from feral cat stomachs

Cat ID.	Date	Mammal	Bird	Reptile	Invertebrate
1 (5400)	August 9	European rabbit			
2 (6590)	August 8	House mouse	Unknown		
3 (3410)	August 6	House Mouse x3 European rabbit			
5 (3980)	August 8	Stomach empty			
6 (7010)	August 8	House mouse			
9 (4590)	August 6	European rabbit	Stubble quail		
11 (8212)	July 25 – August 7	House mouse x1 European rabbit			
12 (5013)	August 8	House mouse x3			
15 (0990)	August 8	Stomach empty			

Cat ID.	Date	Mammal	Bird	Reptile	Invertebrate
16 (5990)	July 20	House mouse x1			
Uncollared 2	August 7	House mouse x3			
Out of study area 1	July 23	House mouse x1			
P263, 4.1kg ♂	November 1	European rabbit			
P397, 4.2kg ♂	November 3		Stubble quail		
P260, 2.5kg ♂	November 1	House mouse x3		*Ctenotus* x1	Orthoptera x1
P290, 3.0kg ♀	November 1	House mouse			Scolopendridae x1
P365, 3.5kg ♂	November 2	House mouse European rabbit	Unknown	*Ctenotus* x1	Scolopendridae x1 Orthoptera x1
P372, 3.0kg ♀	November 3	House mouse			Orthoptera x2
P269, 2.6kg ♂	November 1			*Ctenotus* x2	Scolopendridae x1 Orthoptera x2
P270, 2.9kg ♀	November 1	House mouse x1		*Eremiascincus* x1	Orthoptera x1
P416, 4.1kg ♂	November 3	House mouse x2 European rabbit			Scolopendridae x3
P297, 3.1kg ♀	November 1	House mouse x1		unknown skink x2	Orthoptera x1
P314, 2.7kg ♂	November 2	European rabbit		unknown skink x1	Scolopendridae x3
P344, 2.2kg ♀	November 2	European rabbit		unknown skink x1	Scolopendridae x1

3.2.7 Rabbit spotlight counts

The *Bounceback* project has monitored rabbit populations across this site since 1994. The data collected during the present study is contrasted with historical data dating from March 2009 (Figure 20). The number of rabbits seen during the three spotlight surveys conducted in July fit with the *Bounceback* data.

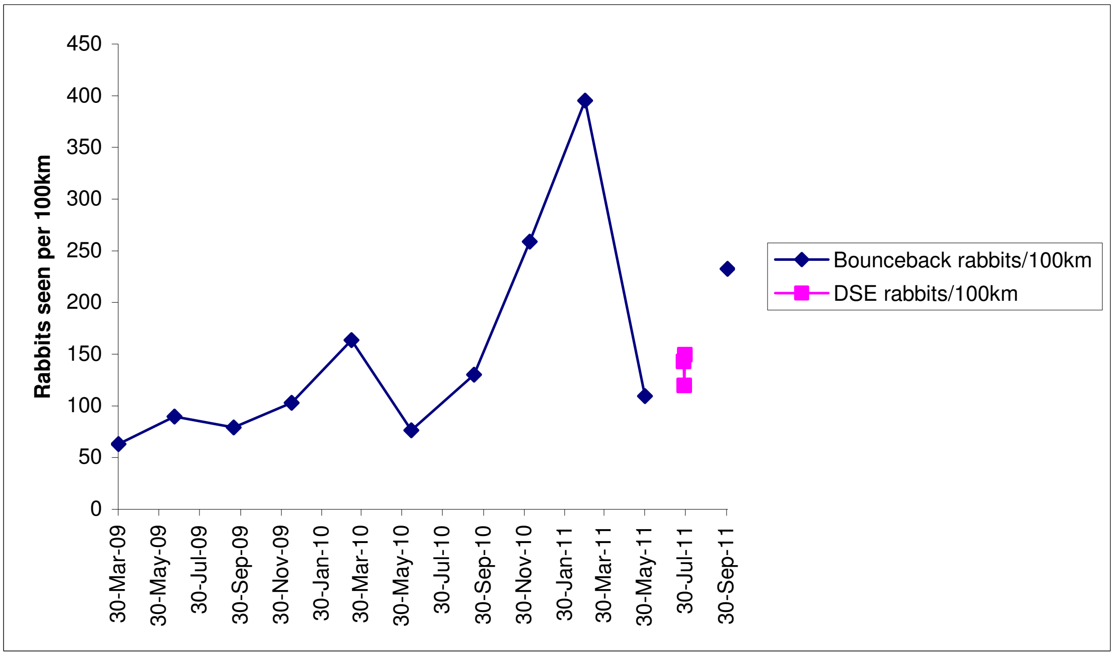

Figure 20. Number of rabbits counted along the 30 km transect by *Bounceback* and DSE.

3.2.8 Examination of whiskers for Rhodamine B bands.

Two of the 15 cats, namely cat 3 and 20, that were recovered at the end of the post-baiting period and examined were found to have had Rhodamine B bands in their whiskers (Figure 21) indicating some exposure to the Curiosity® bait (Table 2). None of the whiskers sampled from twelve cats shot during November were observed to have Rhodamine B bands.

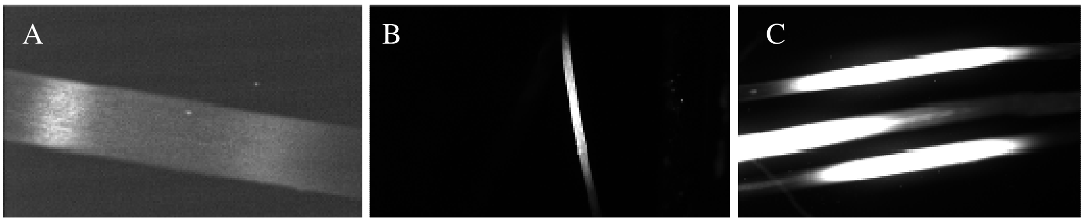

Figure 21. Rhodamine B dye banding in whiskers from A) cat 3, B) cat 20 and C) domestic cat that was given a known amount of dye in a non-toxic pellet (Photos: Frank Gigliotti).

3.2.9 Home range of GPS collared cats

The GPS datalogger collars collected location data over an average of 99 days (range: 79-117 days, n=5). Home ranges were calculated using a 95% minimum convex polygon (MCP) model using the Home Range Extension (Rodgers and Carr 1998) in Arcview 3.3 (Table 5). Cat 18 used two discrete areas during this study. The home range for this cat was calculated by assessing and then summing data from the two areas and ignoring the ten intervening 'in-transit' locations (Figure 22).

Table 5. Home range (95% MCP) of GPS collared cats.

Cat Identifier	No. of locations (days)	Home range (95% MCP)
Cat 4 (0080)	361 (79)	886 ha
Cat 7 (0470)	600 (107)	678 ha
Cat 13 (1580)	676 (113)	684 ha
Cat 14 (3580)	499 (99)	912 ha
Cat 18 (0890)	403 (88)	291 ha (north), 106 ha (south), total = 397 ha

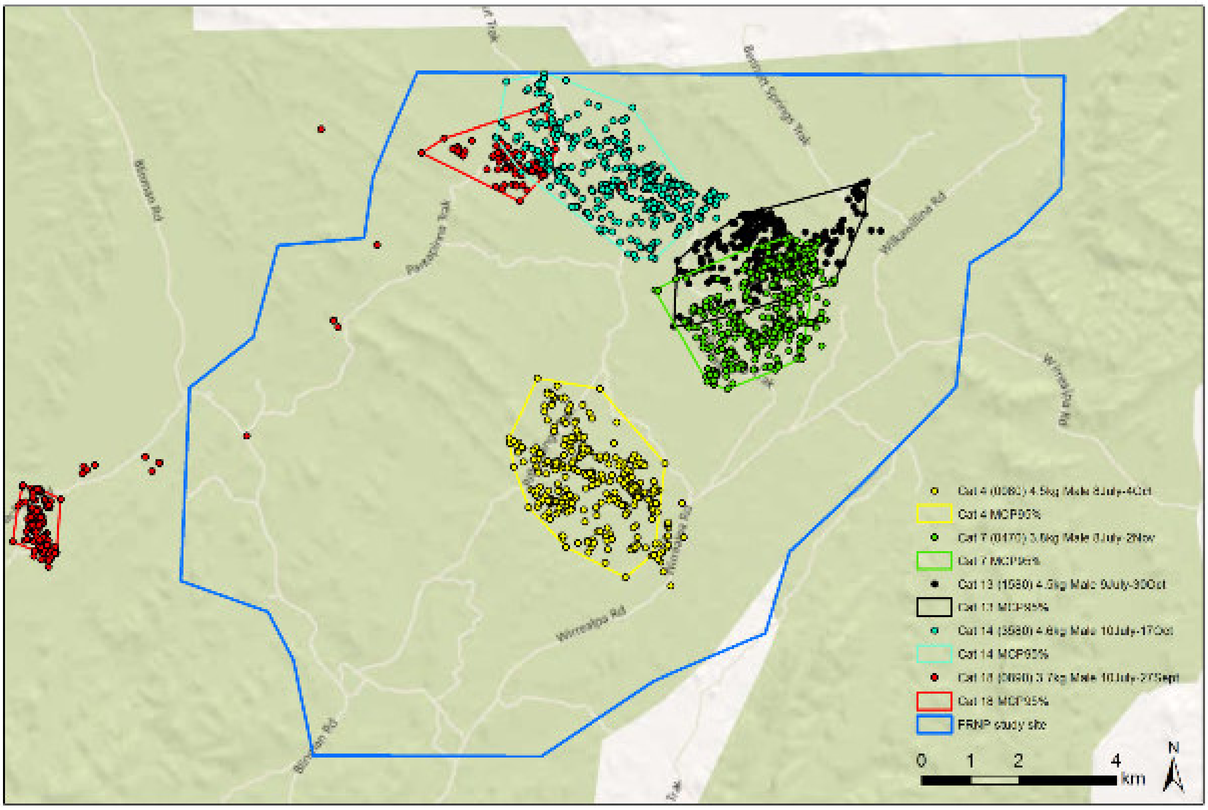

Figure 22. Locations used by GPS collared feral cats in this study and home range calculated using 95% minimum convex polygons.

3.2.10 Non-target species

The analysis of carnivorous bird survey data indicated differing results between the two survey techniques used. Appendix 2 indicates that there was a slight but significant increase in counts of Australian magpies and wedge-tailed eagles following baiting along the 52 km driven transect while other species recorded no significant difference. However, a repeated measures ANOVA analysis for the carnivorous birds observed in the point count surveys before and after the baiting program (Table 6) suggests a significant decrease in all cases where there was a significant result. The *p*-values relate to the test of no change in abundance pre- and post-baiting.

No dead or moribund birds were encountered during this study where death could be attributed to Curiosity® bait, although it is accepted that dead birds may not have been observed and/or left the study area. Ten baits were removed from the 'on-track' camera sites by Australian magpie (1), ravens

(6) with no photograph obtained of the responsible species on the remaining 4 events. Macropods, rabbits, emu and stubble quail were photographed 'visiting' the sites but did not remove baits. Formal bird surveys were not conducted in November, however incidental observations indicated increased populations of wedge-tailed eagles with for example, 14 birds observed feeding on a single euro carcass on November 2 (M. Johnston and M. O'Donoghue pers. obs). A bird list generated during the project is provided in Appendix 3.

Table 6. Mean number of birds recorded during 5 minute point count surveys. Standard deviation values indicated in brackets.

Species	Pre-bait	Post-bait	ANOVA change in observations after baiting (*p*-value)
Australian raven	2.2 (1.9)	2.2 (1.7)	0.193
Brown falcon	1.3 (0.6)	1.0 (0)	0.026
Grey butcherbird	1.0 (0)	1.0 (0)	1.000
Emu	3.8 (3.1)	5.6 (4.8)	0.115
Australian kestrel	1.8 (1.1)	1.4 (0.5)	0.020
Australian magpie	2.5 (1.6)	2.0 (1.0)	0.020
Wedge-tailed eagle	3.9 (2.2)	2.6 (2.2)	0.0003
Carnivore guild total	3.46 (0.36)	6.51 (0.91)	0.0004

Reptiles were rarely observed during the June-August field study despite considerable time spent walking across the site. A central bearded dragon (*Pogona vitticeps*) was observed on July 26, an earless dragon (*Tympanocryptis* spp.) on July 31 and a shingle-back (*Trachydosaurus rugosus*) on August 4. In contrast, six shingle-back and five central bearded dragons were observed over three days while driving around the site in November.

3.2.11 Hardness of the HSDV

This assessment was initiated on July 21 and the first group of five sample baits were inspected on July 24, i.e. five days after baits had been applied. The structural integrity of the HSDV was assessed daily until August 1. Twenty-nine of the 40 polymer encapsulations (72.5%) remained hard and no leakage of toxicant into the meat matrix occurred (Table 7). However, eleven of the forty baits (27.5%) sampled over the 8 days had softened and/or leaked at some point since the time of bait manufacture.

Table 7. Durability of the Hard Shell Delivery Vehicle.

Date	Baits in acceptable condition
24 July	3/5 OK
25 July	4/5 OK
26 July	4/5 OK
27 July	3/5 OK
28 July	4/5 OK
29 July	4/5 OK
30 July	3/5 OK
1 August	4/5 OK

3.2.12 Pen trials with captive feral cats

Nine of the eleven feral cats (82%) tested in the pen trials conducted in Victoria died following consumption of one Curiosity® bait (Table 8). One cat, #131, rejected the HSDV on three occasions but consumed it on the fourth presentation.

Table 8. Results from pen trials using baits returned from Flinders Ranges National Park.

Cat Id.	Morphometric	Bait provided	Bait eaten	HSDV eaten	Collapse	Vomit	Death
126	2.8 kg ♀ pregnant with 4 kittens	29/9/11 1819 hrs	29/9/11 2018 hrs	Yes	29/9/11 2107 hrs	No	30/10/11 0505 hrs
127	2.3 kg ♀	29/9/11 1819 hrs	29/9/11 1826 hrs	Yes	29/9/11 2347 hrs	No	30/9/11 0055 hrs
128	2.4 kg ♀	6/10/11 1227 hrs	7/10/11 0010 hrs	Yes	7/10/11 0625 hrs	Yes	recovered
129	3.6 kg ♂	10/10/11 1902 hrs	10/10/11 1910 hrs	Yes	10/10/11 2032 hrs	No	10/10/11 2113 hrs
130	2.6 kg ♀	10/10/11 1902 hrs	10/10/11 1911 hrs	Yes	10/10/11 2204 hrs	No	10/10/11 ~2220 hrs
131	1.9 kg ♀	10/10/11 1902 hrs	10/10/11 1911 hrs	No			
131		10/10/11 2004 hrs	10/10/11 2023 hrs	No			
131		11/10/11 1900 hrs	11/10/11 1912 hrs	No			
131		11/10/11 1920 hrs	11/10/11 1926 hrs	Yes	11/10/11 2114 hrs	No	11/10/11 2158 hrs
132	3.0 kg ♀	11/10/11 1907 hrs	11/10/11 1914 hrs	Yes	11/10/11 2047 hrs	No	11/10/11 2140 hrs

Cat Id.	Morphometric	Bait provided	Bait eaten	HSDV eaten	Collapse	Vomit	Death
133	3.0 kg ♀	11/10/11 1907 hrs	12/10/11 0212 hrs	Yes	12/10/11 0319 hrs	No	12/10/11 0400 hrs
134	1.9 kg ♀	12/10/11 1959 hrs	12/10/11 2011hrs	No			
134		12/10/11 2024 hrs	13/10/11 0306hrs	Yes	13/10/11 0819 hrs	13/10/11 0819	recovered
135	1.8 kg ♀	12/10/11 1959 hrs	12/10/11 2013 hrs	Yes	13/10/11 0212 hrs	No	13/10/11 0346 hrs
136	2.1 kg ♀ pregnant with 3 kittens	12/10/11 1959 hrs	12/10/11 2008 hrs	Yes	13/10/11 0257 hrs	No	13/10/11 0332 hrs

3.2.13 Bait assay

Results from the analysis of batches tested for this project are presented in detail in Scientec Research Report # 876. To summarise, these results show no impurities (i.e. a single peak at this absorbance wavelength), indicating minimal contaminating components in the formulation which might be attributable to the processing of the drug-core formulation (Figure 23). Impurities would be displayed as additional peaks on the chromatogram if they were present.

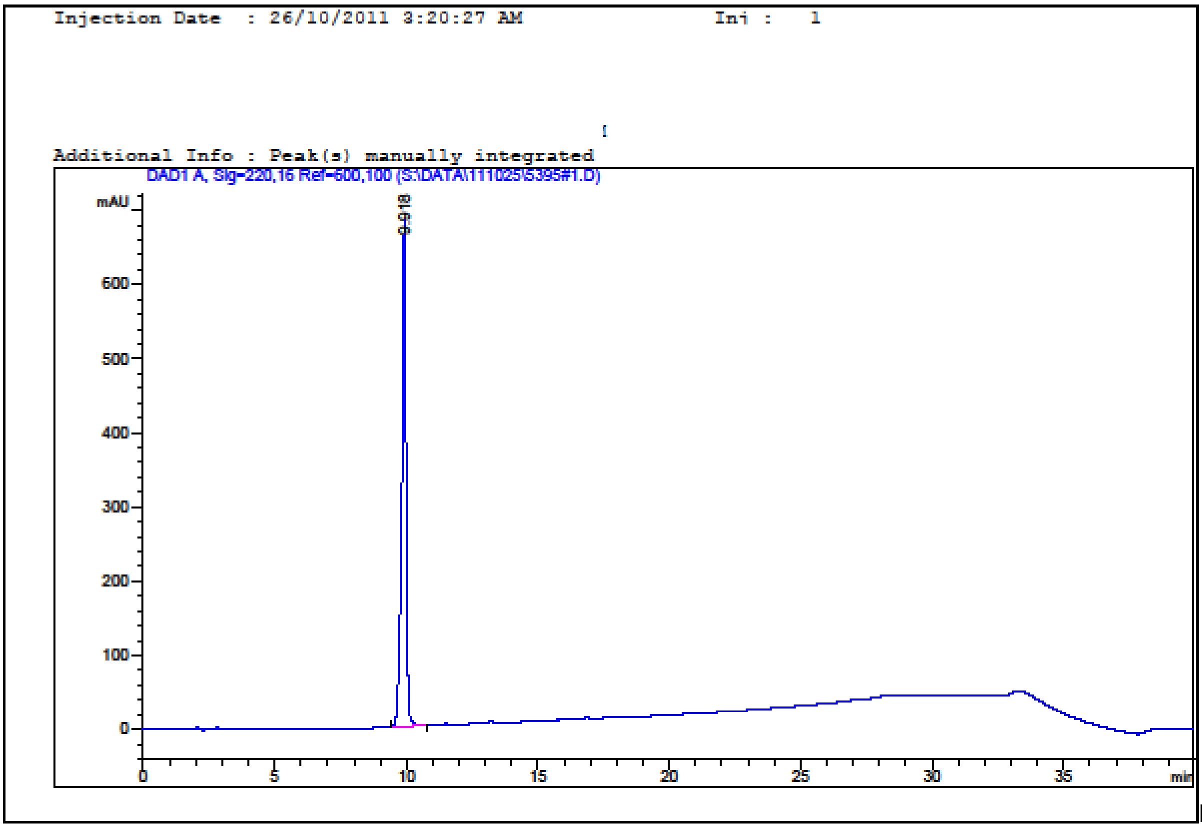

Figure 23. High pressure liquid chromatogram indicating minimal impurity in PAPP sample from baits returned from Flinders Ranges National Park study.

4 Discussion

The objective of the study was to assess the efficacy of the Curiosity® bait in reducing a feral cat population at a semi-arid site. Surveys undertaken using automated cameras, spotlighting and a 'marked' population in the Field Study indicated that there was an abundant population of cats on the site prior to the conduct of aerial baiting. Baits were aerially deployed across a 150 km^2 site in the Flinders Ranges National Park at a density of 50 baits /km^2 on July 19, 2011.

Two radio-collared cats were found to have died as a result of consumption of Curiosity® baits, i.e. 11% of the eighteen collared cats that were known to be alive. Analysis of whiskers recovered from cats that were hunted at the conclusion of the trial indicated that a further two cats had consumed bait but survived. The survival of these two cats is possible through two mechanisms; a) failure to consume the entire pellet, or b) vomiting of some of the dose. Pen trial data conducted prior to and subsequent to this field trial indicated that vomiting does occur and can lead to recovery from PAPP toxicosis (Scientec Research, pers. comm.). Emesis during PAPP intoxication has been previously reported in a variety of mammalian and avian species (Savarie et al. 1983; Murphy et al. 2007) in pen and field studies. The absence of Rhodamine B banding in the cats shot in November was expected given the length of time between baiting and this sampling period (Fisher et al. 1999; Fisher 1998). Additionally, it is not known how long these cats had been resident within the baited area.

Spotlight surveys conducted after baiting suggested that the cat population had been halved. Cats observed during these surveys included a number of sub-adult animals, i.e. a queen with kittens at foot such as seen in Figure 6. The site was suitable for the conduct of spotlight searches given the height and scarcity of vegetation along the transect route. The spotlight survey route was however, proximate to the edge of the study site and this increased the likelihood of observing cats that had recently immigrated into the site. Data sourced from GPS collars suggest that four of the five collared cats had stable home ranges during this study of 678-912 ha. The remaining animal (cat 18, 3.7 kg male) had location data in two 'focus areas' and dispersed twelve kilometres from the location where it was trapped. It is unknown what prompted the cat to initiate this movement. It should be noted also that the GPS location data in this site was sourced from male cats only due to the weight of the collars restricting the size of cats that could be collared.

Site occupancy estimates for cats decreased by 16% following baiting. This figure should be interpreted with care as it does not indicate a 16% decrease in the cat population. The analysis used in this study does not account for multiple cats being photographed by the same camera – which was observed frequently when the data was reviewed. Detailed analysis of the images may allow for identification of individuals and more informative statistical models to be utilised. The actual decrease in the cat population will lie somewhere between 10 – 50% based on the interpretation of the three monitoring techniques.

Currently available data suggests that the bait efficacy achieved in this study was lower than that required to make a significant decrease in the impact of cat predation across the site. However, in this case it appears that the diet of feral cats at the site was heavily biased towards invasive species, house mice and to a lesser extent, rabbits. The abundance of these dietary staples may have been a contributing factor in the bait efficacy achieved given that the feral cat population did not appear to be food stressed. The GPS collar data indicated that these particular cats should have encountered baits. Earlier studies (Algar and Burrows 2004; Algar et al. 2007) have also achieved low feral cat population reductions in the presence of abundant food resources indicating that a bait encounter (even if attractive and palatable) does not lead to bait consumption.

Identification of items in scats and stomachs indicated that house mice and to a lesser extent rabbits were the dietary staple for feral cats during the study period. While house mice were rarely seen during

spotlight surveys, i.e. <1 per 52 km transect, it is apparent that feral cats encountered and consumed sufficient house mice to sustain them. No attempt was made to estimate the abundance of mice within the site but it was apparent that cats were not food stressed. The rabbit population present on the study site was assessed to be relatively low, especially when contrasted to adjoining sites (i.e. within 15 km) that had not been subject to broad-scale control (N. de Preu, pers. comm.). The *Bounceback* rabbit surveys indicate that a spike in the rabbits occurred in March 2011 of up to 395 rabbits / 100 km on the Pantapinna Plain while on the untreated site there were >2324 / 100 km. The combination of this rabbit abundance and house mice irruptions would support a greater number of predators in the neighbouring areas. Reinvasion of vacated territories into the baited area via dispersal from these high population sites into the study site is likely and could have led to inaccuracies in the post-baiting assessments but is beyond the scope of this study to estimate the timing and frequency of this dispersal or reinvasion behaviour (Moseby et al. 2009a,b).

The prey consumed by cats was observed to broaden with samples collected following the onset of warmer weather when reptiles and invertebrates became increasingly active. No traces of *Notomys* or other native mammals were detected in cat scats or stomachs throughout the study period suggesting that the species observed during the pilot study exists in very low densities. Hart (1994) investigated the diet of feral cats and red foxes in the same area during a period of drought and concluded that reptiles were more frequently predated by cats than foxes. However, despite Hart (1994) and this study being conducted at the same site and over similar season, there are some obvious differences in the diet of cats. These differences, such as the proportion of rabbit and house mice consumed are likely to be linked to changed resource availability brought on by broad scale reductions in rabbit populations across the site (DEH 2006) as well as irruptions of mice in response to significant rainfall events (Dickman et al. 1999). The peak in the house mouse population occurred during March-April at this site (M. Trebilcock, pers. comm.) and was preceded by a locust plague in November 2010. Holden and Mutze (2002) found that plague locusts dominated the diet of feral cats and foxes in this area during earlier irruptions. However, invertebrates were infrequently detected in the diet of cats during the cooler months in this study.

There was no reason to doubt the palatability of Curiosity® baits used in this study given that no rain was experienced and ants were not obviously feeding on the baits used in the bait stability experiment. The cats used in pen trials had consumed baits that had returned from the field study and had undergone considerable freight and several freeze/thaw cycles. Three aerially deployed baits were located by field crew walking across the site. These baits were observed to be in good condition in terms of odour, had not desiccated nor had they been subject to obvious ant activity either. The 'pair' of these baits was not located within the immediate area (i.e. within 5m as indicated by the practice baiting exercise) suggesting that it had been moved and/ or eaten. The baits were however, not obviously 'sweating' and at the time this was attributed to the cool, but fine, weather. Alternatives are currently being explored to increase the 'attractiveness' of the baits by enhancing movement of the lipid component of the meat in the bait substrate through the sausage skin (M. O'Donoghue pers. comm.). This is intended to address the limited sweating that occurred on baits observed in the field. Specific inspections of the structural integrity of the HSDV was not initiated until five days after baits had been applied. However, the majority of baits inspected after this date were found to be in a suitable condition. The results indicating leakage of toxicant into the meat matrix probably represents a worst case scenario that was influenced by the handling and inspection process, i.e. storage and transport in vehicle or damaging the pellet with a knife during inspection.

The timing of the study to winter was subject to various factors such as receipt of necessary permits and availability of field crew. However, biological factors were the main determinant with the trial planned to be undertaken when cats were expected to be food stressed (Algar et al. 2007). It was expected that reptiles would be infrequently available during the study as a food resource. Field

observations of reptiles were rare despite considerable time walking across the site servicing automated camera and/or searching for collared cats. This was not a surprising result given the low ambient temperatures experienced. There was an abundance of small bird fauna observed throughout the site with, for example, a high number of stubble quail (*Coturnix pectoralis*) observed. Analysis of stomach contents of cats indicated that this species was consumed by feral cats. Surveys for alternative prey resource such as mice were not undertaken during the pilot study. Had this work been undertaken the conduct of the trial may have been postponed or relocated to an alternative site. An indication of likely prey availability at the site was however subsequently identified. Captures of small vertebrate species during the March 2011 *Bounceback* fauna survey achieved the highest trap success for this survey since January 1999. Seventy-five per cent (n= 132) of the total mammal and reptile captures were of house mice (N. de Preu, pers. comm.).

The application of Curiosity® baits is not thought to have led to decreases in the populations of non-target species despite the apparent decline reflected in the post-baiting surveys. Populations of carnivorous and scavenging bird species such as corvids and large raptors respond to the food resources available (Read and Wilson 2004). The statistical tests used to analyse the bird survey data considered that the death following consumption of baits was the only causal factor in change in bird counts. Clearly, a range of other factors have an impact on bird presence and detectability on any given day. These include migration / emigration, weather, time of day, seasonal dietary preferences. The small sample sizes associated with counts of infrequently observed species also lead to overstating the impact of baits in this analysis. It is proposed that the reduced observations of bird fauna is in part a result of the sampling protocol and secondly due to the ranging behaviour of these birds. This situation was reversed in November when, during a euro (*Macropus robustus*) cull, a greater number of wedge-tailed eagles was evident albeit these were opportunistic observations. The observed repeated removal of baits by ravens from bait camera #1 suggests that the same group of birds were involved and were not being poisoned. Studies using wild caught ravens in captivity have indicated that these birds will reject the encapsulated pellet (F. Gigliotti, pers. comm.) with similar behaviour observed in other corvid species (Avery et al. 2004). Barn owls (*Tyto alba*) were commonly photographed at automated camera sites attempting to pounce on the FAP audio lures. It is likely that this species had also responded positively to the abundance of mice. It is considered unlikely that this and other nocturnal raptors would locate and consume Curiosity® baits (E. McNabb pers. comm.).

There may have also been some behavioural factors that led to cats favouring live prey over baits at this time. Dependent and sub-adult kittens were observed during the study and it is likely that mother cats would be actively teaching juveniles to hunt following weaning. The development of predatory behaviour is fostered by the provision of recently killed or injured prey items (Bradshaw 1992). Play behaviour with the food item follows, during which the physical predatory responses of pouncing, grasping, etc are practiced. Kittens also have a tendency to learn by watching others and they may exhibit a selection of prey/food items that their mother has shown them how to kill (Bradshaw 1992; Leyhausen 1975) and it is therefore likely that the cat population at this site has to some extent a behavioural preference for mice given that this species would have been a dietary staple since the irruption. Bradshaw (1992) notes that the consumption of prey depends both on the palatability of alternative foods as well as hunger *per se.*

Optimal bait consumption rates by cats have been achieved during periods of relative paucity of preferred dietary items (Algar et al. 2007). Consumption of baits by non-target species reduces the likelihood of a cat encountering bait when hungry (Campbell et al. 2011). Use of an attractive bait medium does not necessarily provide for high rates of bait consumption, particularly in situations when preferred food resources are abundant. Cats are considered to exhibit apostatic food selection but will consume rarer food items to maintain nutrition (Church et al. 1996). Achieving high bait consumption

rates by cats will require consideration of these various factors in order to apply baits at an appropriate time.

5 Conclusions and Recommendations

The conduct of this study in the latter stages of an irruption of house mice proved to be a challenging test of the efficacy of the Curiosity® bait. While in this case, the cat diet was observed to be dominated by invasive species, the increased abundance of small-medium fauna populations following periods of above average rainfall will likely remain a challenge for land managers attempting to mitigate the impact of feral cats. Reliance on poison baiting alone in this situation may lead to poor outcomes. Prior to undertaking a baiting programme using the Curiosity® bait an assessment of the abundance of likely prey items should be conducted and consideration of whether a period of food stress or 'baiting window' exists.

Agencies responsible for overseeing and/or funding trials such as this might consider the impact that environmental factors, such as weather, have on the likely success of field trials and build in some flexibility whereby the work may be conducted at an alternative site or time if unsuitable conditions exist at the preferred site.

The results of the study were affected by reliability and design of the radio collars. Three GPS collars were found to be faulty and were not fitted to cats and another seemed operational during fitting but was not located following release of the cat. The mass of these devices restricted their use to male cats only. The mortality mode on the VHF only collars was not reliable. Future studies should review other suppliers of telemetry equipment that might offer more light weight options and other features such as remote download.

The analysis of whiskers indicated that two cats survived exposure to PAPP. While it is unknown whether these animals consumed a partial or complete dose, this result should be considered in the light of impact of welfare to the individual cat. This data provides an in-field demonstration that echoes results achieved in pen trials in which the cats that do survive appear to fully recover following PAPP intoxication.

The key issue to address with respect to development of the bait is improving the manner in which the lipid component of the meat matrix 'sweats' through the sausage skin. The odour of the baits is an important part of making the bait attractive and effectively increases the bait encounter area as cats may locate the bait by following the scent as it is carried by the wind.

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Appendix 1. Site occupancy data generated from detections by automated cameras.

	***P* - values**			**Estimated Occupancy**		
Species	**Colonisation**	**Extinction**	**Detection**	**Pre-baiting (SE)**	**Post-baiting (SE)**	**Bootstrapped χ^2 Goodness-of-Fit**
Feral cat *Felis catus*	0.868	0.0114	<<0.0001	0.923 (0.063)	0.820 (0.103)	0.418
Red fox *Vulpes vulpes*	0.0285	0.839	0.0261	0.034 (0.205)	0.151 (0.275)	0.0249
Dingo *Canis lupus dingo*	0.959	0.883	0.781	0.993 (0.345)	0.0001 (0.0002)	0.279
Western grey kangaroo *Macropus fuliginosus*	0.324	0.739	0.041	0.727 (0.147)	0.776 (0.126)	0.791
Red kangaroo *Macropus rufus*	0.181	0.020	<0.0001	0.578 (0.086)	0.589 (0.083)	0.617
Euro *Macropus robustus*	0.502	0.003	0.495	0.654 (0.072)	0.713 (0.070)	0.846
European rabbit *Oryctolagus cuniculus*	0.104	0.014	<<0.0001	0.532 (0.075)	0.560 (0.074)	0.338
Australian raven *Corvus coronoides*	0.610	0.480	0.839	0.593 (0.212)	0.536 (0.199)	0.786
Australian magpie *Gymnorhina tibicen*	0.733	0.777	0.818	0.545 (0.099)	0.742 (0.108)	0.0498
Barn owl *Tyto alba*	0.572	0.814	0.646	0.625 (0.101)	0.956 (0.112)	0.741
Emu *Dromaius novaehollandiae*	0.0232	0.423	0.766	0.321 (0.101)	0.347 (0.087)	0.766

Appendix 2. Observations of carnivorous birds per kilometre prior to and following baiting along the 52 km survey transect.

	Start location and direction of travel around 52 km transect, see Fig 2.	Australian raven	Brown Falcon	Emu	Australian kestrel	Australian magpie	Wedge-tailed eagle	Peregrine falcon	Grey butcherbird	Brown goshawk	Little eagle	Red-backed kingfisher
Pre-bait survey												
June 2	3 – clockwise	0.77	0.58	12.08	1.92	9.39	4.03	0	0	0	0	0
June 3	1 - anticlockwise	1.27	0.18	11.96	1.81	9.79	3.44	0	0	0	0	0
June 4	2 – clockwise	1.77	0.98	9.44	2.16	16.52	1.57	0	0	0	0	0
June 5	2 - anticlockwise	2.23	1.22	13.99	3.24	11.96	2.64	0.41	0.20		0	0
June 6	3 – clockwise	1.80	0.90	4.49	2.16	12.93	1.98	0.18	0.36	0.18	0	0
June 7	1 - anticlockwise	1.22	0.81	5.49	3.46	1-.17	2.24	0.20	0	0.2	0	0
Mean (st dev)		1.51 (±0.5)	0.78 (±0.3)	9.58 (±3.8)	2.46 (±0.7)	11.79 (±2.6)	2.65 (±0.9)	0.13 (±0.1)	0.90 (±0.1)	0.06 (±0.1)	0	0
Post-bait survey												
July 30	1 – anticlockwise	1.80	0.23	9.25	0.90	4.96	0.90	0	0	0.45	1	0
July 31	3 – clockwise	1.80	0.68	11.05	2.48	7.89	0.45	0	0	0	0	0

	Start location and direction of travel around 52 km transect, see Fig 2.	**Australian raven**	**Brown Falcon**	**Emu**	**Australian kestrel**	**Australian magpie**	**Wedge-tailed eagle**	**Peregrine falcon**	**Grey butcherbird**	**Brown goshawk**	**Little eagle**	**Red-backed kingfisher**
August 1	2 – clockwise	2.26	0.68	15.34	2.03	11.28	2.03	0	0	0	0	0
August 2	2 – anticlockwise	2.03	0.68	6.99	3.38	11.73	1.13	0	0	0	0	0
August 3	1 – anticlockwise	0.68	0.23	11.28	2.03	5.86	0.90	0	0	0	0	0
August 4	3 – clockwise	1.35	0	9.70	2.03	12.41	1.35	0	0	0	0	1
Mean (st dev)		1.62 (±0.5)	0.36 (±0.3)	10.51 (±2.7)	2.08 (±0.8)	9.25 (±3.2)	1.26 (±0.5)	0	0	0.09 (±0.1)	0.2	0.2
***p* values for T test** positive '+' or negative '-' trend of birds counted during post-baiting survey compared to pre-baiting survey		0.60 (-)	0.07 (+)	0.66 (-)	0.34 (+)	0.03 (+)	0.05 (+)	0.11 (+)	0.19 (+)	0.91 (-)	0.36 (-)	0.36 (-)

Appendix 3. Bird species observed in field site

A list of all bird species observed within the field site during the project is provided. This table is divided into pre- and post-baiting sampling periods.

Common Name	**Scientific Name**	**June 1 – July 18**	**July 19 – August 6**
Apostlebird	*Struthidea cinerea*		✓
Australasian pipit	*Anthus novaeseelandiae*	✓	✓
Australian kestrel	*Falco cenchroides*	✓	✓
Australian magpie	*Gymnorhina tibicen*	✓	✓
Australian raven	*Corvus coronoides*	✓	✓
Australian ringneck	*Barnardius barnardi*	✓	✓
Black-eared cuckoo	*Chrysococcyx osculans*		✓
Black-faced cuckoo-shrike	*Coracina novaehollandiae*	✓	
Black-faced wood-swallow	*Artamus cinereus*		✓
Boobook owl	*Ninox boobook*		✓
Brown falcon	*Falco berigora*	✓	✓
Brown songlark	*Cincloramphus cruralis*	✓	✓
Brown tree-creeper	*Climacteris picumnus*	✓	✓
Budgerigar	*Melopsittacus undulatus*	✓	✓
Chestnut-rumped thornbill	*Hylacola pyrrhopygia*	✓	✓
Chirruping wedgebill	*Psophodes cristatus*	✓	✓
Cockatiel	*Nymphicus hollandicus*	✓	✓
Collared sparrowhawk	*Accipiter cirrhocephalus*	✓	
Common bronzewing	*Phaps chalcoptera*	✓	✓
Crested pigeon	*Ocyphaps lophotes*	✓	✓
Crimson chat	*Epthianura tricolor*	✓	
Diamond dove	*Stagonopleura guttata*	✓	✓
Elegant parrot	*Neophema elegans*	✓	✓
Emu	*Dromaius novaehollandiae*	✓	✓
Fantail cuckoo	*Cacomantis flabelliformis*	✓	
Galah	*Cacatua roseicapilla*	✓	✓

Common Name	**Scientific Name**	**June 1 – July 18**	**July 19 – August 6**
Gilbert's whistler	*Pachycephala inornata*		✓
Grey butcherbird	*Cracticus torquatus*	✓	✓
Grey fronted honeyeater	*Lichenostomus plumulus*	✓	✓
Grey shrike-thrush	*Colluricincla harmonica*	✓	✓
Horsfield's bronze-cuckoo	*Chrysococcyx basalis*	✓	✓
House sparrow	*Passer domesticus*		✓
Little corella	*Cacatua sanguinea*	✓	✓
Little eagle	*Hieraaetus morphnoides*		✓
Magpielark	*Grallina cyanoleuca*	✓	✓
Mistletoebird	*Dicaeum hirundinaceum*	✓	✓
Mulga parrot	*Psephotus varius*	✓	✓
Orange chat	*Epthianura aurifrons*	✓	✓
Owlet nightjar	*Aegotheles cristatus*	✓	
Pallid cuckoo	*Cuculus pallidus*	✓	
Peregrine falcon	*Falco peregrinus*	✓	
Red-backed kingfisher	*Todiramphus pyrrhopygia*		✓
Red-capped robin	*Petroica goodenovii*	✓	✓
Red-rumped parrot	*Psephotus haematonotus*	✓	✓
Redthroat	*Pyrrholaemus brunneus*	✓	✓
Rufous songlark	*Cincloramphus mathewsi*		✓
Rufous whistler	*Pachycephala rufiventris*	✓	✓
Singing honeyeater	*Mirafra javanica*	✓	✓
Southern whiteface	*Aphelocephala leucopsis*	✓	✓
Spiny-cheeked honeyeater	*Acanthagenys rufogularis*	✓	✓
Striated pardalote	*Pardalotus punctatus*	✓	✓
Stubble quail	*Coturnix pectoralis*	✓	✓
Tree martin	*Hirundo nigricans*	✓	✓
Variegated fairy-wren	*Malurus lamberti*	✓	✓
Wedge-tailed eagle	*Aquila audax*	✓	✓
Weebill	*Smicrornis brevirostris*	✓	✓

Common Name	**Scientific Name**	**June 1 – July 18**	**July 19 – August 6**
Welcome swallow	*Hirundo neoxena*	✓	✓
White-browed babbler	*Pomatostomus superciliosus*	✓	✓
White-faced heron	*Egretta novaehollandiae*		✓
White-fronted chat	*Epthianura albifrons*	✓	
White-necked heron	*Ardea pacifica*	✓	
White-plumed honeyeater	*Lichenostomus penicillatus*	✓	✓
White-winged fairy-wren	*Malurus leucopterus*	✓	✓
Willie wagtail	*Rhipidura leucophrys*	✓	✓
Yellow-rumped thornbill	*Acanthiza chrysorrhoa*	✓	✓
Yellow-throated miner	*Manorina flavigula*	✓	✓
Zebra finch	*Taeniopygia guttata*	✓	✓
Corvid sp.		✓	
Total Species		**57**	**58**

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